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CALIFORNIA'S FOREST RESOURCES:

PRELIMINARY ASSESSMENT

CALIFORNIA DEPARTMENT OF FORESTRY

1979

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CALIFORNIA
DEPARTMENT OF FORESTRY

FOREST RESOURCES ASSESSMENT AND ANALYSIS

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JULY
1979

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PREFACE

This Preliminary Assessment was prepared in response to the California Forest Resources Assessment and Policy Act of 1977 (FRAPA). This Act was passed to improve the information base upon which State resource administrators formulate forest policy. The Act provides for this report and a full assessment by 1987 and at five year intervals thereafter, prior to the federal reports required by the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) and the Soil and Water Resources Conservation Act of 1977 (RCA).

In fulfilling FRAPA's mandate, the Director of the Department of Forestry is to: perform an analysis and assessment of the supply and demand for forest resources, evaluate current State programs related to forestry, and discuss important policy considerations and other factors affecting management of the forest resources on both public and private lands. The completed report is to be submitted to the Resources Secretary and to the Board of Forestry for support of their responsibilities. The Board develops policy recommendations while the Secretary is charged to formulate programs for agencies connected with California's resources.

The Act defines forest resources as "those uses and values associated with, attainable from, or closely tied to, forest land, including fish, range, recreation, timber, watershed, wilderness, and wildlife." Other values closely associated with the forest land are the soil, mineral, air and wood energy resources.

This Preliminary Assessment, prepared during the past year by the Forest Resources Assessment Program unit (FRAP), represents the first major step in the development

of this Statewide program. It is legislatively termed "preliminary" because of the realization that one year provided an opportunity only to summarize and work with existing data. The Act also mandates the Department to recommend a suitable inventory and data processing system for future assessments. These recommendations will be presented to the Legislature in January 1981.

This Report contains an assessment or summary chapter which describes resource issues and options; background chapters which analyze the status of the various resources, and a variety of original maps and tables. It also contains a description of forest modeling and remote sensing efforts undertaken to date by FRAP.

The material which follows is divided into two sections: The Assessment or summary chapter of the report; and the background and research material chapters.

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The California State Board of Forestry serves as a policy advisory body and regulatory body within the Department of Forestry on all California forest land matters. The nine-member citizen Board enacts forest practice rules, develops regulations and policies for guidance of the State's wildland fire protection system and provides a forest land management and policy forum for the people of the State. It acts as a liaison between the legislative and executive branches of State government, and coordinates federal, State, and local forestry efforts.

ACKNOWLEDGEMENTS

The preparation of this Report was a long and involved process requiring the cooperation and efforts of many people and organizations.

Many resource specialists of the various sections of the California Department of Forestry, the Forest Service, and other State and federal agencies, and many interested individuals from the public and private sectors devoted countless hours to gathering and interpreting the data.

The Forest Resources Assessment program staff wishes to especially acknowledge the contributions of the following individuals, while recognizing that many others also assisted in the task:

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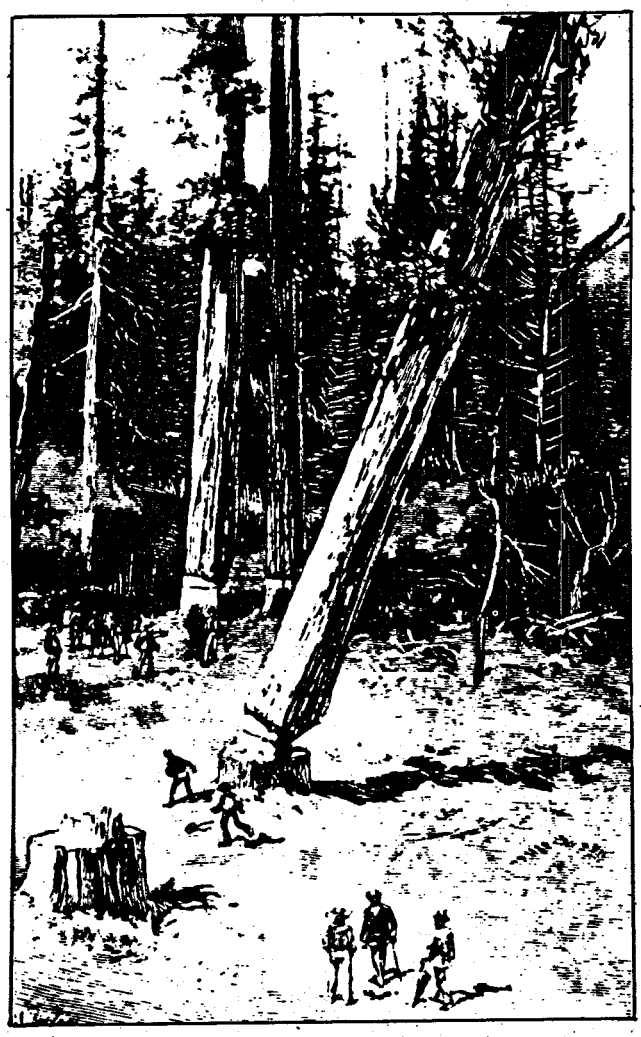
A HISTORY OF ACCOMPLISHMENTS, ACTIVITIES AND EVENTS OF, OR AFFECTING, THE CALIFORNIA DEPARTMENT OF FORESTRY (1813 -1979)



1813: Spanish government decree orders Alta California reforestation measures.

1834: State's first commercial sawmill built in Sonoma County.

1847: James Marshall builds Sutter's mill at Coloma gold discovery site.

1850: State's first forest fire control laws passed by Legislature.

1856: Samuel P. Taylor builds West's first paper mill in Marin County.

1885: State Board of Forestry created (abolished 1893).

1893: First federal forest reserves created.

1903: State's first industrial forester hired at Chico by Diamond Match Co.

1905: State Board of Forestry reconstituted. Forest Protection Act passed; E.T. Allen appointed first State Forester.

1907: Twelve forest-reserve units become national forests.

1909: Luther Burbank's birthday, March 7, becomes State Arbor Day.

1909: Redwood lumber industry begins reforestation program; California Forest Protective Association organized.

1911: Weeks Law starts federal/State cooperation in forest conservation.

1914: Forestry school established at University of California.

1916: California Redwood Association and Western Wood Products Association organized.

1924: Clarke-McNary Act starts federal-State-private cooperation in forest-fire prevention and control and in reforestation.

1926: USFS California Forest Experiment Station established with E. I. Kotok, Director - ("and Range" added 1931, changed to Pacific Southwest in 1959).

U. C. Extension Forester established--Woodbridge Metcalf.

1927: Department of Natural Resources formed with Division of Forestry established within the Department. Board of Forestry modified and authority diminished.

1941: American Tree Farm System begins.

1943: Federal timber-capital-gains tax law passed to encourage private forestry.

1945: California Forest Practice Act and other resource legislation including acquisition of State forests, range improvement, etc. enacted. Forest Insect Eradication Law amended.

1947: Cooperative Soil-Vegetation Survey started.

Sale of commercial timber species from State nursery to private parties authorized by statute, Chapter 778.

Jackson State Forest (51,225 acres, Mendocino County) acquired by purchase, 1947-51 and 1968.

1948: CDF assumes supervision of "Farm Foresters" from USFS.

1949: Range Improvement Standby Crews and additional technicians provided (Chapter 779).

1952: Keep California Green organized.

1954: Federal "Small Watersheds Act," PL-566, passed.

1955: Timber Resource Review of U.S. Forest Service reveals timber growth exceeds removal in nation's forest for the first time.

1958: First interagency "Wildland Research Plan for California" published by State Board of Forestry.

1960: Congress passes Multiple Use Act for National Forests.

1968: Redwood National Park established.

1971: Forest Practice Act declared unconstitutional (September 16). Bayside Timber vs. County of San Mateo, in First Disrict Appellate Court.

1972: Forester registration and licensing bill passed (AB 469).

1973: Z'berg-Nejedly Forest Practice Act passed.

1974: Forest and Rangeland Renewable Resources Planning Act.

1976: National Forest Management Act.

Z'berg-Warren-Keene-Collier Forest Taxation Reform Act of 1976 was passed by Legislature.

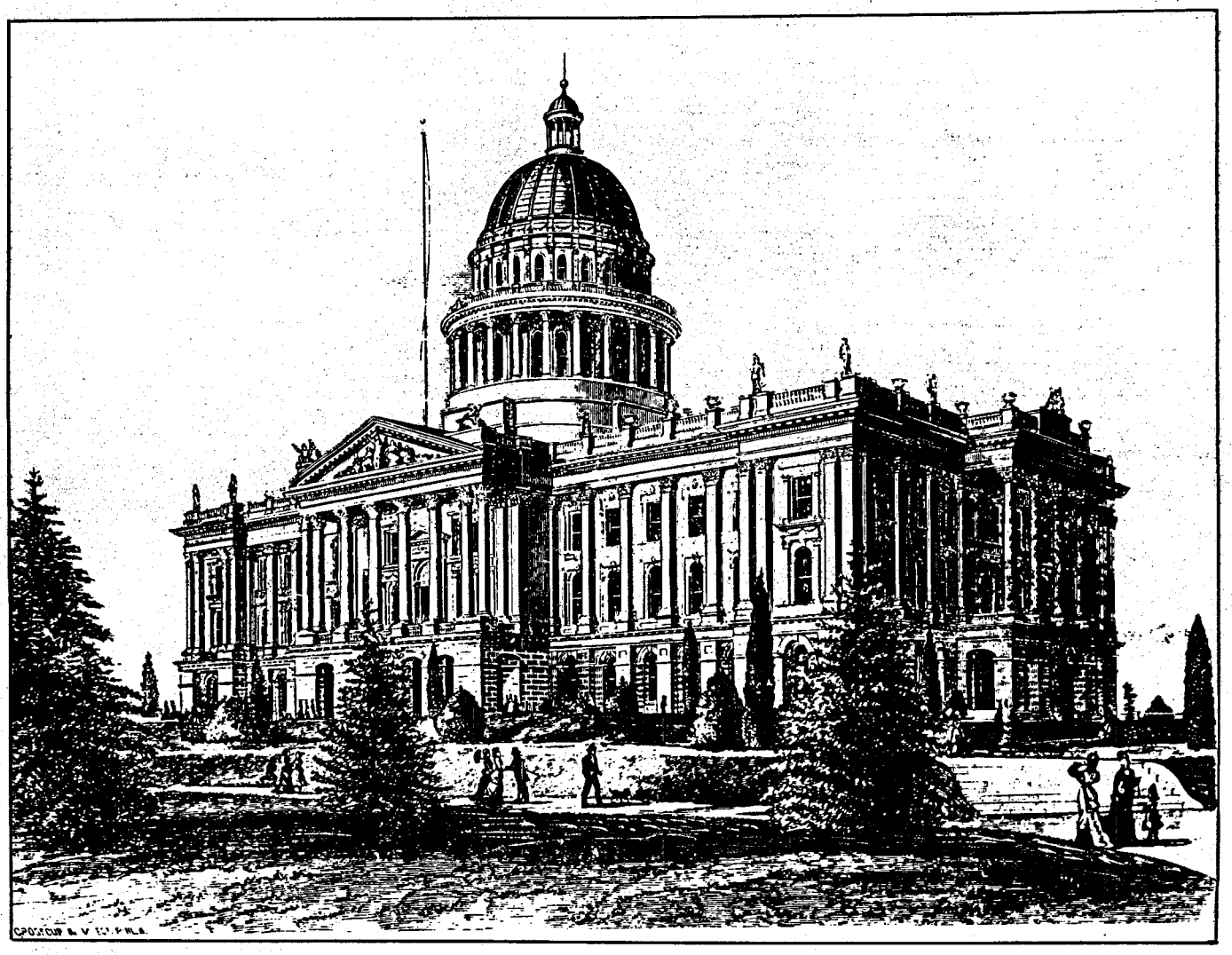
Division of Forestry became Department of Forestry through State legislation.

1977: Forest Resources Assessment Policy Act (FRAPA) was passed by the California Legislature September 1977.

1978: Redwood National Park Expanded.

Forest Improvement Act.

Wildland Fire Protection and Resource Management act of 1978 enacted by California Legislature.



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PRESCRIBED BURNING
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INTRODUCTION

We have reached an era of limits for California's forests. There are no new physical frontiers for the State, and no new reservoirs of forest land to satisfy our needs.

Fifty years from now the desires for timber, forage, and recreation will be roughly twice what they are today, according to the "medium projection" estimates contained in the Forest Service 1980 Resources Planning Act Assessment (RPA). In addition, the amount of wilderness preserved by statute may be doubled during this time. The President, and California's Governor, have already asked Congress to increase by two-and-one-half times the designated wilderness area which now exists in the State.

Can these expectations be met with our limited forested land base that is still shrinking?

Since the days of colonization the forests have been a key factor in the development of our State. During the intervening years the forest land has been converted to towns and cities; second homes and sub-divisions; roads and freeways; reservoirs; canals and powerline corridors; farms; ranches; and so on. For example, riparian forests in the Sacramento and San Joaquin Valleys now exist only as stringers of their former area. Because of their almost complete conversion to agriculture they have largely been omitted from this Assessment. Yet they are very important for wildlife and other values and perhaps should be addressed in depth in future assessments.

Decisions allocating forest lands will determine the quantities of resources and their prices for both present and future generations. For example, "real" prices of standing timber are projected to more than triple by 2030. One consequence of this price rise is that the estimated cut in 50 years will be at about its current level. More wood could be available then, if timber management is intensified now on our best timber growing lands. If this option of high productivity were chosen we could reduce the scarcity reflected in high prices for timber-based commodities that future generations might otherwise experience.

Where there is no "market," as is the case for sport fish, wildlife and wilderness, rising demand may be evidenced by greater use of the resource. Such increased uses can be accommodated for a while but eventually use-rates may overload the capacity of the forest to produce. Special efforts in the form of institutional changes may be necessary to deal with these scarcities.

The reality of these limitations, and the need for comprehensive data upon which to formulate forest policy decisions have been recognized by policy makers. In 1977 the Legislature passed the Forest Resources Assessment and Policy Act (FRAPA) which led to establishment of the Forest Resources Assessment Program (FRAP).

This integrative chapter is an Assessment prepared in response to the Act. Succeeding chapters and the appendices describe supporting data.

If the projected future conditions seem unpleasant it is particularly important that we consider alternatives. These are generally described in the first of the three sections into which this Assessment is divided:

1) The "framework" - The policy options and constraints which affect the supply and demand of various forest land resources are described.

2) Synopses - The status, trends, problems, and options are summarized for the detailed chapters on watersheds; fish and wildlife; forested rangelands; recreation; timber; wilderness; air; minerals, fossil fuels, and geothermal energy; and wood energy. Conclusions for each chapter are brought forward to the synopsis.

3) Major resource issues - When the framework was applied to individual resources, issues became evident. They recognize some of the inter-resource implications which involve resource policy questions. The issues presented are:

*NO MORE LAND!

Our forest land base is limited: How do we best allocate it to produce wilderness, recreation, timber, and other forest outputs?

*MORE WOOD, MORE GAME: COMPLEMENTARITY

It is not always true that increased production of one output competes with another. How can we manage to have more game and more wood?

*SALMON

This resource, much of which depends on habitat in forested watersheds, is being depleted: Can we reverse this trend?

*DATA LIMITATIONS

The lack of sufficient and compatible data hampers efforts to make good policy decisions: How can this situation be improved?

*RESOURCE STANDARDS

Policy actions often lead to the establishment of "standards," or "prescriptions." How are they developed? What tradeoffs are made? What institutional structures should accompany them?

*CUMULATIVE IMPACTS ON WATERSHEDS

The components of watersheds interact with each other. The sum of the impacts of all man's activities may be greater than the sum of individual activities within a watershed. Are there policy dilemmas?

*ENERGY

Will higher energy costs lead to new life-styles? What will be the effect on our forests?

*PRESCRIBED BURNING

Fire is a useful management tool for reducing fuel hazard build-ups and for timber, wildlife, and range production. Will escalating costs present the realization of public benefits? Can the conflict with desires for improved air quality be resolved?

*FOREST SERVICE HARVESTING POLICY

Federal policy determines "allowable" timber harvesting rates by considering only federal land: Would a broader approach be desirable?

*PUBLIC POLICY

Society's efforts to establish resource values and deal with problems involve a complex mix of: acquiring current and complete data, planning and management coordination between the public and private sectors, and improving laws and regulations administered by numerous resource agencies. Are all these interactions effectively meeting society's needs?

THE ASSESSMENT FRAMEWORK

In order to examine the consequences of the status and trends of forest resources in California, an analytical framework was applied to each resource. The framework identified the options for improving adverse resource situations and special constraints which limit society's potential actions.

*THE OPTIONS

There are four general options available for reducing the impact of a perceived scarcity (characterized by decreasing quantities or rising prices) of forest outputs. They are: investment to increase supplies; modification of demand; protect the resource; or change institutions.

*Investment

The amount of output can be increased by investing capital, land, and labor as appropriate. Investments in such things as campgrounds, trails, fences, tree plant-

ing, or wilderness set-asides could increase the recreation, forage, timber, or wilderness "production" of the forest.

*Modification of Demand

It is not always necessary to produce more of a product or service in response to a perceived scarcity. Substitutes for forest products or outputs may be available, and their use encouraged. For instance, chipboard has been developed to partially replace plywood, and cross-county skiing may substitute for down-hill skiing.

It is important in a democratic society to be cautious about attempts to influence demand, particularly by public bodies. It is naive, however, to assume that our attitudes are not now influenced by our social and government institutions. Certainly advertising and educational efforts to reduce wildfire losses, prevent soil erosion, encourage water conservation and otherwise protect forest values are accepted practices.

*Protection of the Resource

Physical and economic means of protecting valuable resources are possible. Preventing soil losses and wildfires are physical protection activities. Protection can also be achieved through use-permits, quotas, or land use restrictions designed to reduce adverse impacts of overuse. Exercise of this option increases the real price and may help to preserve the quality of the resource.

*Change Institutions

Another means of increasing the output of a particular forest product may be by changing the laws, policies, agencies, etc., in other words the "institutions" which limit it. For example, public forest recreation on private lands is to a considerable extent limited by the competition set up by provision of public facilities at less than cost. This, in effect, provides a subsidy to users of public lands because private land owners cannot recover the costs of providing facilities.

When these sorts of options are not readily apparent, research into the problem may identify further alternatives.

*THE CONSTRAINTS

In addition to options available to policy makers several constraints complicate the process of resolving forest policy issues:

1) Forests are systems.

2) The dynamics of forest change involve long time-horizons.

3) They involve uncertainties, short and long term.

4) Changing uses will affect the allocation of benefits and costs to specific groups of people.

5) Forest policy may produce conflicts with other public policies.

*Forests Are Systems

There are interactions within forests and within the larger system of which they are a part. For example, harvesting trees may increase certain wildlife populations and perhaps increase soil erosion while providing sawtimber. Eroded soil may settle in a reservoir outside of the forest land area, curtailing its life or increasing the expense of producing power or water. The sawtimber will move to mills and create jobs and other support for the economy. Increased wildlife on the cut over lands may satisfy society's recreational and emotional desires.

Because of these interactions, regulations may affect forest biology as well as the larger socio-economic system of which the forests are a part.

One of the difficulties of working with systems is the problem of defining boundaries. No boundary will be entirely satisfactory. By limiting this Assessment to the forested lands of California and by also attempting to consider the range resource, we introduce an artificial line between forested and nonforested range. The break is not helpful and may lead to erroneous conclusions unless a broader context is kept in mind. The theoretical boundary dividing the standing timber resource from the people who utilize it constitutes a similar sort of analytical problem. An imbalance between timber availability and mill processing facilities has implications for the resource, for timber values, and for community stability. Appreciating the hazards of looking too narrowly at forest resources because of their geographical boundaries is a key consideration in the development of good forest policy.

*Long Time Horizons

Forest policy decision-making involves longer time-frames than we normally consider. Trees may require a human lifetime or more to mature. Soil development usually requires thousands of years.

*Uncertainties

The factor of uncertainty is interlocked with the long time-horizon. Changes in technology, institutions, and regulations are risks we must consider. Catastrophies such as fire, drought, or epidemics of diseases or insects are important additional risks. We lack the ability to predict such highly influential events so our policies must reflect the existence of these uncertainties.

One strategy for dealing with uncertainties is to favor those options which are least restrictive on future choices. Restocking a cutover forest area, as the California Forest Practices Act requires, is one example.

*Who Benefits From Changes

The allocation of benefits and costs of public policy decisions should be identified. The long time-horizon associated with forest policy issues means that in many instances those who pay for, or receive the benefits of, forest policy choices will be future generations whose interests are perhaps not well represented in today's decision processes. Some choices may benefit the rich at the expense of the poor, or urbanites at the expense of rural residents, or adversely affect the rights of

property owners. The political process, in our society, has responsibility for ensuring that an equitable balance is achieved between who benefits and who pays.

*Conflicts With Other Policies

A final consideration in the development of resource policy is the presence of other, perhaps conflicting, public policies. Balancing the opportunities for public forest investment with current desires to reduce public expenditures is one of several conflicts of this sort. Another example is the conflict of pesticide uses with possible adverse environmental and health impacts. Forest resource policy is simply a component of public policy. It can only be developed with a view to the whole.

SYNOPSES OF THE FOREST RESOURCES

Following are brief synopses of chapters dealing with the resources found on 33 million acres classified as forest land. The watersheds, fish and wildlife, range, recreation, timber, wilderness, air, minerals, and energy resources are explained in depth in the parent chapters.

WATERSHEDS

A watershed, which is the region draining into a river, encompasses all of the forest resources identified in FRAPA. Basic to the watershed are soil and water which are essential to the existence of all other living resources.

Seventy percent of the State's total water run-off originates on forested land. Many characteristics of the watershed influence the quality of this run-off, its timing, and even its total amount. Watershed conditions may also affect the frequency and severity of floods downstream.

Soils, depending on their geologic characteristics, are susceptible to different forms of erosion including, surface, gully, and mass movement. In general, younger, less developed soils are more susceptible to surface erosion, while older, more mature soils with higher clay content located on steep slopes are most susceptible to mass movement. All erosive processes occur in nature, but can be accelerated by human action on the land.

The amount of such accelerated erosion frequently can be correlated with the amount of soil disturbance that occurs. For example, tractor logging often produces more erosion than other timber harvesting methods, especially on steep slopes. Similarly, roads with large cuts and fills built on these slopes may be major causes of erosion. Timber harvesting can degrade water quality by increasing water temperatures (due to removal of streamside vegetation or changes in stream morphology), by adding debris to streams, or by increasing water run-off which may lead to stream

bank erosion. In addition, wildfires may increase erosion by denuding slopes of protective cover.

*Status

Soil mapping is conducted on forested lands primarily by the CDF Soil-Vegetation Survey and the Forest Service. Currently the CDF survey has published maps for about nine million acres of State and private lands; the Forest Service has mapped approximately 14.5 million acres of federal lands.

Published rates of soil erosion range from approximately 0.6 to 180 tons per acre per year, but vary so much that average rates are nearly meaningless. The forest lands in the North Coast Region have some of the highest erosion rates in the State due to their geology, erodible soils, high intensity rainfall, steep topography, and large amount of land disturbance.

Natural erosion is thought to account for the bulk of sedimentation on the North Coast, with estimates ranging as high as 70 percent. This is controversial because it is difficult to determine what is truly natural. Soil scientists hypothesize that present rates of erosion (especially mass movement) are so great that they could not have been a constant process over geologic time or we would have little or no soil today. Most of the private forest land on the North Coast has been logged and burned at some time since 1870. Certain areas of the Sierra Nevada are also highly susceptible to erosion, especially those areas of soils formed on decomposed granite parent material.

Several State and local agencies are responsible for controlling land use practices. Under the Z'berg-Nejedly Forest Practice Act of 1973 the Board of Forestry has adopted, and CDF enforces a system of Forest Practice Rules for the regulation of timber harvesting operations, including restocking, erosion control, stream and lake protection, hazard reduction and associated road construction on nonfederal lands. The Department of Food and Agriculture regulates pesticide use. The Department of Fish and Game is responsible for fish and wildlife, offering comments and recommendations to agencies regulating activities affecting habitats, and, in certain instances, regulating stream use and alteration. Counties may control land-use subdivisions and roads through general plans and ordinances. Other management activities on forested lands, such as silvicultural operations other than logging, road construction not associated with timber harvesting, road maintenance, range and wildlife habitat management, and recreation are generally not regulated.

The Federal Water Pollution Control Act (FWPCA) and the State Porter-Cologne Water Quality Control Act authorize the State Water Resources Control Board and Regional Water Quality Boards to regulate water quality. The Regional Boards set "waste discharge requirements" and standards for acceptable water quality.

Important measures to better protect water quality from damage arising from silvicultural activities are currently being developed by the

responsible State agencies with Section 208 of the FWPCA. A process for continuous development and application of Best Management Practices (BMPs) to regulate land use activities for control of silvicultural nonpoint sources of water pollution has been designed. This provides an on-going method of preventing watershed deterioration. Continued support of this BMP process will be necessary to make it effective.

*Trends

One trend with highly significant watershed impacts has been the rapid development of forest roads and related human activity that has taken place since 1940, particularly with the advent of tractor logging. As a result, the area needing positive watershed protection has increased rapidly.

Other overall watershed trends, because of the many variables involved, are difficult to assess. In certain instances, conditions are improving through natural healing over time or through better land use practices. For example, evidence indicates that the Forest Practice Rules are reducing current man-induced erosion through timber harvesting regulation but a thorough evaluation has not been completed. On the other hand, there appear to be certain watersheds which are being degraded, perhaps as a result of both past and present land-use practices. In some cases this degradation represents cumulative effects.

*Problems

Today, a major problem in dealing with the management of forested watersheds is the lack of reliable data. For example, the use of certain pesticides and fertilizers within the forest can affect the quality of the environment. Aerial application of these chemicals may conflict with certain air and water quality standards. Pesticides have been used to eliminate undesirable plant and animal species, and fertilizers to increase productivity. Although they are applied on only small acreages of forested land (in 1977 "restricted" pesticides were used on 40,250 acres), they are thought to be persistent and dangerous in some cases. Better data are necessary for understanding the effects of these practices and for the establishment of workable standards (see STANDARDS issue).

There is a lack of information about many soils. In particular, there are limited data on problem soils, relative erosion hazards, reactions of soils to certain land use practices, and the effects of resultant erosion on water quality, wildlife, and forest productivity.

Not only is it necessary to have more data to know the interactions of activities within watersheds, but also there is a need for data on the cumulative impacts of one or several activities, either over time or space. The CUMULATIVE IMPACTS issue discusses this further.

There is also a need to identify areas that have been severely impacted by past land use practices and determine possible measures to correct problems in these areas.

Large, hot, uncontrolled fires can create watershed problems by destroying vast acreages of forest, affecting water quantity, quality, soil characteristics, and erosion rates.

*Options

Data deficiencies must be satisfied so that better practices can be devised to minimize watershed impacts. For example, when specific factors affecting erosion are known, land use practices can be modified to minimize water quality degradation. That part of the problem of declining salmon populations due to siltation of spawning gravels in North Coast streams may be somewhat alleviated if stream rehabilitation programs can be combined with improved land use practices to prevent excessive erosion.

Prescribed burning can minimize the effects of wildfires by limiting flammable material buildup, but use of this technique may also cause increased erosion.

Critical forested watersheds where human induced problems exist should be identified; and coordinated management programs developed to mitigate past, and control future problems.

FISH AND WILDLIFE

Habitat is the key to healthy, diverse wildlife population. The fish and wildlife resources in California's forests are more varied than elsewhere in the United States because of the habitat diversity. Early to mid-successional stages of forest vegetation intermingled with nonforest types enhance various wildlife populations including deer, mountain lion, bear, quail, voles, mice, and raptors. About 70 percent of the wildlife species which inhabit forest lands favor these vegetational stages. The other 30 percent of our forest wildlife species tend to inhabit old-growth, and include such species as fisher, marten, spotted owl, pileated woodpecker, and goshawk.

Certain species of fish and wildlife support activities such as sport fishing and hunting and commercial fishing and trapping. Most trout fishing and practically all deer and bear hunting take place on forested land. Numerous species of game birds and furbearing mammals are also harvested from the forest. Salmon supports a commercial and recreation industry. Over one-third of the salmon fishery is dependent on forest ecosystems for spawning. Some species of fish and wildlife are important to the public for such activities as nature study, photography, and observation.

*Status

Most species of forest fish and wildlife exist at acceptable levels. However, rural subdivisions, urbanization, road construction, water developments, and the growth of browse which has matured beyond the stage preferred by most species and the gradual crowding out of browse by young stands of timber are factors which could lead to unacceptable wildlife population levels.

In some areas recently logged land has provided stands of immature brush which constitutes satisfactory habitat for wildlife preferring early-successional stages of forest vegetation.

For wildlife which need late-successional vegetation, substantial acreages of old-growth exist in wilderness, park areas, and other public ownership.

The status of the fish and game harvest in-State for 1978 was: approximately 34,000,000 trout; 31,000 deer; and 655 bear. The salmon resource produced a catch of 841,000 fish; the steelhead catch approached 122,000.

The natural production of salmon and steelhead has declined along the North Coast where water development projects, timber harvesting, and road construction, have led to debris accumulations, siltation of spawning gravels, and unfavorable water levels and temperatures which have interfered with their life cycles. The populations present in the San Joaquin and Sacramento drainages are mainly limited by the dams which have blocked migration and spawning. Increased fishing pressure has also altered salmon and steelhead populations.

Numerous laws and regulations affect fish and wildlife management. The State Fish and Game Commission is responsible for establishing regulations for the protection and harvest of various species. Migratory wildlife is to a large extent regulated by the federal government. The Forest Practice Act requires the Board of Forestry to protect wildlife habitat while regulating timber harvest activities. Regional Water Quality Control Boards protect water quality throughout California.

None of the species on the lists of endangered, rare or threatened plants and animals are limited in their populations by present activities upon California's forests.

*Trends

The deer population in California has decreased 60 percent since the mid 1960's, due primarily to the loss of suitable habitat. If current management practices continue, the deer population is expected to remain at its present level.

Salmon and steelhead populations have declined approximately 65 percent since the turn of the century.

*Problems

The ability to maintain or increase wildlife populations and at the same time produce more forage for livestock, more recreational facilities, and more timber is a major concern for policy makers.

Without habitat improvements or increases in hatchery stocking, substantial increases in salmon and steelhead populations are not anticipated.

Reduction of old-growth timber will reduce the habitat and the populations of species dependent upon large trees or virgin forests. Significant population shifts of any species should serve as a warning of potential problems.

There is overlap in the federal and State laws enacted to protect endangered, rare, or threatened plants and animals. The two jurisdictions have generated lists of animals that do not coincide. Forests provide key habitat for many of these species.

*Options

Two of the issues of this chapter consider in detail how salmon and deer production might be significantly increased.

Resource Secretary Johnson's proposal to create a Renewable Resource Investment Fund offers a specific way of providing funds which can be used to restore and expand fishery, wildlife, and recreational resources.

The retention of snags and some older trees for cavity nesting wildlife for future use could be encouraged. Financial incentives to private land owners would be necessary for this wildlife habitat if significant timber management costs result.

FORESTED RANGELANDS

Forested rangeland by our definition is land which has at least a 10 percent tree cover, and has quantities of native grasses, grass-like plants, forbs, shrubs, or introduced species suitable as food for wild and domestic grazing and browsing animals. In addition to livestock and deer many other herbivores and seed-eating birds depend upon the forested range ecosystem for habitat.

*Status

Nine million acres, or 25 percent, of California's 36 million acres of rangeland is forested range and subject to grazing by livestock. Of this area approximately 3.5 million acres are on national forests and 5.5 million acres on private lands.

Forested range produces 14 percent, or 5.4 billion pounds, of the forage produced on natural range and consumed annually by livestock. About 3.6 billion pounds of this come from the private portion of the forested range. A substantial quantity of forage is produced on State and national parks, but it is not likely to be used under existing institutions and practices. Most of the forage produced on forested land comes from the less productive timber site categories.

The Soil Conservation Service is currently developing "Best Management Practices" designed to control range erosion on private land. The federal agencies managing forested rangelands seem to be using good practices now as are many owners of private rangeland.

*Trends

Over the next several decades the demand for livestock will increase as the population of California grows. Our forested lands can generally be expected to produce greater amounts of forage without major adverse impacts, since the present condition of forested range is probably "stable" or improving slightly. It is known, however, that there are areas in poor condition as a result of overgrazing with consequent erosion and loss of soil productivity, particularly in the Coast Range.

The use of prescribed burning on private lands has declined steadily from a high point of 182,000 acres in the 1954 to 13,000 acres in 1977.

Public policy towards the use of prescribed burning seems to be changing to utilize fire as a natural element of the ecosystem and to recognize the public benefits it provides.

*Problems

Data on range condition are sparse, due partly to the fact that on much of the forested rangeland, grazing practices are not regulated and overall range condition information is not gathered.

FRAP and federal RPA/RCA inventory boundaries do not coincide, which makes a coordinated assessment difficult. FRAP's definition of forest excludes 75 percent of California's total rangelands.

No objective Statewide surveys have been made to determine the status of forested rangeland soils and productivity.

Competition between livestock and wildlife is a problem, and is evidenced by overgrazing which sometimes occurs in riparian corridors, in meadows, and on land adjacent to ponds and lakes.

Prescribed burning to increase forage production on forested rangelands is an important range management tool. The problem with its use lies in the conflict of maintaining air and water quality requirements. Another problem is that increasing costs and potential liability are significant obstacles to the use of fire.

*Options

Expansion of FRAPA to include all the rangeland in the State, would improve the quality of data provided to the RPA/RCA.

Alternatives to prescribed burning include mechanical or chemical means to clear brush. Mechanical methods are very expensive and chemical applications are now largely restrained by public policy.

Research can improve our ability to understand and forecast meteorological conditions which predicate when prescribe burning can most effectively and/or safely be used. Some of the benefits and constraints of this management tool are discussed in the PRESCRIBED BURNING issue of this chapter.

Additional forage could also be provided through investment in intensive management practices such as: prescribed burning, chaparral management or conversion to grass, water developments, fencing, fertilization, and reseeding.

Institutional changes to better utilize forage now produced but unconsumed could significantly increase the present consumption. Some of this forage is on public park lands or on areas presently ungrazed. Substantial costs and/or changes in public attitudes might be required to make use of all of this forage. Data are not available to more than qualitatively describe the feasibility of increasing utilization of this forage.

RECREATION

Forest recreation includes a diverse mix of activities that are pursued at either developed sites or some undeveloped areas located within the forest boundaries. The FRAP analysis addresses both the facilities and the amount of use.

With pressures increasing for use of forest lands, it is fortunate that certain types of recreation may be compatible with other uses of the forest. For example, most types of dispersed and some developed forest recreation activities can occur while wildlife, fish, range, and watershed values are maintained. Although timber harvesting may preclude certain recreation activities for a time, it also opens opportunities for the pursuit of other types. Various species of wildlife populate recently harvested sites, offering nature study and hunting opportunities. Additionally, cleared areas may facilitate the pursuit of winter sports such as cross-country skiing and snowmobiling. Probably the most important benefit to recreation is the access provided by road construction associated with timber operations. Some harvesting is designed specifically to enhance recreation as in the case of vista clearing and hazard reduction.

*Status

Forest recreation (developed and dispersed) on public lands totaled about 45 million 12-hour visitor days in 1977, the latest year for which complete data are available. Camping accounted for about half of this use. Sixty percent occurred on the national forests and use of State and national parks each accounted for about 20 percent. Forest recreation constituted about 34 percent of the total outdoor recreation on public land in California. (Existing private forest land recreation may be locally significant but is not so at the Statewide level. It has not been considered in this Assessment.)

Developed recreation is dependent upon an assortment of facilities such as picnic and camp sites, boat ramps and downhill ski sites. About 39 percent of the recreational facilities and 76 percent of the trail miles are located on forested land.

The total forest land base in California appears to be more than adequate to accommodate increasing levels of forest recreation. There

may be a lack of opportunity at the local or regional level, however, such situations were not identified in this analysis.

*Trends

Participation in forest recreation increased about 3.3 percent per year from 1970 to 1975. A substantial drop during 1975-1977 to about the 1970 level probably was related to the two-year drought. Preliminary estimates of the 1978 totals suggest that the 1975 level has again been attained. If the full 1970-78 period is considered, the growth rate would only be 1.6 percent per year. Forest Service RPA and Department of Parks and Recreation PARIS projections to the end of the century suggest that forest recreation will increase between 1.5 and 2.8 percent per year.

Adverse factors which might dampen growth rates (not considered in the PARIS projections) include increased energy costs, overcrowding of recreation sites, and changing population characteristics. Higher energy costs may restrict the number of recreationists who formerly traveled considerable distances to the forest. Increased entry and user fees could also raise the cost of forest recreation. More crowded conditions could result in a decline in the quality of recreation experiences for some people. Finally, as the population ages, per capita participation is likely to decline.

Subject to fiscal limits, both the Forest Service and the State Department of Parks and Recreation plan to maintain current levels of facility construction. For the Forest Service, this amounts to an annual increase in capacity of developed sites of about 0.3 percent. The Department of Parks and Recreation has been adding campsites at an annual rate of three percent since 1973, but planned additions indicate a rate of two percent. The Park Service plans no increase in recreation facilities at the forested parks considered in this assessment.

*Problems

If participation in developed recreation increases at the historical rate it would appear that facility additions will be inadequate to meet future needs.

A potential problem concerns the impact of the energy crisis on forest recreation. Rising transportation and other energy costs may restrict traditional forest recreation use patterns and require a shift toward providing more opportunities closer to urban areas. On the other hand, if recreationists make fewer trips to forest land, but increase their length of stay per visit, use of the more distant areas may approach the projections.

Privately owned forest land, particularly in the woodland and montane forest, could contribute to the forest recreation base. The present subsidy to users of public facilities limits the ability of private landowners to profitably develop recreational opportunities. At present, certain institutional barriers, in particular laws

relating to liability and vandalism, hinder the development of private lands for recreational use.

The Assessment of forest recreation revealed several data limitations. At present there are minimal data about recreational opportunities on or use of privately owned forest land. The public agencies that gather recreation information use different accounting periods, units of measure and inventory methods. In some cases analysis must rest on data gathered over a decade ago.

*Options

The projected demand for forest recreation may not be realized due to energy, demographic and other factors. If trends are established subsequent to this assessment indicating that the projections are being realized, and society wishes to accommodate this increased participation, several options are available:

Techniques for accommodating increases in developed forest recreation include expanding the quantity of facilities or using existing facilities more efficiently. New facilities or additions to existing ones could be built.

Institutional changes, such as a more even distribution throughout the week of the public's leisure time, would facilitate a better use of present facilities. Further, efforts by agencies to inform the public of vacant sites might also encourage more efficient use.

Increased amounts of dispersed forest recreation could be accommodated in certain undeveloped areas with the construction of additional roads and trails and the upgrading of some existing ones.

The purchase of private land for public use, primarily through the federal Land and Water Conservation Fund, has added to the forest recreation land base. However, acquisition of land per se does not necessarily increase forest recreation opportunities. Minimal "development" of forest land, such as the construction of parking facilities and trails, is important to realizing the potential for accommodating recreation. In some cases it may be desirable to purchase land to preclude development and thereby preserve options for future recreation expansion.

Options for encouraging the development of recreational opportunities on private forest land are discussed in the ENERGY issue.

TIMBER

The timber industry in-State currently produces approximately 75 percent of the 1.23 billion cubic feet of lumber and plywood used annually in California. It is

also an important source of jobs, particularly in the North Coast. The 16.3 million acres of "commercial" timber land which support this economy are located almost entirely in the coastal and montane forest areas.

*Status

An estimated 49.7 billion cubic feet of wood in sound trees are contained in the commercial timber stands.

Approximately half the land area involved, and 38 percent of the volume, is privately owned.

Net annual growth on commercial forest land is 802 million cubic feet. Half of this growth occurs on public and half on private ownerships. The land's potential is double the current growth.

Timber harvesting is regulated on private and State lands under rules developed by the State Board of Forestry through the authority of the Z'berg-Nejedly Forest Practice Act of 1973. The majority of federal forest land is regulated by the NEPA, NFMA, and BLM Organic Act. The State act contains specific stocking requirements for harvested stands.

The State Forest Taxation Reform Act (1976) exempted all standing timber from ad valorem taxes. Instead, timber from all ownerships is subject to a yield tax at the time of harvest. This act also provided restrictive zoning of timber producing land in Timberland Preserve Zones (TPZs). The 5.7 million acres of private land in TPZs may be used for production of forest products and compatible uses. In turn, the taxes levied within TPZs are to be based on the value of the land for growing timber. This law was designed to eliminate disincentives to investments in timberland which resulted from escalating land values.

*Trends

Over the next 20 years California timber harvest is expected to decline about six percent. The decline will be concentrated in the cut from forest industry lands in the North Coast. However, by 2030 private young-growth forests will have reached a merchantable size and Statewide harvest should once again equal or exceed present levels.

Total consumption of lumber and plywood is expected to increase until 2010 and remain at that level through 2030. Consequently, there is expected to be an increase in wood products imported into California. By the year 2030 in-State production may comprise only 54 percent of consumption and timber prices may more than triple. This "real" price increase (over and above inflation) could be in part responsible for the expected decrease in per capita consumption. Important to these estimates are the changes in the level and type of residential construction that are expected to occur as the composition of California's population and rate of family formation change.

It is estimated that the 2030 levels of consumption and imports of paper and allied products will be approximately four times the 1976 level due to increases in population and per capita consumption.

*Problems

Projections indicate that future standing timber prices will significantly increase at a rate above inflation.

Timber growth is currently half its potential.

On private timber lands low productivity often is the result of past repeated "selective" logging. Trees left following the harvest were of undesirable form or species or the logging sometimes damaged them and thus reduced growth. Currently there are about 1.8 million acres of private land in such low-growth stands.

Although the same problem occurs on national forest lands, low-growth stands here are mostly uncut old-growth on approximately 2.7 million acres.

Many acres that once grew softwoods now are unstocked because of unsuccessful or no regeneration efforts following fire, logging or ineffective conversion. Others have stands of less productive hardwoods. About 2.9 million acres of productive timberland are in this category; approximately 70 percent is private.

There presently is only a limited market for hardwoods.

*Options

The major opportunity for improving timber growth in California exists in older timber stands where low-growth is occurring either due to the advanced age of the stand and/or poor stand condition. It is estimated that harvesting public old-growth and reforesting would increase Statewide growth by 43 percent.

Converting low-growth "selective" stands to young growth on private land would increase growth 27 percent. The high and medium sites would show the greatest economic return and yield most of the increased growth.

Replacing hardwoods and planting understocked areas would increase current Statewide growth by 20 percent. Limiting investment to high and medium sites would produce 80 percent of the potential increase while minimizing environmental impacts by disturbing half the area. (For the effects upon wildlife see the MORE WOOD, MORE GAME issue.)

Many forest land owners do not possess or have ready access to forest management expertise or to the capital needed for timber management investment. Investment by nonindustrial private forest land owners is low because of the long time frame and high risks involved. However, reforestation and hardwood conversion efforts may be encouraged by the development of government incentives programs such as the

California Forest Improvement Program and similar federal programs, which offer loans, grants, and technical assistance.

Though harvesting practices have improved and the present Forest Practice Rules require the land to be stocked with commercial species, the rules may not adequately address other aspects of stand quality such as proper distribution of stocking over an area, seed producing capability of reserved trees, and other quality characteristics of residual stands. The actual effects of the rules on timber productivity and quality need further review.

Use of genetically improved planting stock where artificial regeneration is undertaken could substantially increase timber growth.

Improved timber utilization in harvesting and processing can increase the output from a given volume of logs.

Trends in forest products consumption could be modified by wood and paper conservation and recycling efforts.

Research could be undertaken to:

Develop information on the costs and growth response to silvicultural treatments by site and forest type to better evaluate treatment opportunities.

Find economically feasible and environmentally acceptable methods of brush control for use in reforestation.

Determine operational pest control techniques to reduce timber losses.

Develop utilization techniques and markets for hardwoods.

The level of timber harvests from California national forests has a significant effect on timber prices. FRAP studies showed that a 64 percent increase in federal cut over the next 50 years would cause real prices to be only 190 percent of current levels rather than 300 percent. The FOREST SERVICE HARVESTING POLICY issue of this chapter considers this sort of option in more detail.

WILDERNESS

The statutory definitions of wilderness used by the State and federal regulatory agencies are similar. They require a minimum land area of 5,000 acres without roads or permanent improvements and with outstanding opportunities for solitude or primitive types of recreation, and which may contain features of scientific, educational, scenic, historical, ecological or geological value. Wilderness preserves animal habitat for species requiring relatively undisturbed conditions. Historic and cultural features and research baselines can be preserved; and wilderness provides a gene pool of relic flora and fauna species.

*Status

In California the classified wilderness area totals 2,811,500 acres, of which 57 percent is forest land. Four government agencies presently manage this wilderness: the Forest Service - 2.1 million acres; National Park Service - 604,000 acres; State of California - 98,000 acres; and the U.S. Fish and Wildlife Service - 8,600 acres.

One effect resulting from the Forest Service's most recent Roadless Area Review and Evaluation (RARE II) proposals is the potential impact on national forest timber harvests Statewide. About 240,000 acres of "productive" forest land are within the federally proposed RARE II wilderness areas. The potential saw timber yield from this area is about two percent of the annual yield from national forests. The California Resources Agency's proposal would reduce the yield by approximately four percent.

Forest Service estimates show that about 25 percent of existing national forest wilderness in California could be classed as "productive" timber land.

A great disparity exists in the use rates of California wilderness areas. Generally those areas that have an alpine setting, lakes and streams, and are near population centers receive more use than those wilderness areas that are remote, dry, hot, and extensively covered with brushy vegetation.

*Trends

National forest wilderness use over the past nine years has increased an average of six percent annually. Projections indicate this use will continue to increase but at a declining rate, particularly as travel to wilderness areas becomes more expensive.

*Problems

How can the wilderness resource be best preserved for this and future generations?

How much additional land can be added to the Wilderness System without the adverse impacts on other resource management potentials and outputs exceeding the additional wilderness benefits?

Can the public be better informed about what "wilderness" means?

Among federal and State agencies a unified system of counting wilderness visitors does not now exist. Knowledge of actual use patterns and trends which would provide background data for good regulations and management decisions is also lacking.

To date no comprehensive inventory and assessment has been made of wilderness resources and related management activities other than acreage and visitor use figures from national forest wilderness in California.

*Options

The question of wilderness allocation has no scientific answer. It will be decided in the political arena with the market and non-market tradeoffs debated by the various interest groups.

A complete resources inventory of existing and potential wilderness areas, in conjunction with use-data and projections, would identify the resource tradeoffs of wilderness decisions.

Current federal administration proposals to Congress would increase the total wilderness area to about eight million acres; and the potential wilderness could be over 18 million acres or 18 percent of the State's land if most of California's roadless areas, much of which is not forested, were classified as wilderness. The federal administration's RARE II recommendations to Congress (as of September 1979) included 1,022,371 gross acres for wilderness classification, 2,453,728 acres of roadless area to non-wilderness and 2,793,917 acres for further study. Less than one percent is private land and about four million of this 6.3 million acres are forested. As an alternative the California Resources Agency recommended 1,450,000 acres for wilderness classification, 1,682,937 acres for non-wilderness, and 3,084,067 acres for future study. About four percent of the State's proposed RARE II wilderness area is private land.

Results from FRAP's preliminary land use model indicate about two million acres of federal land can be added to wilderness without significantly affecting output increases of timber, forage, or all types of recreation. As measured in Wilderness Attribute Points, which attempt to qualify values such as solitude and scenic beauty, the wilderness would be increased 78 percent by this area addition. (Which acres are selected is, of course, critical.)

The addition of four million acres would increase wilderness values from 78 percent to 90 percent. The cost in terms of potential timber productivity would be about 243 million cubic feet per year or 27 percent of current Statewide production. While data were unavailable for further analysis, more intensive timber management could likely produce greater (potential) timber outputs at high costs. Recreation growth and forage production would not be significantly restricted by the wilderness addition according to the land use model.

Restrictions in growth of motor-based recreation and forage production from wilderness additions were not detected by the land use model. Since the model considered quantity but not quality, its results should not be accepted without appropriate cautions.

AIR RESOURCE

Forest vegetation plays an important part in recycling our air resource. The impact of air pollution on the forests has received increased attention in California

since the 1940's when it was recognized that vegetation was being damaged and killed by air pollutants.

*Status

The most extensive tree damage due to air pollution on forest land has occurred in southern California where thousands of acres of pines have been seriously damaged or killed, primarily due to ozone effects on trees in the mountains adjacent to the Los Angeles Air Basin. Current data indicate that air pollution is a potential threat to pines of the southern Sierra Nevada and perhaps to pines of the central Sierra. No significant problem is apparent in the northern part of the State.

Ozone is an oxidant derived mostly from automotive emissions interacting with sunlight and is an element of polluted air which in sufficient quantity and over an extended dosage time can damage or kill vegetation, particularly pines at the elevations where inversion layers lie against the terrain.

*Trends

Trends in air quality have been difficult to predict, because control measurement techniques, monitoring equipment, and emission standards have been changing frequently.

*Problems

Two major types of air pollution are affecting forest lands in-State, ozone and particulate matter. In addition, the use of pesticides may contribute to air pollution.

Particulate matter in smoke is of special concern, since it can be transported over great distances. Not only is it a health hazard but its reduction involves massive costs in control of wildfires.

Prescribed burning of ground fuels, which contributes particulate matter to the air, can reduce the severity of uncontrolled fires. It is used to improve range forage, wildlife habitat, and to remove timber harvest slash to aid in tree planting and hazard reduction.

The actual amount of ozone and the cumulative dosage time that cause serious vegetation damage are not yet thoroughly identified for all species.

Information on tree damage due to air pollution in California becomes progressively less reliable from south to north, with the least amount of accurate data available from the northernmost, highest timber producing, section of the State.

*Options

State and federal agencies are responsibile for setting air pollution standards. Decisions of the EPA and California Air Resources Board have a significant socio-economic impact on forest lands.

Stronger regulations might be one method of reducing adverse impacts on vegetation.

Increasing federal and State regulation of pesticide use and prescribed burning will have varying impacts on air quality and forest land management options. Smoke management through prescribed burning can improve air quality (compared to the effects of uncontrolled fire) in terms of time and space.

Such resource management needs as prescribed burning of ground fuels have beneficial as well as adverse impacts, and their use requires further research. It is necessary to identify and understand the resource tradeoffs which evolve as the air is made cleaner through regulation.

Research should be undertaken to determine cumulative air pollution dosage times before vegetation is damaged in order to forewarn land managers of future problem areas.

A more intensive air monitoring program on the central and northern California forest lands would provide data on present air quality and trends.

A relatively inexpensive ozone monitoring program which would determine ozone levels along the Sierra Nevada pine belt would produce a baseline from which trends could be traced. Also it would alert forest land managers to potential ozone damage areas.

MINERALS, FOSSIL FUELS, AND GEOTHERMAL ENERGY

Minerals, fossil fuels, and geothermal energy are resources which are presently being extracted from the forest environment. They are especially important in this age of technical advancement, energy limitations, and environmental awareness.

*Status

California ranks third in the nation in mineral production. About 60 percent of the State's production of asbestos, 45 percent of the cement, 15 percent of the stone, and almost all of the tungsten and dolomite are from sources on forest land. Although the mineral and oil industries in California generate multi-billion dollar businesses, and although the forest lands cover over one-third of the State, only about 0.02 percent of the forests are currently being disturbed by mineral and energy extractions.

Where future mining disturbances of forest lands are anticipated, the 1975 State Surface Mining and Reclamation Act provides for State and local government regulation through a permit-approval process based on satisfactory reclamation and resource conservation plans.

Federal regulations require that mining plans for public lands be approved. State air and water quality boards are responsible for the enforcement of laws governing industrial air and water discharges from these operations.

No significant present or potential mineral, fossil fuel, or geothermal energy sources directly impact prime range and timber land or impact rare and endangered wildlife habitat.

Present laws and regulations appear adequate to ensure most resource protection and surface reclamation enhancement. Restoration to an original state of past mining disturbance areas is not required by law; however, the acreages are not large and nature has reclaimed many.

*Trends

Demand for fuel and non-fuel minerals is increasing. Advances in mining technology as well as high market value of these minerals will enable the industry to mine deposits heretofore considered uneconomic. Although full mineral potential of forest lands is not known, the existing information indicates there will be increased mineral activity on these lands.

The State Division of Mines and Geology estimates that from 1965 to 2020 the output of metals is expected to double and production of nonmetallic minerals is anticipated to triple. These higher output levels will probably cause surface land disturbances to increase about 180 percent, to about 24,000 acres or 0.07 percent of the forest land scattered throughout the State.

*Problems

A lack of data makes it difficult to predict the extent of mineral and energy extractive potential and impacts of such extractions on forest lands in future years.

The State has only basic geologic data on what resources underlie unreserved and reserved forest land. Land management planning could be improved with better data on minerals and fuels, the extraction of which has the potential for significant temporary disturbance.

Impacts since 1890 on forest lands from mineral and fuel extractions include localized air pollution from processing plants and open pit mining; deleterious effluent discharges into water courses, particularly from inoperative mines; and a considerable amount of surface disturbance from past gold mining.

*Options

As mineral, fossil fuel and geothermal energy consumption pressures increase, the trade-offs between the resources will need further research and study in order to anticipate problems which may emerge in the future. Present and immediately foreseeable mineral and energy developments pose no serious problems for other forest resources.

WOOD ENERGY

Although wood has always been used for fuel, today petroleum and natural gas provide most of the energy consumed in California. Continued use of these fossil fuels as well as other energy alternatives such as nuclear power, coal and liquified natural gas present California with complex social, economic and environmental problems.

Wood used as fuel for energy production is renewable and domestically produced. It can be burned directly to generate heat, steam and electricity using technologies that are commerically available, reliable and safe. Wood can also be converted into other solid, liquid and gaseous fuels.

*Status

Residues from the processing of logs into wood products is the primary source of fuel for wood energy production today. This source is principally utilized by the forest products industry.

Wood residues from urban areas and agricultural lands, non-commercial forest lands, chaparral and other brush covered lands as well as currently unutilized mill residues and material from logging or forest management operations represent additional sources of wood available for energy production.

Fifty-eight forest products mills in California are currently burning 2.6 million tons of wood waste annually in boilers to produce heat and steam for industrial processes and for generating electricity. (Joint production of heat and electricity is termed "cogeneration.") The current electrical capacity is 124 megawatts, or enough power to meet the needs of a city with a population of 74,000. The remaining 0.7 million tons of wood waste are presently being disposed of by incineration or burial in landfills.

*Trends

Supporting California's growing energy needs has required increased dependence upon imports of oil, natural gas and electricity. The sharp increase in the price of energy following the Arab oil embargo in 1973 has caused a decrease in the growth rate of demand for energy. Real prices (adjusted for inflation) are expected to continue to rise rapidly in the future.

Primarily because (1) projected timber cut does not increase, (2) smaller logs will be harvested in the future, and (3) the utilization of wood at mills will increase, mill residues available for energy are estimated to decrease slightly from 1978 to 1985, level off between 1985 and 2000, but will increase somewhat by 2030.

Mainly due to advanced forest management practices and improved harvesting equipment expected to exist in the future, annual amounts of forest residues potentially available for energy are projected to steadily increase from 1985 to 2030.

Total annual wood resides from all categories are projected to increase from 31 million dry tons in 1978 to almost 33 million by 2030. Amounts potentially available for energy are estimated to increase from 4 million to 10 million tons over this period. Burning the potential residues in wood-fired cogeneration plants would yield about 500 megawatts of capacity by 1985, 900 by 2000, and 1200 by 2030.

Electric utilities and the State government are proposing to use wood energy, mainly in joint projects with the forest products industry. Three hundred thirty megawatts of capacity are expected to be available by 1985. By 2000 a total of 490 is projected.

*Problems

To realize increased energy production; it will become necessary to utilize forest in addition to mill residues. But there is no guarantee that these will be available for energy. Once collected they will logically go to the highest valued use. Competing uses for wood residues include pulp chips, particleboard, chemicals, charcoal, decorative bark and mulch.

Harvesting and collection equipment designed specifically for utilizing wood energy has not been fully developed. Thus present delivered wood fuel costs are high; and there is uncertainty about operation and labor costs.

Firms considering long-term investments in wood energy facilities have found it difficult to negotiate long-term fuel supply arrangements.

Wood-fired power plants fueled with forest residues are currently marginally cost effective when compared to oil- or coal-fired power plants in terms of today's prices.

The optimum size wood-fired plant ranges from 30-50 megawatts due to localized supply, while oil or coal-fired plants proposed by utilities typically range from 800-1000 megawatts. Since planning, siting, and licensing costs do not vary appreciably with size, this may discourage the construction of smaller wood-fired plants.

Manufacturers of lumber and other products are primarily concerned with their own specific processes and products. While some electricity is generated as a byproduct they would prefer not to be classified and regulated as utilities.

Because small cogeneration facilities are relatively difficult to plan and operate and there is only limited experience with coordinating a widely dispersed power generating grid, the utilities perceive cogenerated power as an unreliable source.

Governmental programs and agency motivations related to wood-fired cogeneration sometimes conflict. For example, the Energy Commission seeks to encourage new sources of power which may be discouraged by existing rate structures set by the Public Utilities Commission and

the Air Resources Board reviews air quality effects without particular concern for energy supply.

*Options

Examine various methods to guarantee long-term supplies of wood for energy production. This may be in the form of price supports or a wood marketing facility acting as a brokerage.

Continue research and demonstration of harvesting, collection, and energy conversion equipment.

Re-evaluate the electricity rate structure by considering further changes in purchase prices, standby charges and wheeling tariffs. Capacity credits could also be examined.

To reduce the risk of investment, the State could enact financial incentives such as investment tax credits, low cost loans or a risk underwriting program.

Catalog and coordinate State and local regulations which must be met for the development of wood energy facilities.

State air quality regulations could be reviewed to consider the desirability of promoting wood-fired cogeneration or otherwise recognizing inherent tradeoffs related to their regulations.

RESOURCE ISSUE

A philosphy of "non-intervention," of letting things happen without any particular comprehensive planning, characterized California's early approach to forest land-use allocation. The forest resource was so plentiful that almost anyone could enjoy whatever benefits they sought without having very significant impacts upon their neighbors. However, as the State and nation grew, the cumulative effects of forest use became more pronounced. Concern grew for the well-being of our forest lands. Efforts to protect timber and watershed values from destruction by fire were institutionalized. Wilderness areas and parks were established, "multiple-uses" recognized, endangered species identified, foresters licensed, and tax incentives enacted. As particular problems appeared, the "laissez faire" approach gave way to specific actions aimed at resolving them one-by-one in a social process characterized as "muddling through."

The drawback of this "muddling through" process is that by the time a problem is sufficiently apparent to command attention, the best opportunities to mitigate its adverse effects may have been missed. Resulting costs to society may be very high. For example, we have already witnessed about a 60 percent drop in deer and salmon populations; our "commercial" timber land base has declined in the past few decades; we may no longer be able to save the California condor from extinction due to the

impacts of "civilization." The complexity of interactions of our social and ecological systems also increase the risks associated with resolving problems using the one-at-a-time approach.

An alternative to this "muddling through" approach is to identify in advance key issues which seem likely to emerge in the future, anticipate the resulting problems, and design measures to forestall or mitigate their emergence. The remainder of this assessment attempts to initiate such a process. Ten issue statements are presented, which identify potential problems and pose alternative solutions.

More issues could have been treated, or different ones selected. The intent of this assessment is not to be all-encompassing, but to initiate the process of identifying and clarifying the basic questions -- a process which is the essential first step in building a more comprehensive approach to resource policy making.

This chapter provides only very brief descriptions of the options available for dealing with these issues. Readers are reminded of the complexity associated with any policy options, particularly as outlined earlier under THE CONSTRAINTS and they are encouraged to consult the detailed resource chapters.

ISSUE: NO MORE LAND!

California's land base is limited and competition among various land uses is escalating. One of the assumptions of most of this Assessment is that the forest lands of today will still be available in 2030 to meet these needs. Yet the past 50 years have brought substantial changes in land-use patterns affecting California's forest lands, as will the next 50.

The key issue concerning California's forest land is: How should those lands be "allocated," and land-use shifts made with regard for the total interactive system of which the forest is but one part, in order to produce the mix of outputs which society desires?

The economic, social, and political processes constantly produce land use allocation decisions. Today's solutions cannot be permanent because of the changing nature of society and of technology.

*Status

- Forests in California grow on more than 33 million acres of land. About half are "productive" timber lands. Current land use allocations which may limit the production of some forest outputs while emphasizing others are:

  5.7 million acres of private land in Timberland Preserve Zones (TPZs) designated by the counties. Uses incompatible with timber production are excluded.

  1.6 million acres of forest land designated by Congress and the State as wilderness. Timber harvesting and vehicle based recreation are excluded on

this acreage. The best estimate is that 40 percent of this area would be classified as "productive" timber land were it not in wilderness.

898,000 acres of "productive" national forest land in the "special component" category (which includes vehicular travel zones and habitat of endangered wildlife). Timber production is a secondary use and special management plans are required.

About 54,000 acres, mostly "productive" timber lands, in "special treatment" areas within the Coastal Zone, on which scenic values are of primary concern. Logging is somewhat restricted but not excluded.

Corridors along designated Wild and Scenic Rivers may be set aside to protect scenic and recreational resources. Timber production may or may not be a use deemed compatible with these values in any particular situation.

Over 1.5 million acres of forest land, 60 percent of which is "productive" timber land, are in federal, State, regional, county, and local parks.

Nearly two million additional acres of forest land have been endorsed for wilderness by federal administrators. The Resources Agency has proposed that over 500,000 acres be added to this two million acres. Approximately 40 percent of this area is "productive" timber land.

- Values of forested lands for timber management purposes have historically been lower, throughout much of the world, than for almost all other uses. In the presence of short-run pressures for higher valued goods, timber values are at a serious disadvantage in land markets because of the long period of time necessary for production of timber.

*Trends

- Desires for goods and services from our forest lands are projected to double in the next half century, according to the RPA's "medium" projections. These desires will result in increasing pressures for land allocation to dominant uses in the future.

*Problems

- It is likely that future scarcities will be even greater than estimated in the remainder of this Assessment because of future decreases in the forest land base. These scarcities can be expressed in terms of higher prices, lower quantites, reduced quality or any combination of these factors.

- Subdividing land may make timber harvesting or the use of management practices such as prescribed burning impractical.

- Critical winter habitats and migration corridors of larger game mammals like deer and bear may be depleted by land development.

- The Forest Taxation Reform Act of 1976, which established TPZs, may significantly reduce the loss of forest land to developments. However, two million acres of private "commercial" forest land are not in TPZs. Requests for immediate rezoning of lands that are in TPZs suggests that further regulation may be needed before the problem of timberland conversion is resolved.

- Other shifts may retain lands in general forest ecosystems but tend to restrict certain uses. For example, "wilderness" areas protect scenic, primitive recreation, and retain natural watershed resources while excluding developed recreation and timber harvesting.

- Land shifts or withdrawals made in response to concerns about the inadequacy of the amounts of some forest outputs are, generally, contemplated on an area-by-area basis and the effect of such actions in the aggregate is not identified. (RARE II is a significant exception.)

- Some of the consequences of such withdrawals are that forest products become increasingly costly and greater investments are needed to intensify production on the resulting smaller land base. California is forced to import greater quantities of forest and range products from other states and nations. This is costly and could cause significant adverse effects on the State's balance of payments. However, such imports also result in the export of any adverse environmental impacts.

- For certain forest resources, stability of land use designation is essential. For example, wilderness cannot be easily restored once impaired. The large investments needed to plant and grow a crop of timber would be irrational and counter productive if devotion of the land to timber productivity, until the trees mature, were not assured. Thus, the need for stability in forest land use designation sufficient to achieve wilderness or timber production goals may conflict with the flexibility needed to meet shifting patterns of demand. We do not yet know how to address this problem; yet the conflict will become more serious as demands increase.

*Options

- One approach for resolving land use allocation issues is to simply respond to pressing concerns as they arise. Selection of this option would imply that the problems described above are not especially critical or do not justify efforts to resolve them.

- A second alternative might be for the State to institute comprehensive land use planning for forested lands. Attempts in Congress to establish federal land use controls have been unsuccessful. The values justifying coastal zone planning may have been substantially greater to most Californians than would be the case for most forest land. Further, the coastal area is minimal when compared to our forested area. The state of limbo while plans are being developed and the loss of property rights inherent in comprehensive land use planning do not suggest this would be a popular approach.

- A third option would be to establish a continuing process of evaluating land use allocations which does not now exist. Such a process could provide timely

identification of conflicts of land use programs. It might eventually lead to Statewide guides to regional and local decisions. The task is one of defining "land uses," analyzing appropriate criteria, determining the interactions of land uses, estimating critical deficiencies, identifying alternatives for eliminating them, and describing the consequences. As alternatives are selected and implemented, perceptions and problems change and the need for a new assessment emerges. The cycle must then be repeated.

Economic modeling is one tool available to policy makers for simulating the allocation of resources to illustrate the potential future impacts of such decisions. Mathematical models can consider voluminous, complex interaction processes and provide policy planners with an array of tradeoffs.

Once tradeoffs of this sort have been identified, and incorporated with relevant non-quantifiable considerations, decision makers have a more adequate basis upon which to determine how to proceed. Ultimately, broad policy questions are resolved through the political process.

ISSUE: MORE WOOD, MORE GAME: COMPLEMENTARITY

The forests which produce commercial wood also provide wildlife habitat for species of major significance to man, including deer, quail, rabbits, bear, and the like. These species are largely sustained by early successional stages of forest vegetation.

*Status

- Large areas that once grew conifers now support either dense brush or slower growing, less utilizable hardwood species which produce little wood or wildlife habitat. Within this issue these areas are termed "brush and hardwoods."

- Much of the commercial forest has been "selectively" logged several times and some of it now has residual stands consisting mostly of damaged or diseased trees. ("Selective" logging does not always result in these conditions, but one-eighth of our commercial timber land now has this status.) After any existing brush matures these stands produce little timber or wildlife.

- Old-growth stands constitute a final category of forest lands where current harvest levels of game species are low. Net growth rates of timber are sometimes even negative. These stands are needed, however, for certain nongame wildlife and plant species.

- The maintenance and enhancement of wildlife communities are often related to the conservation of special and unique habitats such as snags, seeps, springs, talus slopes, rimrocks, etc. These features are currently protected by existing laws and regulations. Sustained timber harvest levels generally are not reduced where these habitats are retained. The maintenance of key habitats for deer including fawning areas, migration corridors, winter ranges, and meadows, some of which are not solely within forests.

- While wildlife and trees occur on the least productive forest lands, both are usually sustained at highest densities and growth rates on the most productive soils. Production of harvestable surpluses of game species is especially tied to mid-successional vegetation on good forest soils.

*Trends

- In the past, deer populations increased significantly as a result of habitats resulting from intensive logging and other disturbances, and reached peak levels from 1930 through the early 1960's. Since the mid-1960's they have declined by approximately 60 percent. If key habitat requirements are not further decreased by land-use shifts, and if current timber management practices are continued, deer population levels will likely remain relatively stable. This projected trend assumes that habitat improvements due to timber harvests will be offset by continued deterioration (aging) of existing mature browse species and the crowding out of browse by young stands of timber.

- The demands for timber and game are increasing, yet timber production is expected to drop slightly in California, as well as in Oregon and Washington, which are our principal sources of imports.

*Problems

- California's 16 million acres of "commercial" timber land are producing wood at less than 50 percent of "capacity." Game animal production is also far below the potential yield. (Hunter success for deer in California is now about 10 percent; half as high as it was in the 1950's. Hunting has also declined about 20-30 percent.)

- Conversion of old-growth to early successional stages benefits game species while resulting in a decrease in habitat for other species of wildlife which may fall into the rare and endangered categories. However, not all of the old-growth will be harvested. Substantial areas of parks, wilderness, and special categories of forest land will retain some old-growth forests.

- Timber growing is a long term process involving a series of changes in habitat, some favorable and some unfavorable to wildlife. A complex problem of coordination over substantial areas of land thus arises if both timber and wildlife are to be produced in relatively stable annual yields.

- For many forest owners there is currently little economic incentive to invest in erosion control, watershed protection, or fish and wildlife habitat. As a result we may fail to realize the full benefits of the complementarity of wood and wildlife production.

*Options

- Harvesting old-growth stands in the national forests, followed by reforestation could increase Statewide forest growth by approximately 43 percent. If these stands were harvested and restocked both wood and successional wildlife

resources would increase. Actual levels of timber and wildlife production on these sites will depend on the management prescriptions applied after harvest. This option is a component of the following two scenarios:

Timber and game can be jointly produced in greater amounts on about 12 million acres of forested lands. One scenario would address intensive timber management efforts which would minimize the growth of brush and other browse species favorable to game. Even without consideration of wildlife habitat needs beyond the current statutes, this program would probably increase game populations 5 to 10 percent through disturbance of mature vegetation. At the same time, current timber growth over the State could be nearly doubled by harvesting the old growth, treating the "selective" stands and the "brush and hardwoods" as this scenario suggests. Reforestation of "brush and hardwood" lands on all ownerships could increase timber production over current levels by 20 percent. (In fact, treatment of only the more productive sites would yield 80 percent of this potential increase in growth while only affecting half of the area.) Removing slow growing residuals from "selective" stands and planting or seeding, could produce another 25 percent increase in the State's present timber production.

An alternative scenario also includes "brush and hardwood," "residual," and old-growth conversion treatments. But the prescriptions to accomplish these conversions would be modified to better satisfy wildlife needs. Maintaining 30 percent of the treated area in grass-shrub or shrub-pole successional stages would provide optimum game forage and cover (provided that other key habitat needs exist and continue to be maintained.) Such treatments could increase deer populations Statewide by 50 to 100 percent. Complementary timber production could be expected to increase by 70 percent over that expected from current practices.

- Neither of these scenarios is necessarily recommended by FRAP. Both would require public and private investments. Intensive land management for any particular resource or set of outputs also involves certain biological and institutional factors and foregone opportunities.

- Allowing more private landowner control over the management of game species on these lands would make habitat management more profitable.

- More enlightened public attitudes about harvesting antlerless deer could lead to a harvest program which would justify private investments in deer habitat.

- Improved management on private lands might be effected by providing technical assistance and incentive programs similar to those proposed by the California Forest Improvement Program (CFIP) or by regulations favoring increased timber growth rates. (Some wildlife incentives are included in the CFIP proposals.)

- An institutional change in determining harvest rates for national forests would be needed to produce these benefits on public lands.

ISSUE: SALMON

King and Silver salmon support an important commercial and sport fishery in California. Historically they spawned in the cool and clear waters of coastal and montane forest streams within the Sacramento, San Joaquin and North Coastal drainages. A significant decline in all of these populations has occurred since the turn of the century.

*Status

- Annual salmon runs in the Klamath-Trinity, San Joaquin and Sacramento River systems are estimated to be respectively, 150,000; 15,000; and 263,000.

- At present, the annual Statewide salmon management and research program of the Department of Fish and Game involves an expenditure of about $2.9 million comprised of 65 percent State and 35 percent federal monies. The program includes research, habitat restoration, erosion control, salmon production, and distribution. Hatchery operations account for more than a third of the total expenditure. In addition, the federal Fish and Wildlife Service spends about $650,000 annually for salmon management and research, principally in the Sacramento drainage.

*Trends

- The salmon populations of the Sacramento and San Joaquin drainages have declined by about 65 percent since the turn of the century. In the North Coast, the fall salmon run in the Klamath River has dropped an estimated 63 percent since the mid-twenties. Salmon runs in other coastal streams are estimated to have suffered similar declines. While the rate of decline has slowed in recent years, it is not certain whether a continuation of the present management programs will halt the downward trend.

*Problems

- The following problems are connected with the salmon population itself.

  Habitat loss or deterioration is the most significant factor in the decline of salmon populations. This loss is a result of the interaction between land use activities, water impoundments and diversions, and natural events such as erosion and high intensity rainstorms.

  Dams reduce the flushing of fine sediments from, and the movement of new gravels to, downstream waterways. Another effect of dams is a reduction in the downstream quantity of water for migration and fish habitat. Finally, dams inundate upstream spawning grounds and prevent or impede migration.

  The construction of dams and the subsequent diversion of water are believed to be largely responsible for the drop in populations of the Sacramento and San Joaquin basins. There are fewer water projects in the North

Coast, nonetheless, their presence has added to the loss of habitat. This is especially true in the Trinity River Project where flows have been reduced to 10 percent of their historical levels.

When high intensity rainstorms occur in areas where soils are susceptible to erosion, a certain amount of natural sedimentation results. Storms, which contribute to the siltation of spawning gravels, are of most significance in the watersheds of the North Coast.

Habitats have been impaired when timber harvesting, road building, or other land use activities resulted in the removal of streamside vegetation (which reduced food and raised water temperatures), siltation of spawning gravels, and/or creation of log jam barriers. Some of these problems continue.

- Another problem is establishing trends, a task complicated by the following factors.

Forest Practice Rules and other environmental regulations intended to reduce water quality degradation (among other things) have been in effect less than a decade. It is believed that the implementation of these practices has reduced the degree of soil loss and water quality impairment. A more definitive evaluation of the State's forest practices will be available when the Board of Forestry's soil erosion studies are completed.

Determination of fish trends requires that data be collected over a period of years; at present, such data are weakest for the North Coast.

Population levels fluctuate as a consequence of natural events, such as the 1964 flood and the 1976-77 drought, but to what extent the magnitude of the normal fluctuations has been influenced by man is difficult to determine.

*Options

- Salmon populations can recover rapidly if favorable conditions are restored. Options that could enhance salmon populations include:

Research to identify the relative significance of the variables that have led to the decline in numbers of salmon, including studies to resolve the question of the extent to which timber harvests are adversely impacting salmon populations.

Undertaking habitat restoration programs such as clearing away debris and barriers to spawning areas, providing fish ladders, and reconstructing riffles.

Taking steps to halt the degradation of water resulting from past land-use practices. For example, in the case of poorly constructed roads, erosion control measures (such as the construction of water bars or other means of drainage) and grass seeding could be applied.

Taking further steps to secure minimum flows for fish, where water projects have reduced streamflows. Water in adequate amounts, especially at specified times of the year, is essential for maintaining salmon habitat. The State Water Resources Control Board is beginning to adopt regulations which would establish flow requirements for streams having unappropriated water. These regulations would serve to guide the allocation of future water appropriations and maintain minimum flows.

Treating stream degradation which results from current land use practices. Improvements in the present regulatory approach could (1) bring about more effective implementation of established guidelines and regulations (funding to support adequate enforcement is one technique), and (2) enhance coordination and cooperation between all agencies involved in the protection of water quality.

Upgrading existing hatcheries, or constructing new facilities, which could enhance salmon populations by increasing the quantity of fingerlings (3") and yearlings (7") added each year to streams and rivers. This option could serve as a mitigation measure in areas where dams exist or habitat damage has occurred from logging despite use of the most current or accepted "Best Management Practices."

Reducing the limits and seasons set for the sport and commercial take of salmon. While the effects of the combined commercial and sport harvest on the State's populations have yet to be determined, many fisheries' experts believe that a decrease in the proportion harvested would allow salmon poplulations to at least partially recuperate.

- A program proposed by the Brown administration incorporates many of these options. It includes $50 million for salmon enhancement over a 10-year period. The goal is to double the number of salmon that presently enter California streams (raising it to about 800,000). This would restore the population to two-thirds of its historic levels. Part of the monies would be spent on habitat rehabilitation and the remainder on salmon production. Negotiations with federal agencies to secure stream releases for restoring habitat below federal water projects would be undertaken. Under this program the State would seek Congressional appropriations to support certain aspects of the program. It is estimated that the program would return $30 to $40 million annually to California's economy ($23 to $32 million to the commercial fishery, and $7 to $8 million to the sport fishery), and create 3,000 new jobs.

ISSUE: DATA LIMITATIONS

The focus of FRAPA is to assess and evaluate all of the resources derived from California's forest lands. Data are essential for this task. Important data problems encountered during preparation of this assessment are described in this issue.

*Status

- A basic finding in this assessment is that the necessary data have often proven to be nonexistent, incomplete or incompatible. These deficiencies exist because to date all inventories of any forest resource have been designed to satisfy singular needs for limited areas of California's forests. In terms of basic design criteria or data collected, these existing inventories or surveys are not entirely compatible for any one resource, or between several resources. Many of the results in this Report reflect informed professional judgments based upon those data which could be assembled.

- Modern technology is capable of efficiently supporting an inventory for the entire State accurate to even small land units.

*Trends

- Specific legislative direction to coordinate and integrate data needs was lacking prior to recent statutes such as the RPA, RCA and FRAPA. Subsequent administrative encouragement for such coordination and integration is indicated by the support of FRAP.

- Creation of the Environmental Data Center in the State Office of Planning and Research will assist users in finding natural resource information from various State entities. The National Oceanic and Atmospheric Administration and Environmental Data Service are planning to provide similar information about the federal agencies. These efforts indicate a trend to coordinate new data-gathering and management efforts.

*Problems

- There is no consensus between the various resource agencies about what constitutes a forest, how it should be classified or where the forest lands of California are located.

- Assessing the recreation resource was limited by the existence of incompatible measurements of use and facilities. For example, agencies measure use in a variety of terms such as visitor days, visits, and camper days. In addition, there is a lack of data on private lands.

- Many of the forest resource data for California were obtained from the Forest Service Regional Office and the two western research stations. Their data are collected for various national forest land management needs and to fulfill the dictates of certain federal laws. This resource information is not always collected and recorded in a uniform manner between national forests and research stations. Consequently, these data often are not compatible and do not fully satisfy the State's needs.

- Research station timber data have only been obtained from non-federal forest land, though their statutory authority has been expanded recently to include other resources. However no new inventory work has been done yet in California, and some present timber data are outdated (obtained between 1964 and 1972).

- The research station timber inventory provides area estimates of various forest conditions but the actual location of forests with those conditions cannot be determined.

- Only minimal resource data exist on millions of acres of forest land that produce low volumes of the major coniferous tree species.

- Data on timber age-class distributions are not available for all of the forest lands of California. These data are essential for projecting harvest opportunities and for deriving other age-related attributes of the forest such as wildlife habitat.

- Data on timber stand conditions are not sufficient to thoroughly analyze the opportunities to increase timber growth in California.

- Data are lacking on the potential to provide various forest outputs, such as recreation and water, under specific forms of land use.

- Forest land ownership and owner objectives are critical factors affecting levels of outputs for the various forest resources. Yet little is known about the numbers of private owners, the size of the parcels and where they are located, etc.

- Knowing use-rates for recreationists, livestock, and wildlife which move throughout the forest, is important. The rates will vary as site conditions, facilities and other factors change. Research is needed to validate, improve or establish new rates as changes occur.

- Significant soil loss from erosion will lower site productivity and water quality. Exactly how much erosion and water quality degradation are acceptable is not known. Individuals familiar with particular watersheds can identify areas where problems may be of major concern; however, no Statewide list of such areas or of the severity of our erosion problems is available. Rehabilitation needs thus cannot be determined.

- Mapping of individual soils and rating their reaction to various land use practices are far from complete for California's forest lands. This information is important in order to assess the forest's productive capability and the cumulative effects of activities over time and area.

Data limitations such as these assume major significance in the development of programs such as the California Forest Improvement Program, the management of existing programs such as the Service Forestry Program, or the formulation of alternative policy positions.

*<u>Options</u>

- An institutional adjustment by the Forest Service to standardize inventory systems within the National Forest System, and between the National Forest System and the research stations would substantially improve analytical capabilities.

- An integrated cooperative approach by various federal and State agencies could be initiated rather than the perpetuation of the present fragmented approach to inventory of the forest resources by the various federal and State agencies. Five federal resource agencies have been participating in a national effort for several years to develop compatible classification and inventory procedures. Progress toward resolution of the institutional problems has been slow.

- A multi-resource inventory system based upon forest types could be established. Such a system might measure actual and potential quantities and qualities of forest resources for homogeneous forest types and age classes. Identification of these types, and the utilization of satellite technology, may provide a means of monitoring change and hence provide the ability to quickly, reliably and efficiently update inventories. Political and other boundaries could be superimposed as needed to disaggregate the resource data.

ISSUE: RESOURCE STANDARDS

Land use interactions within the forest environment involve tradeoffs between various outputs. In some instances, the quality of certain resources may be enhanced by management. The same actions may impair other resources.

Over time governmental steps to protect individual forest resources have made use of various standards. Existing standards for air quality, water quality, pesticide use, reforestation, wilderness attributes, silvicultural performance, and even scenic vistas are usually derived independently from each other and as a result conflicts sometimes arise.

*Status

- State water quality standards were established in 1967 on a regional basis, then revised in 1973 and 1974. In some cases, these were supplemented by amendments to the Federal Water Pollution Control Act.

- The 1963 Clean Air Act and its amendments required the development of air quality standards to protect public health. These can influence forest management activities, such as prescribed burning.

- The Z'berg-Nejedly Forest Practice Act has set minimum reforestation standards. Recent amendments require the Board of Forestry to establish more specific guidelines for administering timber harvesting practices.

- The California Wild and Scenic River Act requires agencies to protect "extraordinary scenic, recreational, fishery or wildlife values." The Board of Forestry is now developing visual standards to define "extraordinary scenic values."

- To protect public health from a chemical contaminant (TCDD) present in two herbicides (Silvex and 2,4,5-T) the North Coast Regional Water Quality Control Board has in several cases prevented aerial herbicide applications. Subsequent-

ly EPA suspended use of these chemicals on forested land but not for agricultural purposes.

*Trends

- The Legislature and regulatory agencies have established standards as a way to protect individual resources, e.g., air and water. But, as indicated, standards are subject to change particularly as socio-economic pressures come to bear. For example, the federal government raised the maximum acceptable level of ozone in air as a consequence of the recent fuel crisis.

- Congress, in amendments to the Federal Water Pollution Control Act, departed from full reliance on specific numeric standards. It established a mechanism to develop a system of "Best Management Practices" (BMPs). These are designed to regulate land use activities to control sediment or other pollutant discharges that might contaminate water.

*Problems

- Standards for individual forest resources are still being developed and applied without a complete evaluation of their effect on other forest uses. There is no systematic way to compare standards or to weigh their interaction in advance. As a result, flexibility to accommodate the various potential resource uses is lost. For example:

  Stringent application of air quality standards can prevent controlled burning of accumulated fuels thus increasing the threat of wildfires.

  Very low sediment discharge standards in water can severely limit or effectively prohibit timber harvesting which may be needed to keep the land productive for timber growing.

  Standards are sometimes so inflexible that they will not accommodate site-specific conditions and may dictate the use of poor management practices or prompt circumvention of the regulation.

- Collecting data to define "acceptable" levels of pollutants, habitat requirements, and resource interactions may take many years. Interim or approximate standards may have to be established in such cases.

*Options

- One option is to continue the current approach in which standards are set relatively independently of each other as needs occur.

- Another option is to review existing standards and where conflicts arise, attempt to provide greater flexibility in the way limitations are applied. This might be accomplished through cooperative efforts between various agencies and boards. Air quality requirements, for example, can be applied in ways that are

consistent with the need to burn. Scenic standards can be developed that will, in general, allow for timber harvesting.

- Where strict standards are appropriate and where flexibility is not possible, public funding may be used to find and develop alternative technologies to those made uneconomic. For example, hand control techniques for brush control could be subsidized as an alternative to aerial applications of herbicides.

- Where effective implementation of a standard is particularly difficult, "Best Management Practices" can be emphasized. For example, as an alternative to strictly enforced water quality guidelines, silvicultural practices which significantly reduce stream sedimentation can be required.

- Research could be started to identify areas where future standards or changes in existing ones will be needed. Better understanding of tradeoffs and other resource problems dependent on standards also would be facilitated by additional research.

ISSUE: CUMULATIVE IMPACTS ON WATERSHEDS

The components of a watershed make up a dynamic and interactive ecological system, tending toward a steady state. A particular land or water practice may set into motion a chain of events in this system, the final impact of which may be well downstream and not materialize for years after the event occurred. Watershed components (hill/slope form, vegetative cover, channel geometry and streamflow rate) will be modified to varying degrees.

When several land use practices occur in a relatively short time interval, the complexity of this chain of events is magnified. The likelihood exists that the cumulative effect may be more serious than an analysis of the individual events would suggest. Unanticipated levels of degradation to the watershed may result. It is perhaps not meaningful to evaluate the consequences of any one practice in isolation from others.

Efforts must be undertaken to analyze the effects of an accumulation of practices, and to identify the relative contribution and the costs associated with each. If acceptable levels of degradation (which might be expressed in terms of maximum allowable rates of soil loss and concentrations of suspended sediment) could be established, and the contributions to the degradation by the various practices were known, then we could predict with more certainty the number and mix of activities that a watershed might tolerate.

*Status and Trends

- Because projections call for increasing levels of outputs of the various forest resources, forest lands are likely to be subjected to more intensive management practices. Within each watershed, a greater percent of land is likely to be affected over a shorter period of time. This trend towards more widespread

and more frequent land treatments will intensify the liklihood and magnitude of cumulative impacts.

*Problems

- Assessing cumulative impacts is formidable task because significant technical problems are unresolved, and data are unavailable. All of the questions that must be asked to make such an assessment have not yet been identified. In some cases, the questions have surfaced, but the analytical techniques for addressing them have not. In other cases where the questions and the analytical techniques do exist, data have not been collected or are not compatible. Some of the sorts of questions that must be answered are:

  What effects do various land-use practices and water alterations have on water and soil quantity and quality? Effects separated in time and distance from the original impact must be ascertained.

  Can quantitative relationships between these effects and natural properties of a watershed be established, so that the consequence of specific practices can be predicted?

  What are "background" rates of erosion, and sedimentation, and the natural concentrations of other pollutants? Water projects and a multiplicity of land use activities make determination of these numbers very difficult.

- The present institutional framework for protecting watershed values is not conducive to assessing cumulative impacts. Watersheds are interactive, ecological units. But the protecion of a watershed is fragmented, often due to the presence of multiple ownerships and political boundaries that rarely coincide with watershed boundaries. This phenomenon is illustrated by the fact that more than 45 distinct classes of governmental agencies, including federal, State, regional, and local, are authorized to do something in the way of erosion and/or sedimentation control. Much remains to be done to provide a comprehensive and fully coordinated structure of institutions capable of dealing with cumulative impact problems, once the problem of identifying and assessing such impacts has been solved.

- Beyond the problems of assesment and adequate institutions for control lies an even more difficult issue. When action to reduce cumulative impacts is to be taken, how should the costs (and benefits) be distributed among the numerous land owners who are involved?

*Options

- Continue as we are, letting critical problems emerge and be dealt with by existing institutions.

- Mount a comprehensive watershed analysis to identify predictive measures of cumulative impacts. The process might begin by evaluating existing findings in this area.

- Establish or modify institutions to facilitate coordination among multiple ownerships for assessing cumulative impacts. For example, a cooperative land management organization could coordinate the data gathering and assessment efforts between agencies responsible for private land, and those that manage federal lands.

ISSUE: ENERGY

It is highly probable that the current energy shortage, characterized by escalating prices and the country's dependence on foreign imports of oil, will continue. Traditional lifestyle patterns, which have developed to a large degree as a consequence of relatively cheap energy, will be changed by these increased energy costs. Less energy-intensive alternatives will be substituted where possible and the development of cost-effective energy sources to supplement the dwindling supply of fossil fuels will become increasingly important. These events are likely to significantly affect the use of our forest resources for recreation, for the production of structural materials, and as a source of energy.

*Status

- A 1976 study by the National Academy of Sciences suggests for residential and light commercial construction, structural wood products are clearly superior on the basis of energy requirements to nonwood products such as those made from aluminum, clay, petroleum and iron ore. The study analyzed the energy requirements (extraction or harvesting, transportation, and processing) of substitute materials for three construction end-uses: interior and exterior walls, and roofing. The differences for exterior siding were the most significant: brick veneer walls required seven to eight times the energy of wood construction and those incorporating aluminum about twice that of wood. The durability, ease of maintenance, and insulation characteristics of the alternative materials were not considered in the study, but wood has adequate or desirable characteristics in many of these respects.

- A forest is a solar energy factory utilizing three to four percent of incoming radiation, automatically storing fuel, and operating forever with practically no capital cost. Historically, wood has served as an important energy source. In recent times, more efficient forms of energy have taken precedence over wood. However, as the costs of these sources, especially oil, continue to rise, potential alternatives, including wood, are likely to become more cost effective.

- Most forest recreation occurs in areas distant from major population centers.

*Trends

- It appears that rising fees, more intensive use of local forest areas, and a decline in the relative importance of certain activities will characterize forest recreation use as a consequence of the "energy crisis."

- As cost-effective technologies for uses of wood for energy are developed, future production can probably be expected to increase. The degree to which this energy source can be tapped is also dependent upon a continuous supply of residues (in the form of mill or logging wastes) and/or other wood sources having no higher utility and on the availability of technologies for collecting and utilizing it is a cost effective manner.

- Another consequence of rising energy costs is likely to be a preference for energy efficient materials for construction. This will mean greater reliance on those materials that can be extracted or harvested, transported, and processed with the least consumption of energy. Durability, insulation, and maintenance requirement characteristics are also relevant to the overall energy efficiency of materials.

*Problems

- As current sources of fossil energy become increasingly scare, the pressure to develop alternatives, including the expansion of existing nonfossil sources (such as hydroelectric), will mount. Each of the presently identified alternatives is beset with some combination of: environmental concerns, limited geographic availability (e.g., geothermal energy), fluctuating supply (e.g., hydroelectric), and uncertainty of economically competitive technologies (e.g., solar).

- The availability of wood and related forest biomass is the most important determinant of the degree to which this resource can be substituted for more energy intensive structural materials, or utilized as an energy source. The long production period required for most wood species means that immediate actions must be taken if future production levels are to be increased.

- For most Californians, a trip to public forest land entails travel over significant distances and consumption of considerable amounts of fuel. As a result of the energy shortage people probably will begin to substitute recreational opportunities closer to home. Local, regional, and State parks, and federal recreation sites located adjacent to urban centers in the woodland and coastal forests will receive heavier use. This phenomenon will bring additional pressures to bear on both developed and undeveloped local park sites at a time when cutbacks due to Proposition 13 have curtailed the development, operation, and maintenance of such areas.

*Options

- Techniques which would encourage private investment in the construction of new wood energy facilities that incorporate presently known technologies include the provision of direct and indirect subsidies such as: low interest loans, cost sharing programs, regulatory relief, tax incentives, and favorable rate structures.

- The potential for developing wood combustion and conversion technologies (characterized by increased efficiency, and/or a reduction in environmental

impacts) and other wood sources might be enhanced through research. Development programs to produce energy from unutilized wood sources might be undertaken.

- This Assessment considers the resources presently or potentially available from a fixed forest land base. One option for expanding the supply of wood or other biomass for energy production would increase the forest land base by converting nonforest land to forest plantations.

- Where there are private forest lands close to urban centers, one method for augmenting the supply of recreational facilities or areas offering dispersed recreational opportunities would be to provide incentives for their development. These could be in the form of preferential tax laws or technical assistance provided by recreational agencies.

- Changes in certain institutions could provide additional inducements. At present, vandalism and laws dealing with landowner liability for injury and fire do not favor the development of private land for recreation.

- In certain areas of the State substantial forest land in public or quasi-public ownerships is in close proximity to metropolitan areas. For those lands already open to the public, further development to accommodate greater recreation might result from institutional changes and/or investments. For example, joint planning and development on adjacent local public lands under different ownerships could result in recreational opportunities that could not be realized on the individual parcels alone. Studies could be undertaken to determine the degree of compatibility between recreational use and water quality on public utility lands presently closed to entry.

- The use of less energy-intensive mechanisms of travel would enable more people to undertake those forest recreation activities available only at considerable distances. One option would be the development of mass transit systems to serve heavily used areas. This approach has been implemented in southern California where the Sierra Club provides summer weekend bus transportation to heavily used Sierra trailheads.

- The availability of wood for energy or construction purposes can be increased by carrying out certain silvicultural and harvesting practices. These options for expanding the supply of timber are discussed in the FOREST SERVICE HARVESTING POLICY and MORE WOOD, MORE GAME issues.

ISSUE: PRESCRIBED BURNING

Prescribed burning is a management practice which provides several benefits including range improvement, wildlife habitat improvement, and vegetative conversion. In addition, the use of prescribed burning to eliminate natural fuel buildups as well as those from such things as timber slash can lessen the potential for large uncontrolled wildfires, and the attendant problems of serious soil erosion and air pollution.

Fires have long influenced California's vegetation. The impact has been major: without natural fires the millions of acres of mixed conifer and the Giant Sequoia groves would not exist as we know them today.

*Status

- Burning has different impacts on timber production, wildlife, recreation, and water quality.

- Techniques and applications of prescribed burning are still under development. They are not fully understood or accepted by many technicians and by much of the public.

- The current institutional or regulatory environment involves agencies which are each primarily responsible for only one aspect of the prescribed burning conflict, the burning or the air.

*Trends

- Prescribed burning is being used less on private lands including nonforest lands. The opposite trend has been reported by the Bureau of Land Management, the National Park Service, and the Forest Service. These agencies have carried out prescribed burns on an increasing number of acres, and plan to continue this trend.

- Acceptance of prescribed burning by the public as well as professionals is increasing.

*Problems

- A factor which might decrease the use of prescribed burning is a conflict with air pollution control requirements. The 1963 Clean Air Act and its amendments propose State enforcement of air quality standards varying from no human-caused visibility impairment in Class I areas such as parks and wilderness to less stringent standards around metropolitan areas. Inability to predict precisely where smoke will drift, how much will be created, or how long it might last creates problems between the use of fire for resource management and strict air pollution standards.

- Prescribed fires have some of the disadvantages of wildlifes. Erosion, for example, may be a problem following these fires if severe storms occur and/or insufficient precautions are taken to prevent soil loss.

- Historical viewpoints of professional foresters and attitudes and structures of fire protection organizations have often served to put severe constraints on prescribed burning.

- Private land owners are dissuaded from using prescribed burning by the risk that a fire will escape and they will be held liable, particularly for damage to other property owners.

- Efficient prescribed burning usually covers hundreds of acres. When the land is broken up into subdivisions or other developments it tends to make prescribed burning less efficient or impossible. Small blocks of public land inside private ownerships can create similar problems.

- Prescribed burning may reduce fuels which could instead be used for energy production.

*Options

- Resource tradeoffs must be weighed when dealing with problems connected with prescribed burning. For example, in spite of the smoke produced, prescribed burning is currently being used to eliminate whitewood competition in Sequoia National Park in order to return redwood groves to a status similar to that which existed before the arrival of settlers.

- An approach for addressing the problem of having one agency administer burning and another air, might be to establish an institution having joint responsibility or otherwise ensure coordination of responsibilities. For example, the State Water Resources Control Board is currently cooperating with the State Board of Forestry, Forest Service, Bureau of Land Management, and others to develop "Best Management Practices" to maintain water quality under Section 208 of the Water Pollution Control Act. A comparable approach could reduce potential conflicts between air quality requirements and forest management needs.

- Research may improve our ability to minimize smoke pollution and to better predict meteorological conditions, so that the tradeoffs between air quality and resouce management are reduced. Further research on the problems that a fire may initiate in a watershed, such as soil erosion, could be undertaken.

- The conflict between air quality and forest management might be resolved by using other vegetative control techniques. It is possible to use hand crews or machinery for vegetative clearing, but the magnitude of the area needing treatment and high costs involved discourage wide adoption of these techniques.

- Chemicals such as 2,4,5-T have been utilized but they may also involve environmental and pollution risks. Their use is becoming increasingly restricted, suspended, or banned.

- The public benefits of prescribed burning include fuel reduction and wildlife habitat improvement. For private landowners the costs and risks are likely to be greater than the benefits. Thus, compensation to landowners and/or exemption from civil liability might be justified.

ISSUE: FOREST SERVICE HARVESTING POLICY

Growing more timber is a way of keeping prices from rising so fast and encouraging the use of this renewable resource. Increasing growth now and in the decades imme-

diately ahead responds directly to the concern that future generations have an adequate timber supply. But what about enlarged wood supplies for the current generation? The single most important potential source of such supplies is the reserve of old-growth timber on the national forests. The supply currently available from this source is determined by the "non-declining even flow" policy of the Forest Service, and the way in which that agency applies the policy.

Most of the discussion of Forest Service harvesting policy has focused on the appropriateness of the non-declining yield constraint and on the limits of allowable departures from it. Another (largely overlooked) aspect of the present process of harvest scheduling has to do with whether "even-flow" should be based on national forest lands alone or on some more comprehensive concept of the regional timber resource base. The present issue examines the question in terms of two options: one basing "even-flow" on national forest lands alone and the other basing "even-flow" on public and TPZ lands in a given forest subregion. The illustrative case used is the Northern Interior Region (Lassen, Modoc, Siskiyou, Shasta, and Trinity Counties). The case suggests consequences characteristic of other regions in the State where there is a substantial mixture of public and private ownerships of timberland.

*Status

- The Forest Service develops management plans to produce non-declining even-flow timber harvests in accordance with its interpretation of the National Forest Management Act of 1976. This is a form of sustained yield planning whereby timber harvests cannot decline at any decade in the future. (Decades constitute the period of analysis.) The cut may vary from year to year but the planned average level for a decade may not decline. Once it is determined, the average level is termed an annual "allowable cut" or "potential yield."

- The allowable cut is influenced by the area and timber characteristics of the planning unit employed. Forest Service policy limits planning units to national forest land on the grounds it has no assurance that adjacent private lands will continue to grow timber.

- In California, law now provides for the classification of Timberland Preserve Zones and requires the restocking of these (and other non-federal) lands when they are harvested. Thus, there is some assurance in this State that timber will be produced on these private lands.

*Problems

- The current method of calculation of Forest Service allowable cut considers only national forest land. Since a major objective of an even-flow policy is to enhance the stability of communities dependent on the timber resource, this method may be illogical whenever private timber resources are a significant element in regional resource dependency. Not only would stability be improved by considereding all timber resources, regardless of ownership, that contribute to the dependency relation, but under many circumstances the allowable cut calculated for private and public land together would be greater than the sum of even-flow cuts calculated for the two classes of ownership separately.

- Under present policy, if the cut from private land should decrease, total timber production in the region would fall, resulting in a drop in employment and various other adverse economic consequences. The national forest cut would not be raised to compensate for the decrease in private harvest. By including private land in the planning units the increased allowable cut would mitigate these adverse effects, without violating the constraint of sustained yield for the entire area.

- Another serious consequence of present harvest policy is that cutting of substantial areas of federal old-growth timber will be deferred for one to several decades. During this interim, growth on these areas will be much below site potential. Increasing national forest old-growth harvests in the decades immediately ahead would accelerate annual growth on such lands.

*Options

- One option would be to continue the present form of sustained yield. The harvest for the region as a whole under this approach is shown on Figure A-1 and is about 240 million cubic feet per year at present. It will probably decrease to about 220 million over the next three to four decades. This decline will occur in the non-Forest Service holdings primarily because of the deficiency of certain age classes of trees. The national forests have an annual allowable cut in this region of approximately 156 million cubic feet. (That is, by projecting growth and considering present standing timber inventories the Forst Service has determined that this much timber is available for annual harvests from the national forests in perpetuity.)

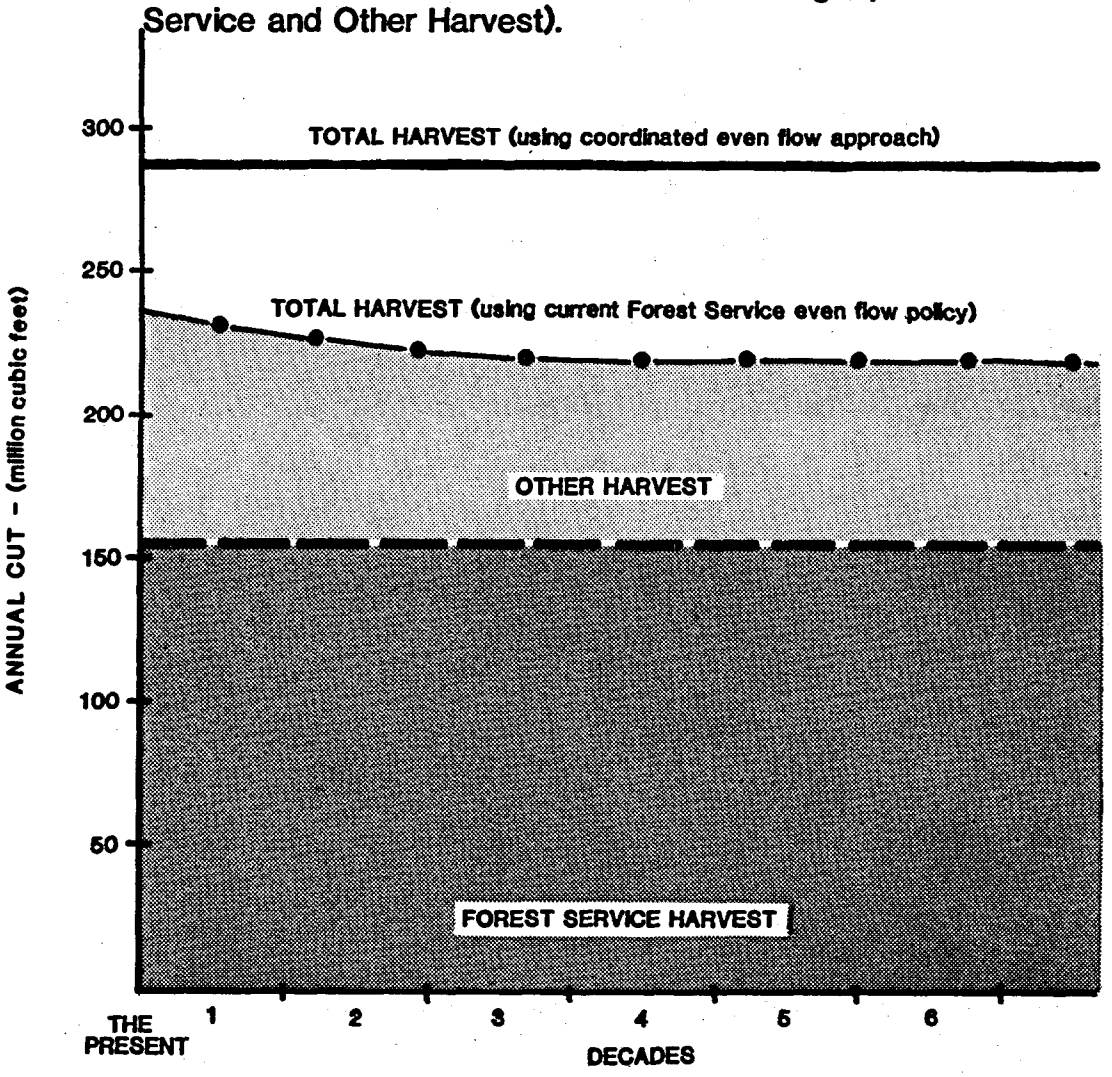
- As an alternative, the Forest Service might change its policy to determine the regionwide sustainable yield considering both private and public timber reserves and assume that public and private cutting would be coordinated. Using this approach, FRAP has estimated the maximum annual sustainable yield for the Northern Interior to be 284 million cubic feet from public and private land. For any given period the source of the timber harvested would depend upon the age-class structure on the different ownerships. The split of the harvest between timber ownership categories is shown in Figure A-2. As the figure indicates the approach would result in an immediate increase of 57 percent (about 64 million cubic feet) during the next 20 years in national forest harvest because they contain most of the old-growth timber.

  Old-growth will not be eliminated by exercise of this option. There are considerable areas of wilderness and special categories of land (e.g., special component, marginal component) which will retain very old trees.

  Over time, as the available public old-growth is harvested and private inventories increase, the majority of the cut would shift to private land.

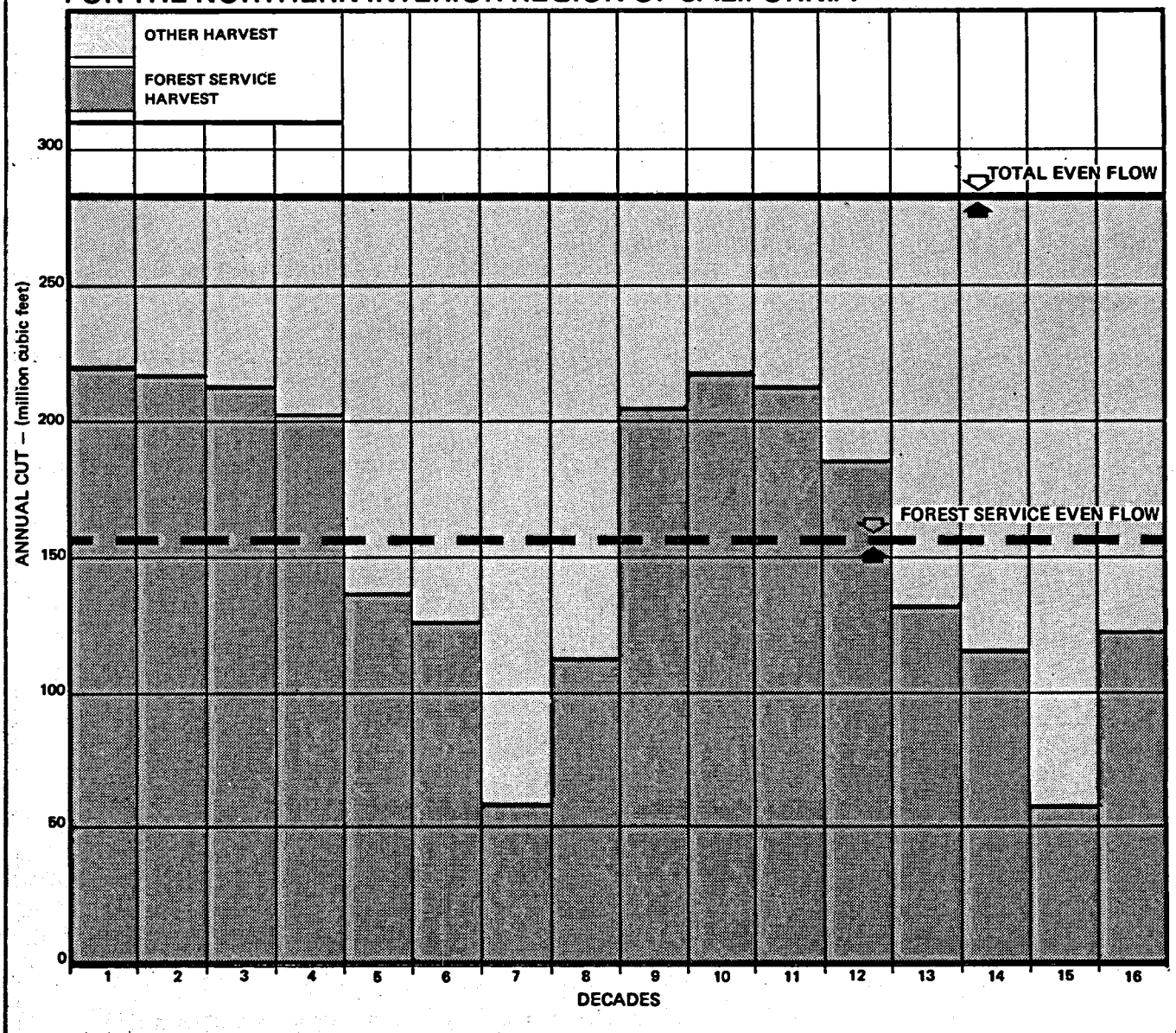
  The timber supply for future generations would be adequately protected because if, during the first decade private cuts were not adequately controlled, the public cut could be revised before old-growth reserves were seriously impaired.

FIGURE A-1 Projected Harvest in the Northern Interior Region with Coordination of Public and Private Harvest Scheduling, and with Uncoordinated Timber Harvest Scheduling (split into Forest Service and Other Harvest).



SOURCE: CDF

PROJECTED FOREST SERVICE AND OTHER HARVEST FOR THE NORTHERN INTERIOR REGION OF CALIFORNIA



SOURCE: CDF

ISSUE: PUBLIC POLICY

Institutions, represented most prominently by laws and regulatory agencies, are one of society's mechanisms created to cope with competing pressures for products from finite resources.

As we examine institutions concerned with forest lands, certain questions suggest themselves as appropriate for arriving at policy decisions. These rhetorical questions are presented as the sorts of items the Board of Forestry may wish to address as it develops recommendations from this Report. The remainder of this issue presents further information about problems, trends, options, etc., related to our public institutions. Such information should provide insight into these questions:

1) Are existing State laws and regulations related to forest resources consistent with one another, as they affect the management and conservation of our forests?

2) Do federal statutes and regulations suggest the need for revisions in State laws to eliminate conflicts, fill voids, or otherwise enhance wise use of our forests?

3) Is better information needed for the development and implementation of sound forest policy?

4) Are public budget processes compatible with long-range resource investments?

5) Should efforts be undertaken to increase the coordination of private and public, and State and federal resource planning and management?

*Status

- The thrust of California's forest policy is basically aimed toward stewardship of the State's forest resource base.

- Information and understanding of wildland resources systems lags behind the need for more detailed policies to implement this thrust. FRAP was created in response to this situation as an institution which would attempt to better define options on forestry-related issues and to give policy makers the best available information for choosing between options.

- The resources provided by California's forests come from a variety of intermingled ownerships, each having different management objectives and practices. There is little incentive for coordination of land use decisions between ownerships.

- Federal statutes to some extent preempt State law. Examples are the Clean Air Act and Federal Water Pollution Control Act. Both of these give the Environmental Protection Agency final approval authority over State programs in air and water quality as they affect forest lands. Other federal statutes may actually

preclude effective coordination of federal and private managements; for example, see the issue on FOREST SERVICE HARVESTING POLICY.

*Trends

- Most early State legislation and policies related to forestry focused on protection or preservation of the various resources. With the exception of park development, State programs for investment in forest resources have only seriously evolved in the past decade.

- Research in forestry-related matters has never been a high priority and, in fact, has declined about 25 percent since the late 1960's. This decline in research is counter to trends in population, economic growth, expenditures in other areas of research, and increasing pressure on the State's forest resources.

- An encouraging trend has been the establishment since 1975 of RPA, RCA, and FRAP. Taken together these institutions provide for the first time an informational and analytical base for developing improved forest policy coordination between responsible federal and State agencies.

*Problems

- A frequently heard complaint is that the State's regulatory system on private forest land discourages private investment. FRAP has not yet examined this question but there is the potential for overlapping authority and permit-power affecting private forest resources. The present system may be more cumbersome than is necessary, or it may require meeting certain resource standards that have been developed without appropriate reference to their effects on investment incentives for timber growing.

- Various land uses conflict with each other. Independent agencies are often created to deal with a single use or problem. They are usually not charged to consider tradeoffs inherent to their decisions. The resulting conflicts may severly affect resource management programs.

- Because of the cost, long time delays for investment returns, and lack of a clear stewardship responsibility, the positive actions needed to stabilize soil and restore fisheries are not likely to be undertaken by private enterprise. If these investments occur, the scarce forest land base would be better utilized. Perhaps only the State has the financial resources, and long-range perspective necessary to undertake these kinds of programs.

- Due to deficient coordination of authorizing legislation and other factors, assessments of natural resources are not being done in ways that permit full analyses of the interactions of resource supplies and demands among federal, State, and private lands. The federal RCA and RPA cover different lands than FRAP is authorized to consider.

- Annual budget priorities are basically directed at shortrun financial concerns. An example of this at the federal level is the funding of reforestation

on national forest non-stocked lands by annual appropriations. State programs to rehabilitate private forest resources are also usually too limited in funding, long-term commitment, and comprehensive scope.

- Forest resources and problems are not confined by ownership and other boundaries. Forest resource planning and programs on federal, State, and private lands are not integrated. Management efficiency could be improved by coordination. For example:

  Summer range for deer is largely publicly owned while much of the winter range is on private lands. Uncoordinated deer management programs produce lower yields of animals than coordinated ones.

  Public and private timber lands can supplement each other in providing raw material for timber dependent economies. But there are few institutions and very little planning to take advantage of these potentials.

- Because forest resource decisions often involve conflicting values, forest policy choices can be controversial. The role of the public in influencing these decisions is consequently important. Greater efforts have been made to involve the public but three basic institutional questions arise: 1) how best procedurally to provide the opportunity for public input and obtain a high level of participation; 2) how to evaluate the results of such inputs; and 3) how do these efforts relate to our traditional local, State, federal political systems?

*Options

- Forest policy makers must understand the long-run nature of public investment in the State's forest resources. A strong statement of the need to invest in renewable resources is contained in the administration's "Prospectus for the Future: Renewable Resources Investment Fund." The premise is that investments in reforestation, salmon rehabilitation, and soil stabilization programs are an appropriate function of government. These investments are a means to increase the productivity of California's renewable resources.

- An adequately funded, well directed program of research could provide badly needed understanding of limits to the use of forest resources, and in the long run be the most cost effective instrument for improving forest conditions in California.

- Forms of encouragement for private investment to improve forest productivity that could be considered include additional financial incentives, increased public information and education, pilot projects showing compatible use potentials, reduced regulatory structures where possible, and cooperative forestry programs.

- To facilitate assessment coordination, State and federal resources agencies might assume the leadership through an interagency cooperative agreement which would address areas of mutual interest and responsibility for resource inven-

tories. Cooperative efforts should address the basic problems of type and scope of information needed, definitions, classification systems, units of measures, minimum statistical standards, conversion factors, storage and retrieval systems, etc.

- If FRAPA were amended to assess resources on all California wildlands, decision makers could benefit by the much greater compatibility between State and federal assessments. Another advantage would be that cooperative inventory work would be much more feasible.

MEEDER

CHAPTER ONE

INTRODUCTION TO THE FOREST RESOURCES ASSESSMENT PROGRAM

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RESOURCE DATA BASE 64

INTRODUCTION

California's forest lands cover almost 33 million acres of the State's 100 million acre area. They provide a wide variety of contributions to the State ranging from timber for homes to wilderness preserves for recreation; from habitat for wildlife to natural air-resource regeneration; from sources of minerals for modern technology to sources of streams and rivers, and many more. The extent of this forested area is indicated on Figure 1-1, which was prepared from data obtained by the "Classification and Assessment with Landsat of Visible Ecological Groupings" (CALVEG) project of the Forest Service. This map has been used throughout the Forest Resources Assessment Program Assessment as a base upon which other pertinent data has been overlayed.

As the population of the State grows the desire for forest land contributions expands. Data needs are also consequently increasing. Planners in all disciplines must have access to data which are as accurate and complete as possible, and as current as can be obtained through the use of traditional and modern technological research tools. Vital deficiencies in existing information should be identified and methods devised for filling them.

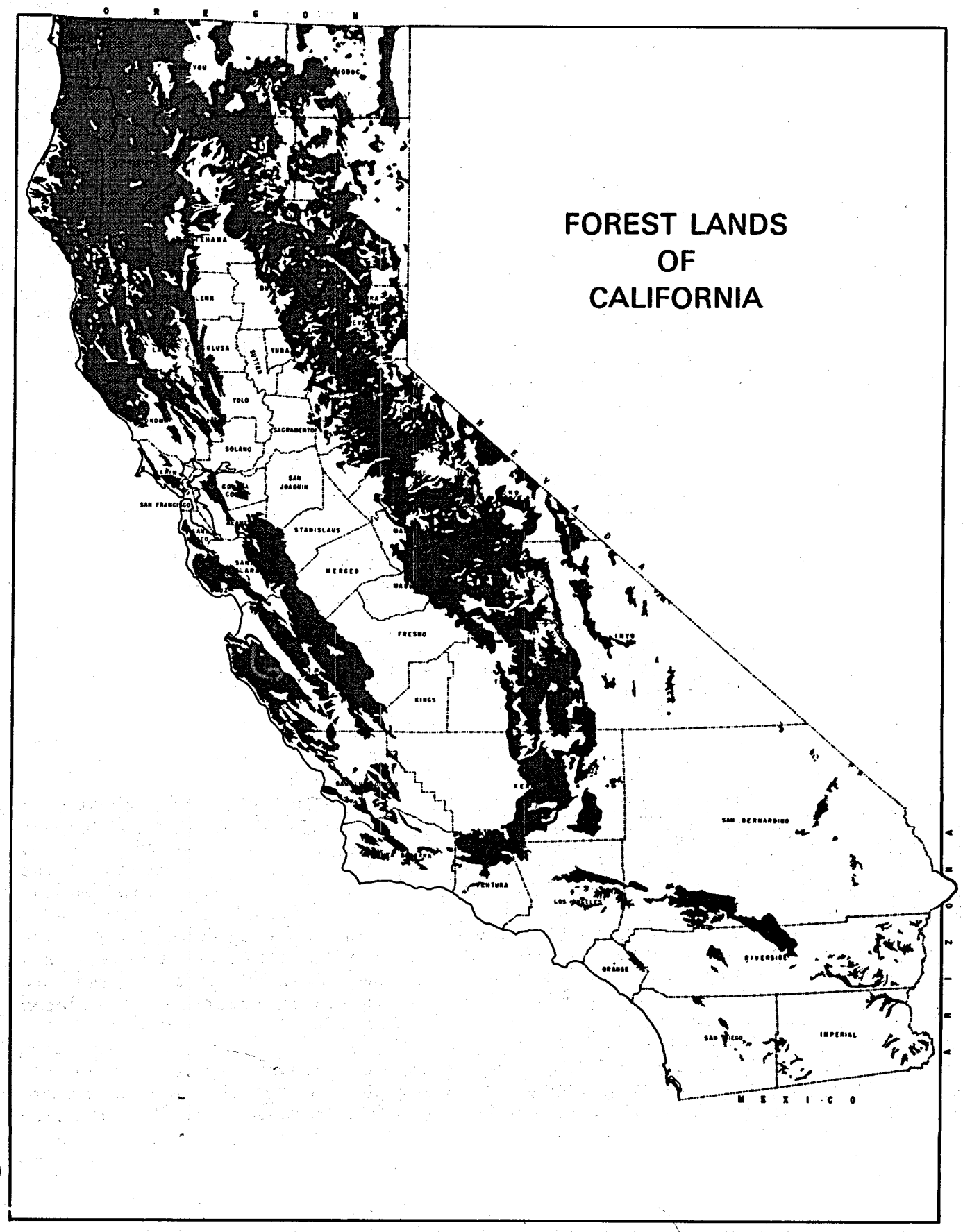
The Report is not intended as a final effort. In addition to its value for the Board of Forestry, for Resourcces Secretary, and the Legislature in developing policy and management programs for the California forest lands it will provide an evaluation of alternative program levels for the reports mandated by the federal Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) and the Soil and Water Resources Conservation Act of 1977 (RCA). The Report will also serve as a foundation for developing a forest resources inventory and analysis system as further mandated by FRAPA.

Studies done by many entities and individuals reveal that serious resource utilization conflicts are multiplying pressures on all forest lands. The existence of strippable mineral deposits and energy sources, for example, creates a land use conflict with both short- and long-term implications. In some areas, the needs of the State's population for water may become as important as those for timber, and decisions regarding such options must be made by resource planners.

Many of the critical problems associated with forest land outputs and services are local or regional in nature, yet impact the total economy of the State and the nation.

Programs and policies at federal, State, and local levels often have great impact on the present and future availability of, and use of the forest, even though they are designed and implemented as the result of non-forest pressures. It was to examine these complex factors that the Forest Resources Assessment Program (FRAP) was created. A copy of the enabling legislation, the Forest Resources Assessment and Policy Act of 1977 (FRAPA), including the amendments, is in Appendix Item I.

This preliminary Forest Resources Assessment provides a compilation of numerous sources of information about the forested lands of California and attempts to integrate them into a cohesive document. A comprehensive list of published resource material and other source notations is included in the Bibliography section of the Appendix. Many people are very surprised by the tremen-


FOREST LANDS
OF
CALIFORNIA
O R E G O N
N E V A D A
A R I Z O N A
M E X I C O
YOLO
SACRAMENTO
SOLANO
SAN JOAQUIN
STANISLAUS
MERCED
FRESNO
KINGS
SAN BERNARDINO
VENTURA
ORANGE
IMPERIAL

dous data voids associated with forest resources which are so important and visible, yet the voids exist. The Legislature has mandated this program to identify them, assess their significance, and investigate the means and feasibility of filling them. Considerable care has been exercised in preparing the material in this Report and in soliciting the cooperation of many experts for contributions and review. The authors believe the results are reasonable and represent the most comprehensive picture to date of our forest resources.

The most immediate needs are to list data deficiencies, set priorities, and analyze the degree and means of collection, storing, and processing these data. Such efforts will be undertaken following completion of this Report. Alternatives will be developed for administrative and legislative review over the next 12 to 18 months. As this Report should clearly indicate, much work will be required in this area.

FOREST RESOURCES ASSESSMENT PROGRAM UNIT FORMATION AND STAFFING

The Forest Resources Assessment Program unit was formed subsequent to March 1978 when the program manager was assigned. Staff was added as the opportunity was created. In addition to the forestry discipline the staff was developed to include the fields of soil science; remote sensing; economics; operations research; wildlife and fisheries biology; and technical writing and report preparation (see Figure 1-2).

Contracts with supplemental individuals and entities were entered into when it became necessary to provide data and services which did not exist within the State structure, in order to complete certain segments of the report.

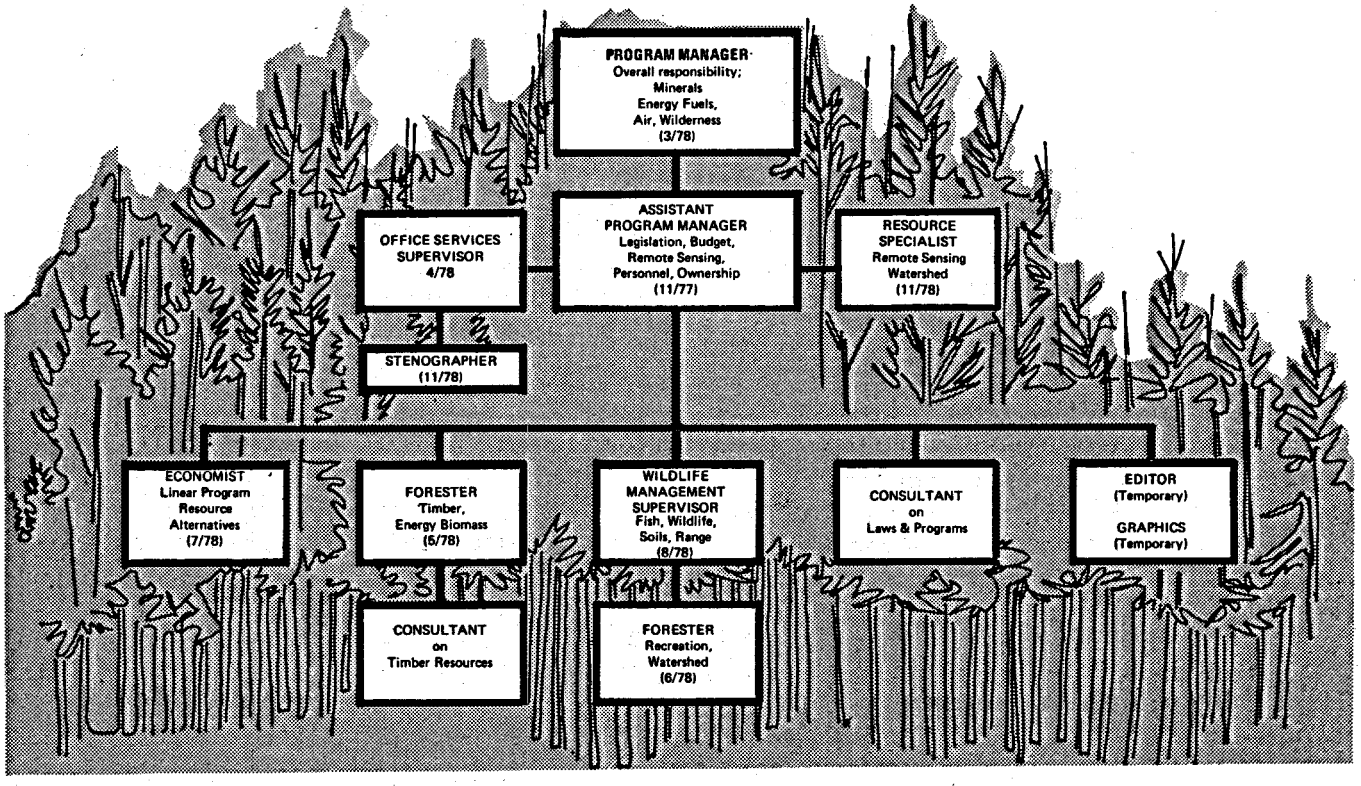
METHODOLOGY

This preliminary California Forest Resources Assessment includes the contributions of many individuals, organizations, groups and agencies which the FRAP staff contacted for information and assistance. Over half of the information presented here has been developed through accumulation of scattered information and statistics, direct conversations with knowledgeable sources in various disciplines, and staff review of prior studies. This activity has in some cases produced a discrepancy in statistics which should be recognized as an inherent problem in this assessment. The development of statistically valid estimates of the forest resources of California is one of the future goals of FRAP.

The program adopted by the FRAP unit was the result of an early recognition of time constraints and the unit staff size. The methodology used in this Assessment was adopted in response to the mandate set forth in the Forest Resources Assessment and Policy Act (FRAPA) which states:

> "In preparing the Assessment, the Director, under policy guidance of the Board, shall solicit the cooperation of and information collected by, public and private organizations, federal forest resource agencies, state agencies concerned with forest resources, county planning and taxation agencies, and state-supported forest resource research agencies."

All federal and State agencies having a major interest in and knowledge of forest land resource data were contacted in May 1978 with a questionnaire which asked for itemization of their past and



on-going studies. An example of this form is included as Appendix Item II. County planning groups and State supported research agencies were contacted on a more limited basis. Information on public forests owned and/or managed by local government entities, for example, was requested of all counties in October, 1978 (see Appendix Item V for an example of the questionnaire).

In June 1978 a public meeting was held which served as an information session on the FRAP program. The purpose of the Assessment was discussed with interested individuals and representatives of various groups. Public participation was invited and many helpful suggestions were made. In some cases approaches and directions suggested by participants at the meeting had already been incorporated in the FRAP work-plan; in others, the comments provided a fresh viewpoint which was used to prepare this preliminary Assessment, and which will be utilized in work planned for the period subsequent to July 1, 1979.

The Act suggested that certain advisory committees might be formed to assist the Director and the Board in preparing the Assessment and its revisions. On several occasions, the Board and its Chairman were apprised of the status of the Assessment and specific direction was requested by Staff. An advisory group of experts on range management was formed by representatives from seven State and federal organizations. In addition, a special advisory group on timber productivity potential was created, consisting of nine members from private enterprise and five from governmental and educational institutions.

Many resource agencies appointed a liaison person or persons to work with the FRAP unit. These people often referred FRAP staff to other technical experts within their respective fields.

The program was presented to a number of groups and their input was solicited. These organizations included, among others:

California Cattlemen's Association
California Forest Protective Association
California Soil Survey Committee
Forest Improvement Committee
National State and Private Forestry Advisory Committee
Resource Interagency Group
Society of American Foresters
Range Improvement Advisory Committee
State Forestry Committee

Evaluating data from different sources on different resources inevitably presents a problem of data grouping. For this Report FRAP elected to use a system of regional county groupings for which a considerable amount of forest resources data were already compiled. This basic regional breakdown is not necessarily the best from many perspectives: ownership, geomorphic, hydrographic, and air resource regions, etc., do not coincide with these boundaries. There is no optimal breakdown and the one used does have the advantages of tying the resource base to aggregated political units. This regional breakdown coincides with the Forest Survey (officially known as the Renewable Resource Evaluation Research Unit, Pacific Northwest Forest and Range Experiment Station, Forest Service, in Portland, Oregon) base which currently provides the majority of timber data concerning our forested lands. This regionalization is illustrated on Figure 1-3. Further analysis of resource interactions and the process of designing an inventory system may reveal a superior system for data grouping.

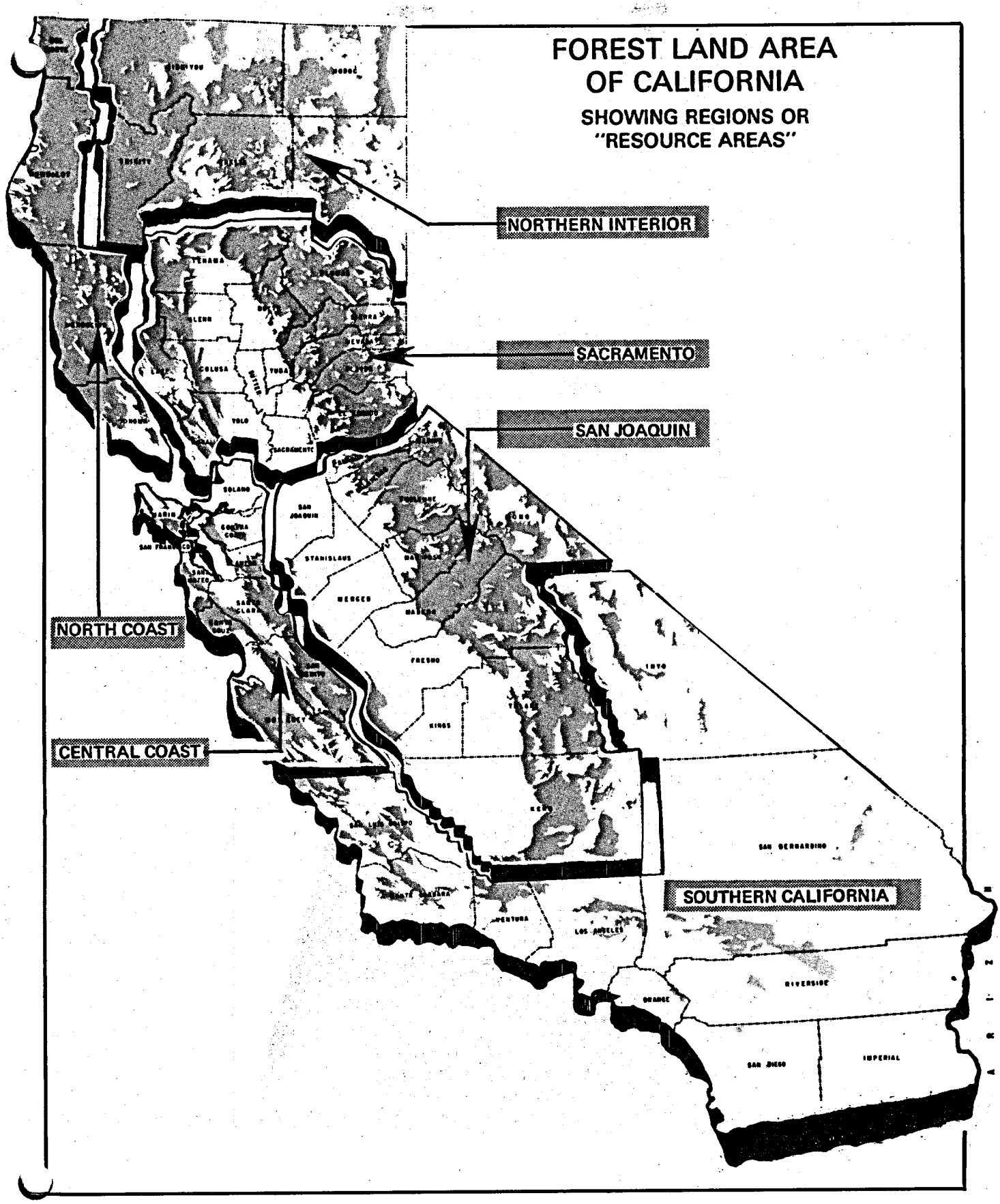
FRAP assessment needs fell especially heavily on external sources for some forest resources. For example, a timber demand study was prepared through contract with Dr. William McKillop of the University of California. This study included segments on the economic importance of the timber resource in California, consumption of forest products, supply potentials and demand schedules for lumber, plywood, and stumpage. This material has been incorporated into the chapter on timber.

Almost all of the timber resource data were derived from various reports of the Forest Survey, especially from the draft of the California Timber Survey completed in 1979 by Charles Bolsinger of the Pacific Northwest Forest and Range Experiment Station. Mr. Bolsinger helped write the Timber Resource Chapter.

William Cannon, a "multiregional specialist" with the Forest Service in Portland, Oregon, wrote Chapters Fifteen, "Important Forest Resources Legislation," and Sixteen, "State and Cooperative State/Federal Forestry Programs," and the Appendix Item XII on State and federal forest resources laws, regulations, and programs.

The forest land map used throughout this Report was based on the "Classification and Assessment with Landsat of Visible Ecological Groupings" (CALVEG) mapping effort which was completed in 1978.

Satellite imagery is being computer analyzed through a cooperative program with the National Aeronautics and Space Administration (NASA) to obtain information in a digital format on the ground cover of the State. This program is an evaluation of the applicability of satellite technology as an element of a multistage, multiresource inventory system of the State's forested land. Sixteen broad land cover classes (i.e., conifer, hardwood, brush, etc.) are being identified. Acreage summations of each class have been compiled by counties. Products are available both as digital data and in a photographic format registered to the U.S. Geological Survey 1:250,000 scale map series. Details on the CALVEG and NASA/FRAP projects are in the chapter on Remote Sensing.


FOREST LAND AREA
OF CALIFORNIA
SHOWING REGIONS OR
"RESOURCE AREAS"
NORTHERN INTERIOR
SACRAMENTO
SAN JOAQUIN
NORTH COAST
CENTRAL COAST
SOUTHERN CALIFORNIA

Another method chosen to improve understanding of the interactions of the various forest resources is the development of a linear programming model. This model is used in the Report to identify some of the resource use tradeoffs implicit in potential policy decisions.

RESOURCE DATA BASE

Data about resources are gathered and kept in many forms by a variety of organizations. The extent of such data and their availability and useability also vary greatly. Many Federal and State agencies gather resource data, and it is generally available to anyone who might wish to use it. Its useability, however, is very low since there is no coordinated approach to gathering like data. Most agencies have their own data definitions, and unilaterally determine what data elements to collect.

Many private individuals and companies also own wildlands. Some, mainly the commercial companies with large holdings, have considerable resources data. Small landowners usually do not have any formal data about their properties. Data on private landholdings are generally not made available to others.

Data about landholdings of federal and State agencies are in a variety of locations, in many different forms. Some agencies have data in digital form readily accessible in a computer. Others have data in aerial photo, map, or paper form which may not be readily accessible.

Those charged with long-range planning on a Statewide basis need access to data from this complex matrix of ownerships, geographic locations and forms of storage. Because of the complications, the only present possibility is a duplicate data gathering effort.

State government could provide a valuable coordinating role by furnishing the means to permit utilization of resources data already gathered. Government agencies could be encouraged to use common standards and data definitions. The California Environmental Data Center (EDC) indexes and provides a catalog of data held by State agencies. Perhaps the EDC could also catalog that data held by federal agencies. An attempt should be made to convince large land holding companies to provide their data to the State under the assurance of confidentiality with respect to their competitors. In other words, private sector data would only be available to the public in aggregated form.

In summary, obtaining resources data for Statewide, long term planning is a time consuming and costly process the way it must be done currently. Since this data will continue to be necessry in the future there is much opportunity through a coordinated approach led by State government, to cut costs for obtaining the data and make it more widely useable.

CHAPTER TWO

THE FOREST AREA:

A GENERAL DESCRIPTION

THE SETTING 66

TOPOGRAPHY
CLIMATE
VEGETATION

THE SETTING

TOPOGRAPHY

California is a State with a great diversity of land forms and a complex geologic history. The exposed formations range from the ancient pre-Cambrian to contemporary Cenozoic periods (Lantis 1973). The forested area lies almost completely within six of the 11 basic land form provinces used by the California Division of Mines and Geology. Characteristic rock types and geologic structures of these land form divisions are shown in Table 2-1 and illustrated on Figure 2-1, "California Land form Provinces."

The Sierra Nevada Range occupies about one-fifth of the total land area of California and is the largest forested land form of the State. It varies from 40 to 80 miles in width and extends some 400 miles in a northwest-southeast direction. Its structure is that of a block, raised sharply at the faultline on its east side, and eroded to moderate and low relief on the western slope. The block is dissected by a dozen major rivers, many occupying deep canyons or valleys, and there is widespread evidence of glaciation. As indicated in Table 2-1, the main part of the block is an exposed granite batholith. Slopes range from moderate on some ridgetops and glacial moraines, to steep and very steep on canyon walls, mountain side slopes, and upper glaciated slopes. Elevations range between 1,500 feet at the front of the western slope to 14,000 feet at the peaks on the eastern margin.

The Cascade Range is of recent volcanic origin with numerous volcanic peaks and lava flows of variable age and degree of erosion. Slopes are moderate to steep on the main mountain areas with very steep slopes existing on some of the volcanic peaks and canyon walls. Elevations vary from 1,000 to 14,000 feet.

The Modoc Plateau is also of volcanic origin and represents an extension into northeastern California of the Columbia Lava Plateau. It has an undulating surface with an average elevation of about 4,500 feet on top of which a number of hilly and mountainous areas are superimposed (Durrenberger 1967).

The Klamath Mountain Province is an old land mass consisting of modified sedimentary and igneous rock which has been uplifted, folded, faulted, and eroded a number of times. Elevations reach 8,000 to 9,000 feet, slopes are moderate to very steep, and gravitational movement such as colluvium and landslide is common. The Klamath and the Trinity, the principal rivers, have cut deep, twisting gorges through the mountains.

The California Coast Ranges are lower and younger than the Klamath mountains. Moderate to steep slopes are common and landslides occur frequently. These ranges represent a series of fault block mountains, some tilted, others folded or arched and some nearly flat due to erosion (Durrenberger 1967). Their numerous, often indistinct ridges, rise from 2,000 to 7,000 feet and are separated by the valleys of the Eel, Mad, Russian and Salinas Rivers as well as by those of smaller streams. These ranges are markedly linear and extend nearly 600 miles along the California coast (Framework Study 1971, Appendix II).

The only major east-west trending mountain system in the forested area of California is included in the Transverse Ranges, a complex set of fold-fault

TABLE 2-1

LAND FORMS AND GEOLOGIC STRUCTURES OF THE FORESTED LANDS OF CALIFORNIA		
LAND FORM DIVISION	MAJOR LITHIC TYPE	GENERAL STRUCTURE
Modoc Plateau	Volcanic	Lava flows as fault blocks
Cascade Range	Volcanic	Igneous tableland capped by volcanoes
Sierra Nevada	Granitic-metamorphic	Tilted fault block
Klamath Mountains	Granitic-metamorphic-sedimentary	Folds-faults
Coast Ranges	Sedimentary	Folds-faults
Transverse Ranges	Sedimentary (western),	Folds-faults (western)
	Granitic-metamorphic (eastern)	Fault blocks (eastern)

Note: Refer to Figure 2-1 for locations of these provinces.

Taken from California: Land of Contrast by Lantis, 1973.

mountains and valleys in southern California. These contain a variety of rock types and are characterized by a wide variation in elevation with some peaks exceeding 11,000 feet.

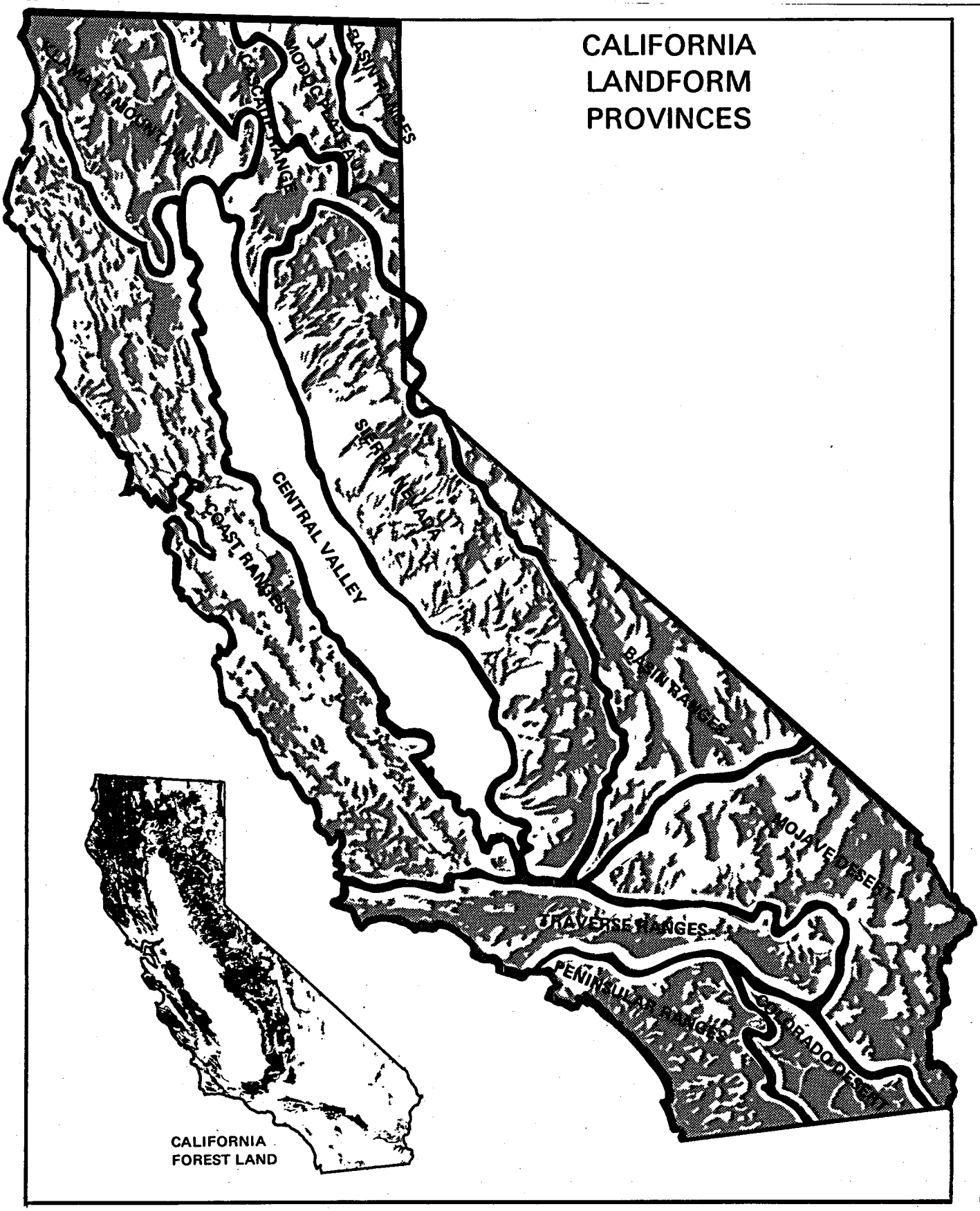
CLIMATE

Much of California's forest land lies in areas with only two distinct seasons instead of the usual four. Wet winters alternate with relatively dry, warm summers.

Although the change in latitude is great, latitude does not exert as much influence on climate in California as elsewhere. Topography is of greater importance, causing isotherms to follow topographic contours and move in a north-south direction, rather than the usual east-west direction. Because of the abrupt changes in topography, the range in temperature, wind velocities and amount of precipitation can vary greatly, often within a few miles. The Sierra Nevada and Cascade Ranges effectively block the movement of continental and arctic air masses from the east (California Yearbook 1975).

The Pacific Ocean and the movement of the Pacific high pressure areas also affect the climate. The ocean's influence makes summer and winter temperatures along the coast and nearby foothills more equable. The Pacific highs stationed offshore move southward in the

FIGURE 2-1


CALIFORNIA
LANDFORM
PROVINCES
MODOC PLATEAU
BASIN RANGES
CASCADE RANGE
SIERRA NEVADA
CENTRAL VALLEY
COAST RANGES
BASIN RANGES
MOJAVE DESERT
TRAVERSE RANGES
PENINSULAR RANGES
COLORADO DESERT
CALIFORNIA
FOREST LAND

winter; cold Canadian air and winter storms can then enter northern California. In the summer, the highs move northward, deflecting the cool air masses from Canada to the north of California.

Winter storms from the west bring precipitation which falls as rain at lower elevations and is deposited as snow in the mountains. The mean annual precipitation is shown on Figure 2-2. The amount of precipitation increases from south to north and is heaviest on the west side of the mountains up to about the 6,000 foot elevation. When the snowpack melts in the spring, the runoff is heaviest in streams on the west side of the mountains. In the southernmost portion, heavy rains in early fall are the result of cyclonic storms occurring to the southeast.

Figure 2-3 shows the various climatic zones within California. Most of California's inhabitants live in the zones classified as Mediterranean where winters are mild and wet and summers are warm and dry (Framework Study 1971).

The California coast has a marine or Mediterranean type climate with warm winters, cool summers, little daily and/or seasonal temperature range, and a high relative humidity. Inland, as the marine influence lessens, the climate becomes more Continental with warmer summers, colder winters, greater variation in daily and seasonal temperatures, and lower humidity. The change from Mediterranean to Continental climates is determined by the topography, with the Sierra Nevada and Cascade Ranges having primarily a Continental climate.

Topography also controls the amounts and distribution of winter precipitation. In large portions of the windward slopes of the Cascade-Sierra Nevada and northern Coast Ranges mean annual precipitation is 50 inches or more. Mean annual precipitation, as shown on Figure 2-2, ranges from 120 inches in the Coast Ranges to less than five inches in the southern Great Basin Ranges. Most of the precipitation falls during the winter season which is five months (November to March) in the southern part and seven months (October to April) in the northern part of California's forest area.

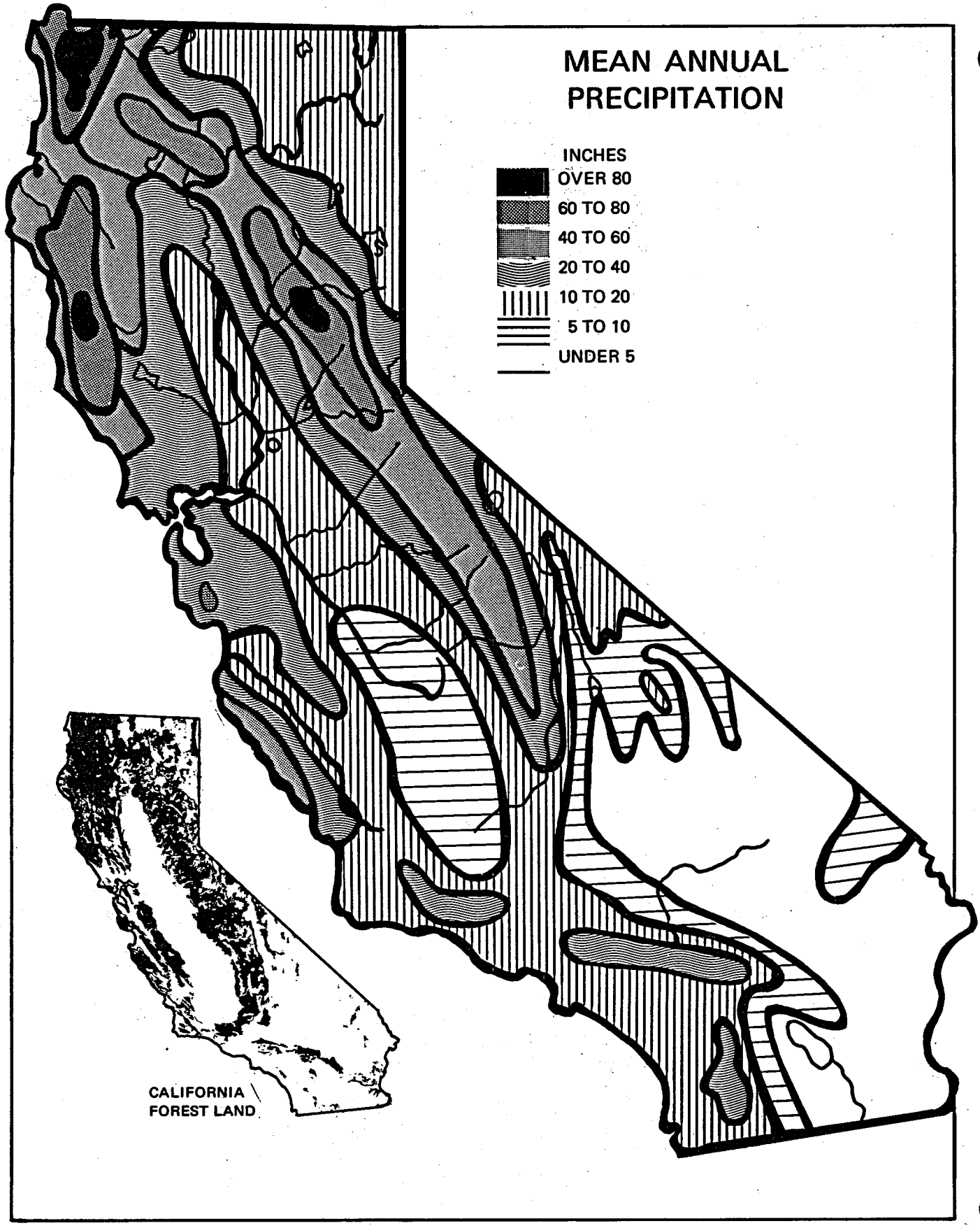
Snow in moderate amounts falls in the Sierra to elevations as low as 2,000 feet, but does not remain long below 4,000 feet. In the central Sierra, the zone of heavy snowfall is at 7,000 to 8,000 feet elevation. Snowfall at Tamarack in Alpine County is about 450 inches annually, which, according to the 1975 edition of the California Yearbook, is one of the heaviest snow falls in the United States.

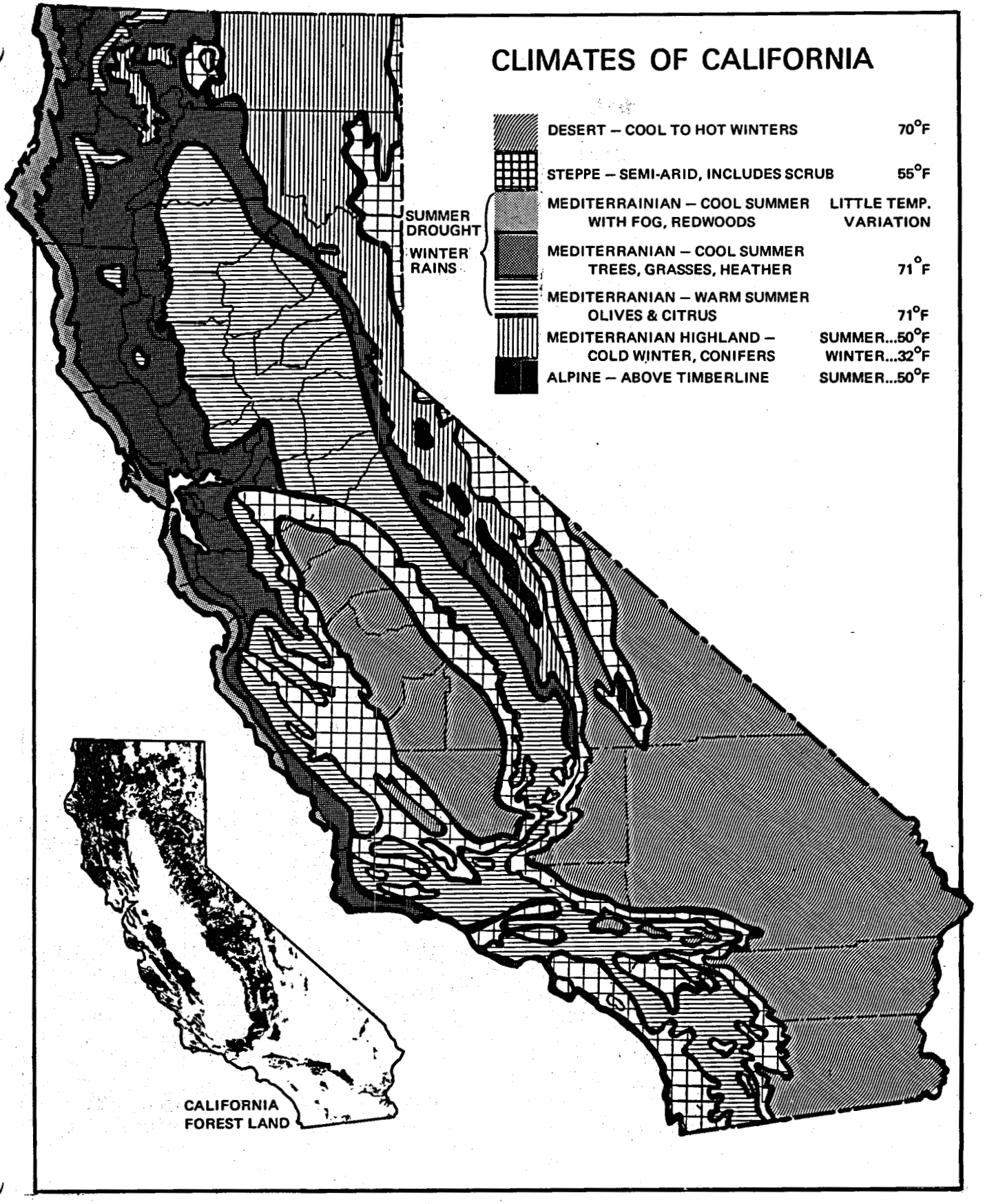
Thunderstorms occur in summer in the interior mountains. Where precipitation is very light, lightning can start destructive forest fires. Thunderstorms on the coast are weaker and infrequent and can occur in any month. Although flooding can occur at any time of the year, the worst floods usually occur in winter as a result of prolonged rain storms accompanied by high temperatures which melt the snowpack. Erosion and mudslides are prevelent following wild fires. Occasionally, persistent dry weather or drought occurs during the winter season.

Temperatures in the forested areas vary from 120° in the Sierra Nevada foothills to -45°F in the High Sierra. Along the coast, the variation in temperature from day to night and from winter to summer is very small. Daily and seasonal ranges in temperature increase with distance from the coast.

Winds from the northwest prevail along the coast, due largely to the presence of semipermanent offshore Pacific highs. Elsewhere, surface winds are influenced by local topography, mountain barriers, atmospheric pressure gradients, and proximity to the ocean. Warm Santa Ana

FIGURE 2-2


MEAN ANNUAL
PRECIPITATION
INCHES
OVER 80
60 TO 80
40 TO 60
20 TO 40
10 TO 20
5 TO 10
UNDER 5
CALIFORNIA
FOREST LAND


CLIMATES OF CALIFORNIA
DESERT – COOL TO HOT WINTERS 70°F
STEPPE – SEMI-ARID, INCLUDES SCRUB 55°F
MEDITERRAINIAN – COOL SUMMER WITH FOG, REDWOODS LITTLE TEMP. VARIATION
MEDITERRANIAN – COOL SUMMER TREES, GRASSES, HEATHER 71°F
MEDITERRANIAN – WARM SUMMER OLIVES & CITRUS 71°F
MEDITERRANIAN HIGHLAND – COLD WINTER, CONIFERS SUMMER...50°F WINTER...32°F
ALPINE – ABOVE TIMBERLINE SUMMER...50°F
SUMMER DROUGHT
WINTER RAINS
CALIFORNIA FOREST LAND

winds off the desert have contributed to the wild fire damage on the South Coast.

VEGETATION

California's diversified geography and climate create a number of unique vegetation zones. The forest vegetation resource here is among the most varied in the world.

The vegetation has been classified into many different systems. A.W. Kuchler (1977) has mapped natural vegetation of California which is either actual or potential depending on whether the natural vegetation has been modified by human activities.

The Forest Service has classified California's actual vegetation using a system based on visual interpretation of satellite imagery (CALVEG 1978). This system is the source of the forest land base map used throughout this Report (Figure 1-1).

The Forest Survey has inventoried most forest lands outside national forests and compiled data for national forests in California. These data were used in this Assessment.

Forest land, as defined by the Forest Survey, is land with at least a 10 percent tree canopy cover at maturity, including land formerly having such tree cover that could be naturally or artificially reforested and not developed for non-forest purposes. The forest land of California is approximately 33 million acres or about 33 percent of the State. (The Forest Survey includes an additional 7.5 million acres of chaparral which are not included in this Assessment.)

The Forest Survey has classified forested lands into single-species forest types based on a plurality of current tree stocking. For example, a mixed-conifer stand that contains 40 percent Douglas-fir, Psuedotsuga menziesii, 35 percent ponderosa pine, Pinus ponderosa, and 25 percent white fir, Abies concolor, would be classified as Douglas-fir type because this species has the majority of stocking.

The commonly termed "mixed conifer" forest, the most widespread type, is characteristic of the interior Klamath mountains and the North Coast Range, the west slopes of the Cascade Range and the uppermiddle west slopes of the Sierra Nevada from 4,000 to 7,000 feet. Ponderosa and sugar pines, Pinus lambertiana, normally dominate the south and west facing slopes, while the Douglas-fir and white fir dominate the north and east slopes, with incense cedar, Libocedrus decurrens, as a secondary component on all slopes. Hardwood associates in the North Coast include big-leaf maple, Acer macrophyllum, madrone, Arbutus menziesii and red alder, Alnus rubra. Understory shrubs include manzanita, Arctostaphylos sp. and ceanothus, Ceanothus sp.

California's second largest forest type is oak woodland. This type occupies foothills bordering the Central Valley, much of the Central Coast Ranges and portions of southern California. Oak, Quercus sp.; and other broadleaf trees such as buckeye, Aesculus california; along with digger pine, Pinus sabiniana; are the predominant plants, and the ground cover is mostly grassland having good forage value, with some shrubs.

The next largest forest type is a relatively pure one dominated by ponderosa, Jeffrey, Pinus jeffreyi, or sugar pines. It occupies a drier habitat than the mixed conifer type and usually appears more open. Pine forests occur in the Sierra Nevada between elevations of 1,000 and 8,000 feet and are widespread on the east slopes of the Cascades, on the Modoc Plateau and on the Transverse and Peninsular Ranges.

Douglas-fir dominates a large forest belt in northwestern California. It is located mostly inland from the coastal redwood zone, and extends to 6,000 feet above sea level. It often occurs in pure stands, but is sometimes mixed with true fir, Abies sp.; and western hemlock, Tsuga heterophylla and various hardwoods, such as tanoak, Lithocarpus densiflorus, mandrone and red alder. Usually the density is so great that little grazing is possible.

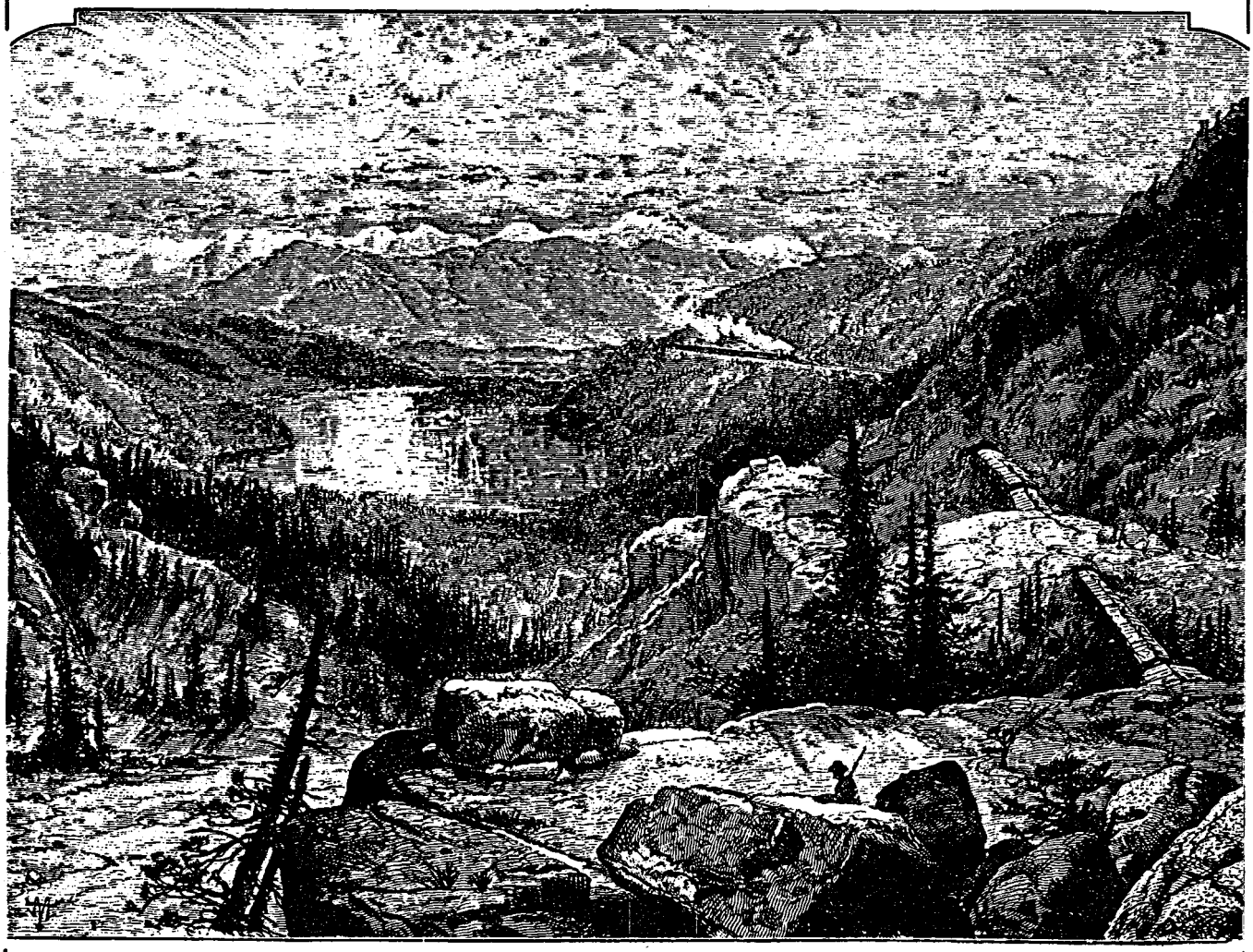
The coast redwood, Sequoia sempervirens, extends along a coastal strip from Big Sur to Oregon and as a type does not grow more than about 45 miles inland or much above an elevation of 3,000 feet. Douglas-fir, Western hemlock, Sitka spruce, and grand fir, Abies grandis are usually important associates. Pure stands of redwoods are closely confined to the alluvial flats in coastal valleys. Redwood sorrell, Oxalis oregana, and swordfern, Polysticum munitum, are typical understory herbs. There is widespread interest in this unique species, not only in the area of redwood type by standard definition, but also in the total area in which the species occurs, regardless of type. The area of forest land in California having at least one coastal redwood tree per acre, or one stump in recently logged areas, is 1.6 million acres (Bolsinger, draft, 1979).

Fir forest, mainly white fir and red fir, Abies magnifica, occur above the mixed conifer forest from 5,500 to 9,000 feet elevation in the Cascades and Sierra Nevada. Jeffrey pine, western white pine, Pinus monticola, lodgepole pine, Pinus contorta, and hemlock are often intermixed, along with a ground cover of manzanita and ceanothus.

Lodgepole pine, occurs above the fir forest, generally above 7,000 feet elevation. It grows in open or closed even-aged stands or adjacent to meadows.

The pinyon/juniper forest is most common in northeastern California and on the western slopes of the southern Great Basin Ranges. It consists of scattered stands of bushy junipers, primarily Juniperus occidentalis, and low growing pinyon pine, Pinus monophylla. The intervening ground cover includes several shrubs, such as basin sagebrush, Artemisia tridentata and bitterbrush, Purshia tridentata and a variety of grasses.

The preceding forest types as inventoried by the Forest Survey are not completely synonymous with the CALVEG classification system mentioned earlier. The CALVEG forest land base map used in this Assessment includes desert forest type trees such as Joshua tree, Yucca brevifolia, palm, Washingtonis filifera, paloverde, Ceridium floridum, and ironwood, Olneya tesota - species not inventoried by the Forest Survey. See Tables 3-2 and 3-3 in Chapter Three for a breakdown of forest types by ownership.



CLASSIFICATION OF THE FOREST LANDS

INTRODUCTION 76

FOREST AREA BY REGION 76

OWNERSHIP 76

SITE 78

TENURE AND ADMINISTRATION 79

PUBLIC

Multiple-Use Public Lands
Wilderness
Research Natural Area
Other Federal Agencies
Bureau of Indian Affairs
State

PUBLIC/PRIVATE

Wild and Scenic Rivers
California Coastal Zone

PRIVATE

CHANGES IN FOREST AREA 82

PRIME RANGELAND AND PRIME TIMBERLAND 82

PRIME RANGELAND
PRIME TIMBERLAND

INTRODUCTION

The forest area may be separated into many different sorts of categories. For purposes of mathematical modeling and for much of the discussion in the remainder of this Report a different and somewhat finer breakdown is needed than the forest type description found in Chapter Two, "The Forest Area: A General Description." Table 3-1 shows the breakdown of forest land area and the categories used by FRAP. The following discussion summarizes the entries presented. Aggregates of counties shown on Figure 1-3 define the regions or "Resource Areas," used in the table.

FOREST AREA BY REGION

Totaling by region the areas shown on Table 3-1 produces the following tabulation (in thousands of acres):

North Coast (NC)	4,463
Northern Interior (NI)	9,290
Sacramento (SM)	6,598
San Joaquin (SJ)	7,275
Southern California (SC)	3,144
Central Coast (CC)	1,788
	32,558

OWNERSHIP

Ownership as shown in Table 3-1 includes two private categories. "Forest Industry" (FI) as used by FRAP includes companies which manage their lands with an objective of producing timber or wood products. (See the Glossary for the distinction between this and the Forest Survey definition.) The remaining private forest lands are termed: "Other Private" (OP).

"Public Reserved" (PR) identifies the category of lands set aside by statute, ordinance, or administrative order for parks and other specific uses, but does not include wilderness. Timber utilization is minimal or restricted. "Reserved and Wild" (RW) lands are those which could be wilderness because they are generally unroaded or otherwise of such "unspoiled" character. This category includes all forested lands currently in wilderness as well as those now being or recently considered for such classification (RARE II). The category is included not to suggest wilderness adoption but to provide a capability for modeling the effects of changing the area of wilderness. "Public Unreserved" (PU) includes other lands administered by various government agencies. The final category, "Unknown", (XX), includes land of the North Coast and the land outside national forests in the Southern California region--these would be mostly "other private" but probably also include some public lands.

Totaling the areas in Table 3-1 by these ownership categories produces the following tabulation (in thousands of acres):

REGION	OWNERSHIP					
	FI	OP	PU	PR	RW	XX
NC	1180	1599	588	132	318	646
NI	1551	2081	4175	141	1342	
SM	1067	2313	2638	4	576	
SJ	236	1929	2461	179	2470	
SC		39	23	4	801	2277
CC		1156	276	2	354	
	4034	9117	10161	462	5861	2923

ESTIMATED FOREST LAND AREAS IN THOUSANDS OF ACRES BY REGION, OWNER AND SITE

SITE CLASS = TIMBER SITE + FORAGE SITE + RECREATION SITE

REGIONS

NC=North Coast Counties
NI=Northern Interior Counties
SM=Sacramento Counties
SJ=San Joaquin Counties
SC=Southern Calif. Counties
CC=Central Coast Counties

OWNERS

FI=Forest Industry
OP=Other Private
PU=Public Unreserved
PR=Public Reserved
RW=Reserved & Wild
XX=Unknown

SITES

TIMBER

1-3 = >120 ft^3/ac/yr
4 = 85-119 ft^3/ac/yr
5 = 50-84 ft^3/ac/yr
6 = 20-49 ft^3/ac/yr
7 = < 20 ft^3/ac/yr

FORAGE

E = Best 1/3 of land for forage
O = Other forage lands

RECREATION

E = Best 1/3 of land for recreation
O = Other recreation lands

Hence: 6EO means the land has the capability of producing 20-49 ft^3/ac/yr of timber, is among the best 1/3 of forage lands, and is among the poorest 2/3 of recreation lands in the region. For the public unreserved ownership in the North Coast this area is eight thousand acres (as highlighted below).

OWNERS	SITES: 1-3 EE	1-3 EO	1-3 OE	1-3 OO	4EE	4EO	4OE	4OO	5EE	5EO	5OE	5OO	6EE	6EO	6OE	6OO	7EE	7EO	7OE	7OO
NC																				
FI	15.	22.	247.	503.	48.	104.	15.	21.	20.	37.	45.	94.	1.	3.	2.	3.	0.	0.	0.	0.
OP	8.	5.	239.	489.	66.	146.	82.	155.	41.	81.	95.	187.	1.	1.	1.	2.	0.	0.	0.	0.
PU	0.	0.	84.	178.	28.	48.	28.	58.	14.	28.	33.	69.	0.	8.	0.	8.	0.	0.	0.	0.
PR	14.	26.	30.	62.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
RW	0.	0.	0.	0.	0.	0.	0.	0.	13.	32.	32.	70.	0.	0.	0.	0.	47.	91.	11.	22.
XX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	171.	346.	43.	86.
NI																				
FI	5.	8.	107.	216.	17.	36.	108.	214.	32.	64.	142.	283.	28.	56.	65.	131.	7.	15.	6.	11.
OP	0.	1.	15.	30.	3.	6.	24.	48.	18.	37.	81.	162.	46.	93.	108.	216.	254.	509.	143.	287.
PU	1.	0.	17.	236.	17.	35.	176.	347.	81.	161.	388.	777.	46.	94.	112.	219.	331.	664.	158.	315.
PR	0.	0.	0.	0.	0.	0.	0.	0.	7.	15.	33.	65.	0.	0.	0.	0.	5.	9.	2.	5.
RW	0.	0.	0.	0.	0.	0.	0.	0.	13.	28.	207.	411.	0.	0.	0.	0.	50.	604.	9.	20.
XX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SM																				
FI	1.	2.	96.	193.	8.	16.	67.	133.	44.	88.	66.	132.	19.	38.	44.	88.	6.	11.	5.	10.
OP	1.	1.	29.	61.	3.	8.	53.	103.	33.	66.	49.	98.	17.	35.	41.	81.	270.	542.	274.	548.
PU	0.	0.	191.	382.	6.	11.	122.	244.	67.	135.	95.	191.	20.	42.	48.	96.	167.	335.	162.	324.
PR	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	1.	0.	0.	0.	0.	0.	1.	0.	1.
RW	0.	0.	0.	0.	0.	0.	0.	0.	50.	95.	72.	145.	0.	0.	0.	0.	37.	67.	37.	73.
XX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SJ																				
FI	1.	1.	49.	99.	2.	6.	14.	26.	1.	2.	6.	13.	0.	1.	5.	10.	0.	0.	0.	0.
OP	0.	1.	9.	15.	1.	1.	11.	23.	4.	7.	23.	46.	3.	6.	27.	55.	291.	583.	274.	549.
PU	5.	9.	73.	149.	11.	25.	88.	173.	29.	57.	142.	287.	17.	28.	108.	216.	158.	315.	190.	381.
PR	0.	0.	0.	0.	0.	0.	0.	0.	7.	13.	40.	79.	0.	0.	0.	0.	7.	13.	7.	13.
RW	0.	0.	0.	0.	0.	0.	0.	0.	41.	83.	248.	496.	0.	0.	0.	0.	267.	534.	267.	534.
XX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SC																				
FI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OP	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	6.	12.	7.	14.	0.	0.	0.	0.
PU	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.	0.	0.	0.	14.	0.	6.
PR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	1.	0.	1.	0.	1.
RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	22.	46.	26.	53.	2.	234.	139.	279.
XX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	220.	440.	538.	1075.
CC																				
FI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OP	1.	0.	63.	126.	3.	7.	3.	5.	0.	0.	0.	0.	1.	1.	3.	7.	125.	251.	187.	373.
PU	1.	0.	1.	4.	0.	1.	1.	0.	0.	1.	1.	0.	0.	0.	0.	0.	35.	72.	53.	106.
PR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	1.	0.	0.	0.	0.
RW	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	60.	118.	3.	7.	100.	19.	16.	31.
XX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

THIS IS A REDUCTION STAT OF A COMPUTER READOUT SHEET.

TABLE 3-1

SITE

Within each region and ownership category the forest area is further categorized into various "sites" based on the land's potential for producing timber, forage and recreation. The productivity ("site") of these lands is indicated by a number and two letters. The number indicates the timber site class. Forage productivity is shown by the first letter and the recreation potential by the second.

The potential of these lands to produce timber is evaluated in terms of cubic-foot-site-classes. The most productive lands (Sites 1-3) are capable of growing on the average, more than 120 cubic feet per acre per year. Lands capable of growing on the average less than 20 cubic feet per acre per year are considered to be in the lowest productivity class. (The break points for the other categories are shown at the top of Table 3-1.) Most of the Site 1 lands are in the North Coast region. The total acreage in each timber site class by region is (in thousands of acres):

REGION	TIMBER SITE				
	1-3	4	5	6	7
NC	1915	796	903	32	817
NI	636	1031	3005	1214	3404
SM	957	774	1428	569	2870
SJ	411	381	1624	476	4383
SC				191	2953
CC	196	20	2	202	1368
	4115	3002	6962	2684	15795

(Note: Blank spaces in this list indicate areas of less than 1,000 acres)

The productive potential of forest land for forage and recreation has not been inventoried. However, FRAP has developed a classification system for these resources which divides the acreage in each region into the best one-third and the other two-thirds in terms of the land's potential for producing forage and recreation. This classification includes breakdowns by ownership and timber site class.

The Range Productivity Advisory Group estimated the forage producing potential of the State's forested rangelands. The best third and the remaining two-thirds of each region are shown as "E" and "O" respectively on Table 3-1. The proportion of these forage categories among the various ownerships may be significantly different depending on the productive potential of the land. In general, the best forage lands correlate with the poorer timber lands.

Recreation productivity is also broken into regional best third and other two-thirds categories, also shown as "E" and "O" respectively. These categories are tied to the Parks and Recreation Inventory System (PARIS) geopieces to correlate facilities and recreation use to the best and poorest areas. (See Chapter Nine, "Forest Lands as a Recreation Resource.") An ownership breakdown is implicit in the boundaries of various geopieces but in general it has not been possible to differentiate recreation potential by ownership. The table assumes homogeneity of recreation capability by ownership category, timber site and forage site. Thus the area included in the poorest two-thirds recreation category is twice the best third acreage for each category shown. A tabulation by regions here would simply show one-third and two-thirds of the regional forest area in each category.

The data presented in Table 3-1 are in large measure based on Forest Survey estimates. Adjustments, however, have been made where it has been considered reasonable and desirable for purposes of analysis and modeling. The statistical validity that can be attached to some of

these estimates is low. If, however, the categories prove useful to policy analysts, accuracy can be improved over a period of time. The entries are best estimates which do not precisely match other published figures.

TENURE AND ADMINISTRATION

What happens to California's forest land obviously depends upon the objectives of the owners. While a few management and policy goals may predominate in each of the broad ownership categories previously described, considerable diversity also exists. This section attempts to identify some of the differences and to indicate the importance of ownership patterns.

PUBLIC

The 10.2 million acres of Public Unreserved forested lands are controlled by a number of agencies besides the Forest Service, as the following tabulation indicates (in thousands of acres):

	TIMBER SITE CLASS		TOTAL
	1-6	7	
Forest Service	6774	1949	8767
Bureau of Land Mgmt.	239	unk	239
Indian	114	unk	114
Other Federal	40	unk	40
State	79	unk	79
County and Municipal	27	unk	27
			10161

Public Reserved (and "Reserved and Wild") lands are under the jurisdiction of many of these same agencies (data shown in thousands of acres):

	TIMBER SITE CLASS		TOTAL
	1-6	7	
Forest Service	2141	2724	4821
Park Service	747	607	1354
State Parks	125		125
County and Municipal	23		23
			6323

Constraints upon the use of publicly-owned forest lands in California are the consequences of legal and administrative mandates. These laws and regulations dictate management objectives for the land-tenured agencies. At the federal level, national parks, monuments, seashores and memorials, are all under the jurisdiction of the Park Service, and have been established to meet recreation and preservation objectives.

Multiple-Use Federal Lands

The majority of federal forest land in the State is under the jurisdiction of the Forest Service and is managed to meet multiple-use objectives. Recent legislation directs the Bureau of Land Management, which controls the next largest acreage of federal land, to manage it for multiple-use also.

Wilderness

The National Wilderness Preservation System, the Wild and Scenic Rivers System, and the National Trails System incorporate some of the forested acreage controlled by the Departments of Agriculture and Interior. Those program-mandates may also constrain the uses to which such land may be put. At present 2.1 million acres of national forest land in California, about 41 percent of which is forested land, have been formally designated as wilderness.

Research Natural Area

Federal land management agencies utilize "Research Natural Area" as an administratively designated land classification. The uses of these lands are very restricted, however the forest acreage involved is not significant.

Other Federal Agencies

Federal agencies whose predominant responsibility is other than land management but which control forested lands in California include the Department of Defense (DOD) and the Bureau of Indian Affairs (BIA). Lands of these agencies are managed for forest resources if they exist in sufficient sized blocks and the management is compatible with their other objectives. The DOD controls about 3.7 million acres in California. The area of forest land adminstered by this federal agency is unknown, however, it is estimated to be several hundred thousand acres. The DOD encourages nonmilitary use of its forested lands when such use does not conflict with the primary military objective. Compatible activities include wildlife management programs and the leasing of lands suitable for grazing. About 100,000 acres of the DOD's holdings are administered by the Army Corps of Engineers for use in the development of dams, reservoirs and channels. Lands adjacent to the sites are commonly used for recreation. The Corps is at present buying more land around its projects than it has in the past to serve as a buffer zone and for recreational purposes.

Bureau of Indian Affairs

Productive forest land under the jurisdiction of the Bureau of Indian Affairs totals some 114,000 acres with about 105,000 acres under some form of timber management. Excluded from any timber operation is a 160-acre reserve of such forest land on the Hoopa Indian Reservation.

State

State agencies controlling forest land include the State Lands Commission and the Departments of Forestry, Parks and Recreation, and Transportation. Although the State Lands Commission has no land management authority, the sale of timber from its lands was authorized by the Legislature in 1969. About 35,000 acres of the Commission's 600,000 acre total are under study for timber management.

The State Park System incorporates about a million acres of land, the great majority of whch is managed for recreation. At present, the Department of Parks and Recreation manages two State wilderness areas which include some forested acreage. According to a Department of Transportation policy first established by its commission in 1917, forest land under its jurisdiction is reserved from timber harvesting. All lands under the jurisdiction of the Departments of Forestry, Fish and Game, and Parks and Recreation have been reviewed for their potential as State wilderness consistent with the 1974 Act and recommendations have been made to the Legislature. Some 3,500 acres, or five percent of the total acreage in the State forest system of the California Department of Forestry, is not forest land. All but about 900 acres (reserved) of the 68,664 acres of forest land is managed primarily to provide timber and recreation, and to provide for research and demonstration in modern forest management practices.

PUBLIC/PRIVATE

Wild and Scenic Rivers

The 1968 federal Wild and Scenic Rivers Act as amended through Public Law 94-486 (1976) provides that certain selected rivers of the Nation which possess outstanding remarkable resources and other values be maintained in a free flowing condition and that the rivers

and their immediate environments be protected. The act classifies the rivers as "Wild" which are inaccessible except by trail, free of impoundments, primitive, and unpolluted; "Scenic" which are free of impoundment and largely primitive but accessible in places by roads; and "Recreational" which are readily accessible for road and may have some development and impoundment. The federal act designates the middle fork of the Feather River as a Wild and Scenic River and portions of the American and Tuolumne Rivers are listed as potential additions to the system. The Secretary of the Interior and/or Secretary of Agriculture (depending upon amount of National Forest Lands involved) will develop management plans and recommendations for inclusion of rivers designated as potential or not designated in the Act. Boundaries included in any river system can include an average of no more than 320 acres per mile on both sides of the river and no more than 100 acres per mile of private land may be acquired. The Secretary of Interior may accept rivers designated by a State Legislature into the system.

The 1972 California Wild and Scenic Rivers Act designates portions of the Klamath, Scott, Salmon, Trinity, New River, Smith, Eel, Van Duzen, American, and other rivers which may be recommended to the Legislature by the Secretary for Resources. The State legislation also permits classification as wild, scenic, or recreational.

The Secretary determines the aforementioned class, prepares management plans (now delegated to the Department of Fish and Game) for submission to the Legislature in a hearing system format in cooperation with the counties. Resources such as lumbering and grazing will not be unreasonably limited where such uses do not conflict with public use and enjoyment of the rivers.

The Department of Fish and Game and the United States Forest Service have entered into a Memorandum of Understanding to cooperate in the preparation of management plans for wild and scenic rivers. The Department of Fish and Game prepared and the Secretary has submitted Waterway Management Plans (in 1977) to the Legislature covering the Salmon River, the Van Duzen, and the North Fork and the lower American River.

However, many objections were voiced at the legislative hearing on the Van Duzen plan so that it and the Salmon River plan have been withdrawn, to be revised, adding 11 new criteria for public input and other planning considerations.

California Coastal Zone

The California Coastal Zone extends from the Oregon to the Mexican borders, is from one-half to ten miles wide, and includes about 1.3 million acres of public and private land. The California Coastal Zone Conservation Commission together with six Regional Commissions developed the "California Coastal Plan" which was submitted to Governor Brown on December 1, 1975. The plan was designed to achieve the long term protection and the productivity of all coastal resources. The plan seeks to protect conservation and harvesting of natural resources including maintenance of the long term productivity of coastal farmlands, grazing lands, and timber lands for their long term economic value. It also would protect ocean fishing (commercial and sport) coastal estuaries, wetlands, and watersheds.

Regular Forest Practice Act and Rule provisions govern timber harvesting except in Coastal Zone "Special Treatment Areas" established by the Commission. These Special Treatment Areas, totalling 54,636 acres, were identified for their ecological fragility, recreational uses, or scenic values. The Coastal Commission and board of Forestry developed special forest practice rules for timber harvesting to give maximum protection to

these areas. These special rules, now in effect, are administered by the Department of Forestry.

PRIVATE

Two-thirds of "Forest Industry's" four million acres of forest land are located in the North Coast and North Interior regions. The 9.1 million acres owned by "Other Private" owners constitute 28 percent of California's forested lands. The number of such owners is unknown and their objectives vary from preservation to speculation and from intensive management to nonuse. Studies of forestland ownership in various subregions of the State--usually counties--have been conducted from time to time. Very little is really known about these lands. FRAP has initiated a study to compile statistics on parcel sizes and other county tax assessment variables which can be examined for correlation with ownership objectives. This study has not produced data for analysis yet.

In 1976, the concept of "Timberland Preserve Zones" (TPZ's) was created to provide special tax treatment to forest landowners. Lands designated at the local level as TPZ's are restricted to the growing and harvesting of timber and other compatible uses. They are taxed as timber producing lands. The total acreage zoned in this manner is 5.7 million acres.

Tables 3-2 and 3-3 show the major forest type groups by ownership. The mixed conifer forest is spread among several categories depending on the plurality species. Unreserved public land and all private land in the timber site categories 1 through 6 have historically been termed "Commercial" forest and are the source of all timber production in California. (This area constitutes 16.3 million acres.)

CHANGES IN FOREST AREA

The estimate of total forest area decreased from 34 million acres in 1953 to 32.6 million acres in 1975. The comparison in Table 3-4 gives a fair picture of the changes in forest land classification.

Estimated commercial forest area in California has decreased about one million acres. Documented refinement in site classification accounted for 80 percent of the net difference. In national forests, closer inspection of forest lands and 20 years of experience provided a basis for reducing the area classified as commercial forest. On lands outside national forests an improved method of estimating forest productivity was used in determining commercial forest area (MacLean and Bolsinger, 1973). Physical conversions for reservoirs, roads, residential areas, agriculture, and other nonforest uses, and wilderness and park expansion amount to an estimated 202 and 175 thousand acres respectively. National forest land deferred to wilderness study and unexplained differences were responsible for the remaining change in commercial forest area (Bolsinger, draft 1979).

The unproductive forest declined about 681 thousand acres primarily because of the clearing of oak for range development.

PRIME RANGELAND AND PRIME TIMBERLAND

The Williamson Act, was adopted primarily as a means of keeping prime agricultural land in production by the utilization of tax incentives to the landowners. It presents certain criteria

TABLE 3-2

AREA OF PRODUCTIVE FOREST LAND BY MAJOR FOREST-TYPE
AND OWNERSHIP IN CALIFORNIA, 1975
(THOUSANDS OF ACRES)

FOREST TYPE	PUBLIC RESERVED	COMMERCIAL FOREST LAND: PUBLIC UNRESERVED	COMMERCIAL FOREST LAND: FOREST INDUSTRY	COMMERCIAL FOREST LAND: OTHER PRIVATE	ALL CATEGORIES
Redwood	121	41	308	301	771
Douglas-fir	256	1,632	499	699	2,987
Ponderosa and Jeffrey pines(1)	501	3,172	368	819	4,860
True firs	555	2,604	524	623	4,306
Lodgepole pine	146	189	10	62	407
Incense cedar	(2)	(2)	199	424	623
Hardwoods	51	648	588	1,603	2,890
Nonstocked		351	111	296	758
Unclassified	15	30	180	117	340
TOTAL	1,645	8,667	2,688	4,944	17,944

Source: Forest Survey

(1) Includes sugar, knobcone, coulter, and monterey pines.

(2) Combined with ponderosa and jeffrey pines.

for quality agricultural, forest, and/or range prime land. Forested lands are a category of open space lands to which the Act also applies. As of October 31, 1976, 47 of the 58 counties, and 19 California cities were participating in the Williamson Act.

The word "prime" is often used as related to soils or the land's productive capability, and as it is used by the Williamson Act and other federal and state documents is not universally agreed to by land managers. Perhaps this is because "prime" has been difficult to define or at least is a word on which it is hard to get agreement as to definition. (A discussion of the Williamson Act is included in Chapter Fifteen, "Important Forest Resources Legislation.") What might be considered prime to one person could be considered inferior by another. The idea of substituting the term "high yield" or "most productive" has been suggested. "Prime" is a policymaker's word, not a scientific term. The public policy meaning of "prime" can easily be changed (Bohrer 1978).

TABLE 3-3

AREA OF UNPRODUCTIVE FOREST BY FOREST TYPE AND OWNERSHIP IN CALIFORNIA, 1975 (THOUSANDS OF ACRES)

FOREST TYPE	PUBLIC RESERVED	PUBLIC UNRESERVED	ALL PRIVATE	ALL OWNER-SHIPS
Redwood			5	5
Douglas-fir	19	227	29	275
Ponderosa pine	295	1,382	637	2,314
True firs	357	1,148	96	1,601
Lodgepole pine	274	179	188	641
Commercial hardwoods	7	613	699	1,319
Pinyon-Juniper	56	350	2,290	2,696
Oak woodland	84	164	5,531	5,779
TOTAL	1,092	4,063	9,475	14,630

Source: Forest Survey

Senate Bill 193, which was introduced in 1977 but did not pass, set forth as a definition of "prime" the criteria of the amount of acreage necessary to support one animal unit per year. This was set at 17 acres when the land is managed at potential. Table 3-5 contains an illustration of proposed criteria for prime rangeland.

PRIME RANGELAND

In general, the definition of highly productive rangeland will vary considerably between different users.

Three different descriptions of prime rangeland are now in use or are being considered for use in California. Generally "prime rangeland" refers to the most productive rangeland. Because of its soil, climate, topography, vegetation, water, and related attributes, it is better than other rangeland in its ability to produce forage for grazing animals without degredation of related values and environmental quality.

About 17 million acres of the most highly productive rangelands in the State fall into this category according to data developed by Darwin Briggs in 1975 for the Soil Conservation Service. A conservative estimate would be that nearly half of the prime rangeland, or seven million acres, is forested. (See Figure 3-1, "Prime Range and Timber Lands.").

TABLE 3-4

CHANGES IN THE FOREST AREA
1953-1975

COMMERICAL FOREST - TIMBER SITE 1-6

CAUSE OF CHANGE	AREA CHANGE 1953-1975 (THOUSAND ACRES)	PERCENT OF 1953 COMMERCIAL FOREST AREA
Conversion - reservoirs, roads, powerlines, residential, grazing, etc.	- 202	- 1.2
Refinement in site classification	- 812	- 4.7
Park and wilderness expansion	- 175	- 1.0
Deferred areas	- 268	- 1.5
Unexplained differences	+ 439	+ 2.5
Net change	- 1,018	- 5.9

	UNPRODUCTIVE FOREST TIMBER SITE 7	PERCENT OF 1953 UNPRODUCTIVE FOREST AREA
Grazing clearings	- 681	- 4.4
Reservoirs, roads and all other sources, including refinement in site classification and unexplained differences	- 102	- .7
Net change	- 793	- 5.1

Source: Based on Boisinger, draft, 1979.

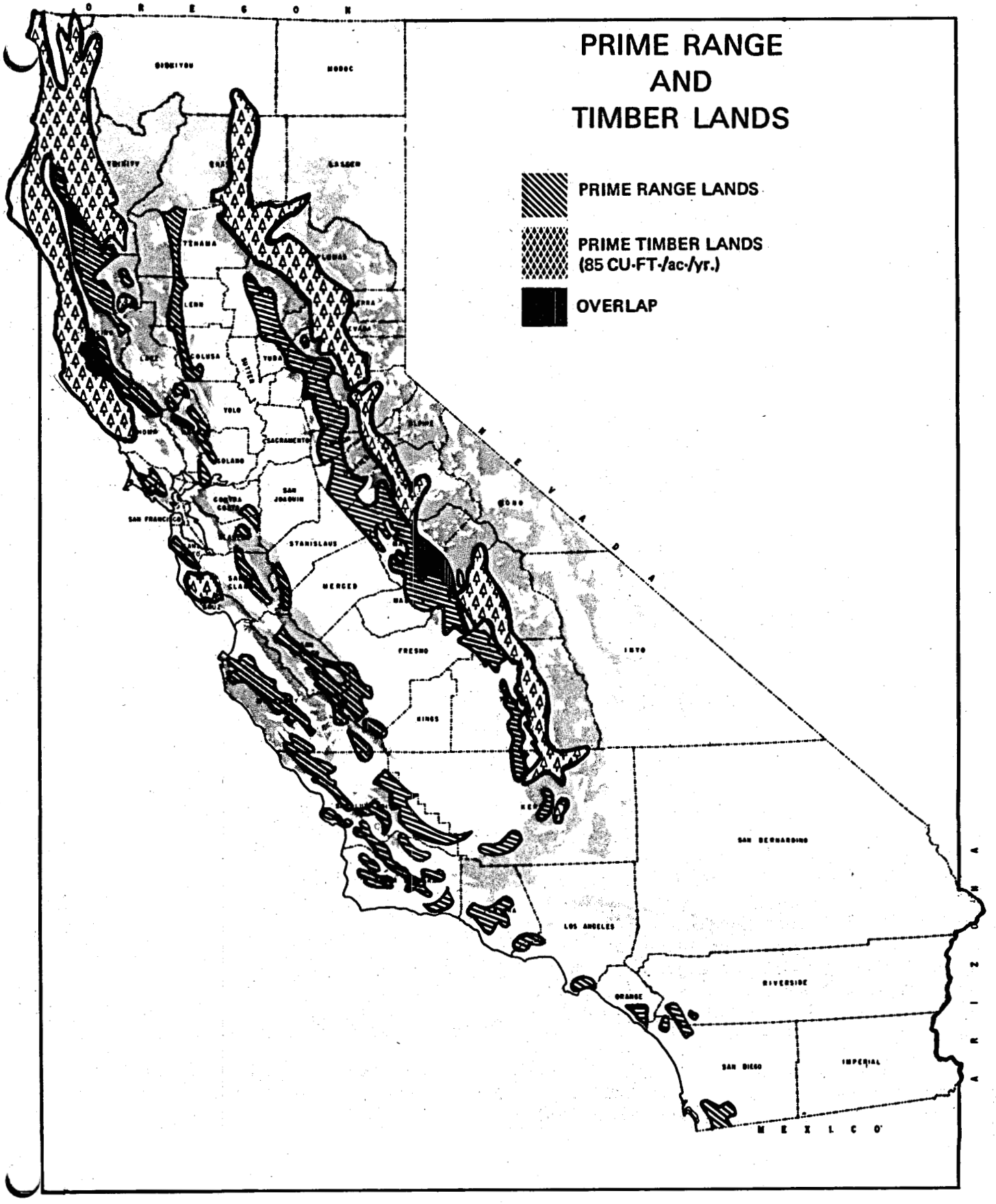
TABLE 3-5

PROPOSED CRITERIA FOR PRIME RANGELAND

CRITERIA	USDA DEFINITION* (ARE IN DRAFT FORM)	SCS STATE DEFINITION** (ARE IN DRAFT FORM)	SENATE BILL 193 (1977) (NOT PASSED IN 1978)
Soil Depth		20" or more	12" or more
Soil Texture		Fine, sandy loam to clay	Fine, sandy loam to clay
Soil Permeability		Rapid to slow	Rapid to slow
Soil-water Holding Capacity		At least 2.5"	At least 2.5"
Slope	Less than 50%	30% or less	Less than 30%
Climate		80 or more frost free days per year	80 for more frost free days per year
Precipitation		12" or more	10" or more
Productivity	Annual air-dry yield of the potential plant community in an average year at least 750/ lbs/A		17 acres to support one animal unit per year.
pH		5.5 - 8.5	
Other	Water supply of suitable quality or water that can be economically developed within two miles. Poisonous plant or plants with a toxic imbalance of minerals are not present in amounts or under conditions that severely restrict grazing.	6.0	

*Agriculture, U. S. Department of, PRIME RANGELANDS, draft version, September, 1978, p. 7. Agriculture, U. S. Department of, STATEMENT OF PRIME FARMLAND, RANGE, AND FOREST LAND, Secretary's Memorandum No. 1827, Supplement June, 1976.

**Briggs, Darwyn, Prime Agricultural Land and Rangelands, unpublished data, 1975.


PRIME RANGE
AND
TIMBER LANDS
PRIME RANGE LANDS
PRIME TIMBER LANDS
(85 CU-FT-/ac-/yr.)
OVERLAP
O R E G O N
N E V A D A
A R I Z O N A
M E X I C O
SISKIYOU
MODOC
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
LEN
LAKE
COLUSA
YUBA
BUTTE
YOLO
SACRAMENTO
SOLANO
SAN JOAQUIN
CONTRA COSTA
SAN FRANCISCO
STANISLAUS
MERCED
FRESNO
KINGS
INYO
SAN BERNARDINO
LOS ANGELES
RIVERSIDE
ORANGE
SAN DIEGO
IMPERIAL

Descriptions in current use are listed on Table 3-5, which includes the criteria suggested by the U.S. Department of Agriculture, the Soil Conservation Service, and the legislative language for Senate Bill 193.

In preparing the high yield range land portion of Figure 3-1, the Soil Conservation Service (SCS) utilized one of the three current (but not necessarily standardized) definitions of prime to delineate such range land Statewide.

PRIME TIMBERLAND

Figure 3-1, "Prime Timber and Range Lands," and Table 3-6," Prime Timber Growing Soils," were derived from Forest Service knowledge of timber growth as referenced in the SCS's unpublished Soils, Vegetation and Land Use Maps of California. Initially, 1976 SCS subregion 1:1,267,000 scale soil maps were utilized in conjunction with Forest Service determinations of soil associations generally capable of producing at least 85 cubic feet/acre/year of wood increment. Figure 3-1 is a composite of such soil associations from the SCS subregion maps, plus some additional information from the Soil-Vegetation Survey.

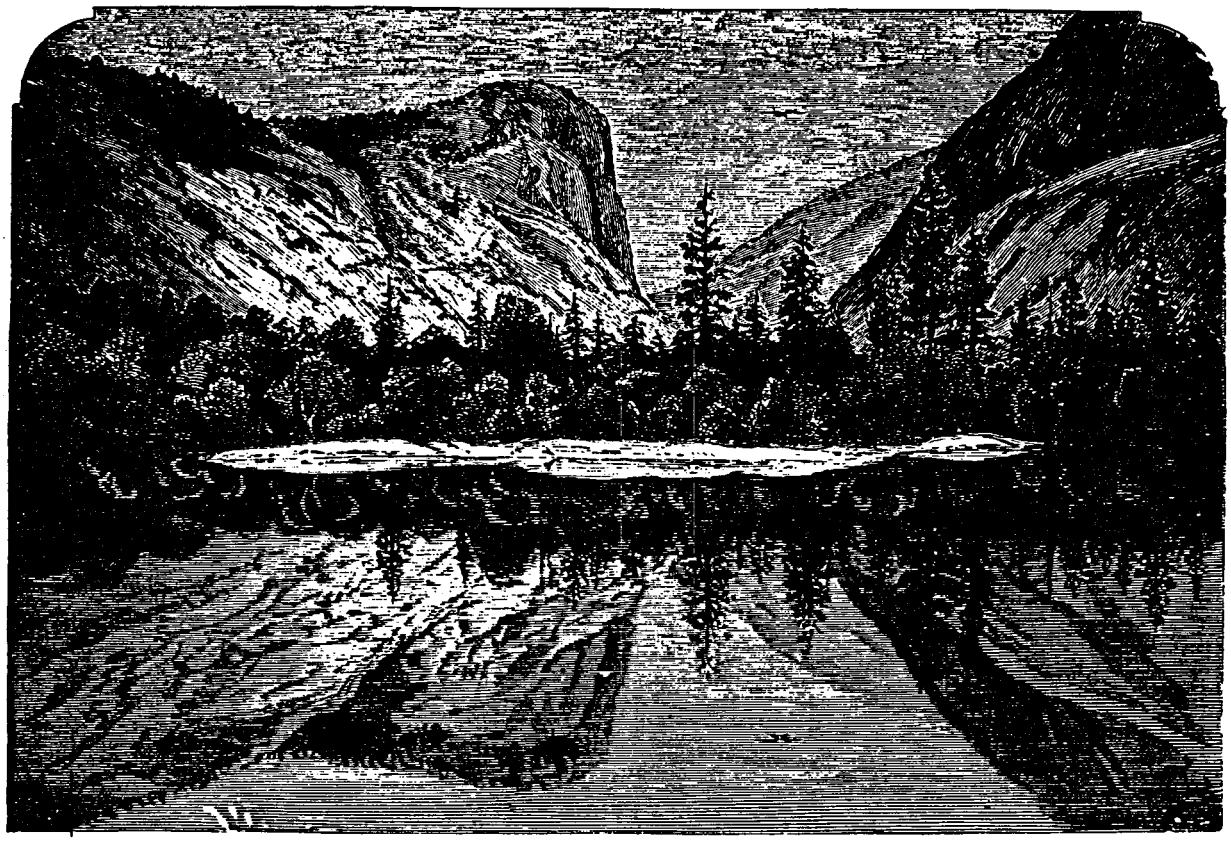
The 9.2 million acres of prime timber-producing land shown in Table 3-6 represents only 25 percent of all forest land but 56 percent of available commercial forest land in California. Available commercial forest land is defined as that which will produce at least 20 cubic feet of industrial wood per acre per year and is not legislatively preserved from cutting. Over half of this prime timber growing acreage is within the North Coast sub-region with its good tree growing soils and high precipitation rates.

TABLE 3-6

PRIME TIMBER GROWING SOILS
ACRES AND EROSION POTENTIAL

SOIL ASSOCIATION SYMBOL	SOIL SERIES	EROSION HAZARD	EROSION ACTIVITY	ACRES (000)	% of SUB-REGION ACRES	SUB-REGION % OF CALIFORNIA
NORTH COAST SUB-REGION						
FR	Ferndale Russ Timmons	None to Slight	None	128	3	
GS	Goldridge Steinbeck Empire	Moderate	Moderate	296	6	
HJ	Hugo Josephine Maymen	High	Moderate	4,303	89	
RK	Rohnerville Kneeland	Moderate	Moderate	60	1	
XT	Timmons Ferndale	Slight	Slight	40	1 1	
				4,827		
SAN JOAQUIN SUB-REGION						
CA	Cohasset-Aiken	Moderate	Moderate	47	4	
HS	Holland-Shaver-Chawanakee	High	Moderate	707	60	
MJ	Mariposa-Josephine-Sit	Moderate	Moderate	424	36	
				1,178		
T[illegible] BASIN SUB-REGION						
[illegible]S	See Above	High	Moderate	636	75	
MJ	" "	Moderate	Moderate	214	25	
				850		
SAN FRANCISCO BAY SUB-REGION						
GS	See Above	Moderate	Moderate	12	12	
HJ	" "	High	Moderate	61	62	
RK	" "	Moderate	Moderate	25	26	
				98		
NORTH LAHONTAN SUB-REGION						
CA	See Above	Moderate	Moderate	30	100	<1
SOUTH LAHONTAN SUB-REGION						
MJ	See Above	Moderate	Moderate	8	100	<1
		California Total		9,185		100%

From: Data supplied by Charles Goudey, USFS Region V, for round wood growth of at least 85 cubic feet per acre per year and from "Inventorying California's Wildland Resources" by L. T. Burcham, California Department of Forestry, 1973 - Table I-2.



THE WATERSHEDS

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THE SOIL COMPONENT 92

SOIL SURVEY STATUS
- California Department of Forestry Soil Vegetation Survey
- National Cooperative Soil Survey

FOREST SOILS
- Soil Formation and Classification Criteria
- Forest Soil Relationships
- Forest Soil Productivity

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INTRODUCTION

A watershed is commonly defined as the region draining into a river. It encompasses to varying degrees all of the other forest resources identified in FRAPA. The underlying geology forms the framework on which the watershed deveops its characteristics, including soil and drainage patterns. Soil forms the basis of the watershed for vegetative growth with the dynamic force within the watershed being the water itself. These two components, soil and water, and their interactions affect the nature of the entire watershed. For example, in dry environments, trees will often be found growing on north facing slopes and brush on south facing slopes due to the greater amount of water available on north slopes. The rich alluvial soil in drainage bottoms supporting the tallest trees in the world is created by flowing water moving and depositing soil particles. The other side to this coin is that in the forested watersheds the most common water pollutant is sediment.

This chapter discusses the basic characteristics and inventory aspects of these two components and also examines the results of the interaction between the two, such as soil erosion and the degradation of water quality. Laws and regulations governing the control of water quality are outlined.

THE SOIL COMPONENT

Soil is the aggregate of weathered minerals and decaying organic matter covering the earth in a thin layer. Man's very existence depends on good soil, while the maintenance of soil quality (and quantity) depends to a large degree on man. Population pressures, and our shrinking per capita land base, make knowledge of the characteristics and limitations of our soils mandatory for all uses of the land. Soil must be considered a nonrenewable resource because of the great time span that is required for its formation.

SOIL SURVEY STATUS

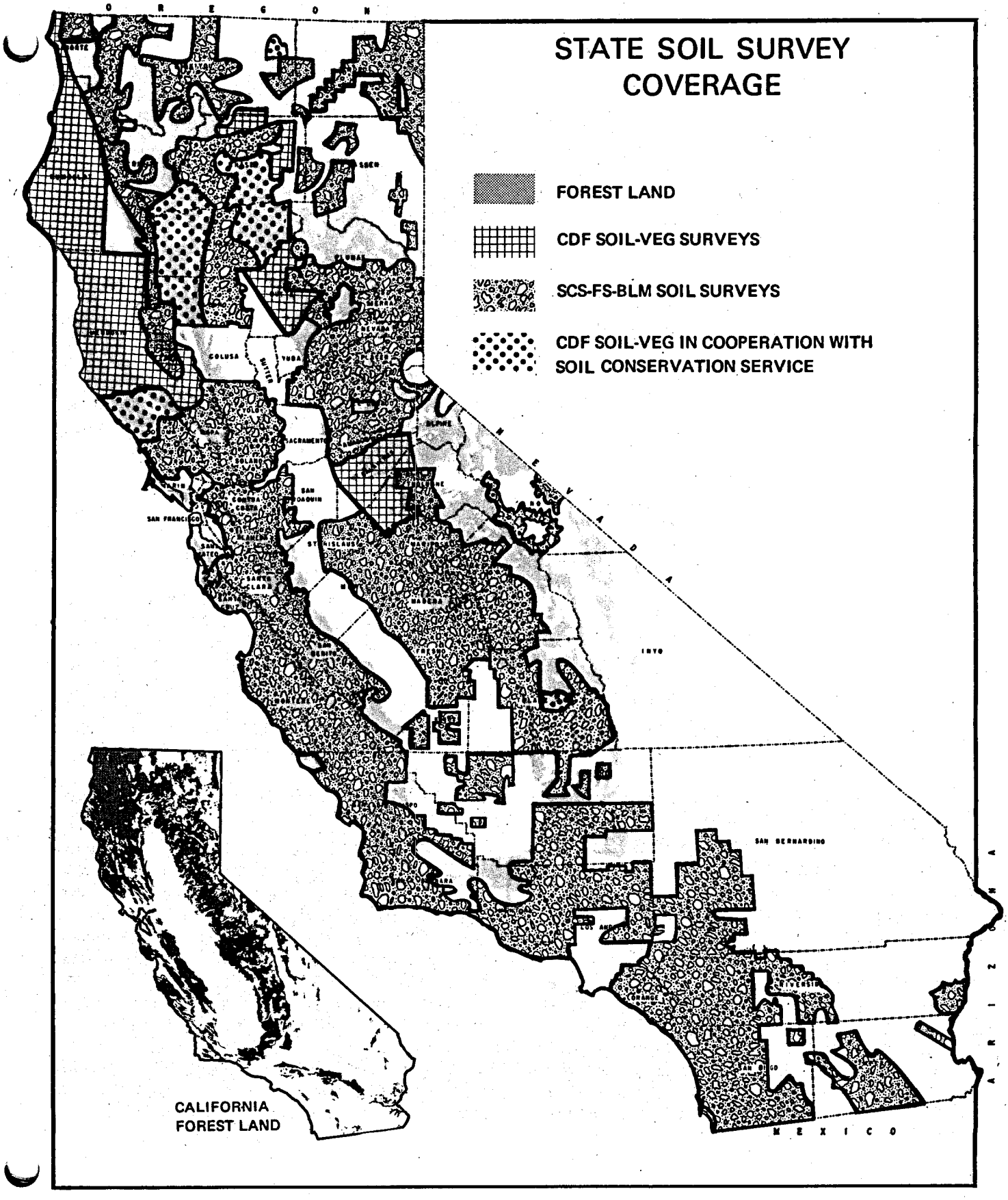
For the past thirty years, State and federal agencies have been conducting soil surveys on the forested lands of California. The Forest Service (FS), the Soil Conservation Service (SCS), and the CDF have been the three lead agencies. The areas for which soil surveys have been completed are shown on Figure 4-1.

The California Department of Forestry Soil-Vegetation Survey

When the Soil-Vegetation Survey was begun in 1947, there was no active program for mapping soils and vegetation on the forest and range areas of the State. At that time, most soil mapping was directed toward identifying lands suitable for intensive agriculture.

In that year the Board of Forestry recommended that the State Legislature appropriate money for the (then) Division of Forestry to survey the forest, range, and watershed lands in cooperation with the (then) California Forest and Range Experiment Station, now called the Pacific Southwest Forest and Range Experiment Station (PSW). Legislation was passed which authorized the Division of Forestry to participate in a cooperative survey of soils and other resources.

The Soil-Vegetation Survey as it has been and is now conducted is concerned with wild lands in private or State ownership. It is a detailed mapping of the different kinds of soils and the exist-


STATE SOIL SURVEY
COVERAGE
FOREST LAND
CDF SOIL-VEG SURVEYS
SCS-FS-BLM SOIL SURVEYS
CDF SOIL-VEG IN COOPERATION WITH
SOIL CONSERVATION SERVICE
O R E G O N
N E V A D A
A R I Z O N A
M E X I C O
SAN FRANCISCO
SACRAMENTO
SAN BERNARDINO
CALIFORNIA
FOREST LAND

ing vegetation cover. It includes information on site quality for timber, suitability for range, soil erodibility characteristics, etc. The level of the data corresponds to Order 2 within the guidelines of the National Cooperative Soil Survey (NCSS). These criteria are shown on Table 4-1 "Summary of Soil Resource Inventory Orders." Maps have been published covering approximately 8.99 million acres of surveyed lands in California (Malain 1979).

The State's Soil-Vegetation Survey was begun prior to the establishment of the national standards designated by the NCSS. NCSS standards have not been applied since, because of the lack of a cooperative agreement, the need for acreage counts, and the need for detailed descriptions of map units.

The latter two have been considered excessively costly by CDF. As a result, many of the soil series used by CDF on forested land are not recognized by the NCSS (Hartman 1978).

The National Cooperative Soil Survey

Congress and the USDA have appointed the Soil Conservation Service as the lead agency for the National Cooperative Soil Survey. This Survey is primarily concerned with obtaining a national soil classification and inventory of soils. This survey is being developed by means of a cooperative program involving federal and state agencies.

The SCS has a memorandum of understanding with the Forest Service and Bureau of Land Management, under which each agency has responsibility for mapping all lands included within their jurisdiction. The SCS has the responsibility of providing soil surveys on all nonfederal lands and is responsible for soil classification and quality control on all lands. The SCS has mapped approximately 27 million acres of agricultural, forest, and range lands in California. Much of this mapping has been in cooperation with the University of California Agricultural Experiment Station and is generally at an Order 2 level. SCS soil surveys can be used for a variety of purposes such as urban land planning, timber harvesting use, farm and ranch conservation planning. Vegetation is described as a part of the mapping unit although it is not shown on the published map sheets.

The Forest Service is responsible for conducting soil surveys on approximately 23.5 million acres of land in California. Thus far approximately 14.5 million acres have been mapped; 3.4 million at the Order 2 level and 11.4 million at the Order 3 level. (Note: Due to some overlap caused by resurveying, the figures given do not represent the total acreage mapped.)

The remaining nine million acres of unsurveyed land will be mapped at the Order 3 level. This project is scheduled for completion by 1980. Once the basic inventories are completed, future soil surveys will be conducted on specific sites to provide data for timber compartment planning purposes, range and forest improvement projects, and recreational developments. It is expected that these surveys will all be at the Order 2 level. Soil monitoring programs will also be increased to determine the effects of management practices on the soil resource.

The NCSS data is continually updated and improved through conferences at national, regional and State levels. A National Soil Survey Conference is held every other year. Regional conferences are held during alternate years. The California Soil Survey Committee (CSSC) meets quarterly to discuss rules, regulations, and standards pertinent to classifying soils. The CSSC consists of members from the Forest Service, Bureau of Land Management, Soil Conservation Service, Soil-Vegetation Survey, the universities, local agencies, and others interested in soil classification.

TABLE 4-1

SUMMARY OF SOIL RESOURCE INVENTORY ORDERS

	SCOPE AND CURRENT MAP EFFORTS	DATA SOURCE	HOW CONDUCTED	INVENTORY UNIT MAPPED	PRODUCT
ORDER 5	Exploratory	Selected areas (15 to 25 sq. mi) mapped at order 1 or 2. Projection by landscape and photo interpretation.	Office 90 percent Field 10 percent	State or Region Minimum map delineation 10,000 acres or more	Soil maps and data for very broad planning Predicting major land uses
ORDER 4	Reconnaissance	Representative soil delineations are sampled. Projection by photo interpretation and observation.	Office 70 percent Field 30 percent	Multi-forests or portions of forest. Minimum map delineation 640 to 10,000 acres	Soil maps and data for broad planning of multi-forest areas or lands with limited land use alternatives.
ORDER 3	Reconnaissance USFS National Forest Soil Survey	Soils identified in representative delineations. Projections by observations and photo interpretation.	Office 50 percent Field 50 percent	National Forest Minimum map delineation 40 to 640 acres	Soil maps and data for forest level and some compartment planning. Capabilities and limitations identified for allocation of uses and some management systems.
ORDER 2	Detailed Soil-Vegetation Survey Soil Conservation Service Mapping	Soils identified in each delineation. Projections by close observations and photo interpretation.	Office 30 percent Field 70 percent	Portions of forest Minimum map delineation 5 to 40 acres	Soil maps and data for compartment planning and some project design. Capabilities and limitations for alternative systems of management are identified.
ORDER 1	Detailed	Soils identified in each delineation. Boundaries plotted from field observations.	Office 20 percent Field 80 percent	Project areas 0.5 to 5 acres	Soil maps and data for individual project design.

Source: Watershed Resource Management Handbook, Forest Service, USDA, Region V, 1978.

FOREST SOILS

Soil Formation and Classification Criteria

Soils are classified on the basis of their natural chemical and physical properties. These include such characteristics as texture, pH, depth, stoniness, color, soil temperature, horizon development within the soil, and parent material.

The factors affecting the formation of soil are: parent material, climate, biological organisms (including vegetation), time, and topography. Due to great variation in these factors within the State, there is a wide variation in soil types. Certain soils will form on more than one parent material. At the present time, there are more than 870 individual soil series and 2,500 soil phases which have been recognized and mapped within California. Phases of soil series are an important consideration since they are normally based on slope, stoniness, erodibility, and other factors significant to man's use of management of the soil, all of which are important factors in erosion. Many more series and phases will probably be identified as detailed mapping of the wildlands progresses since there are many forested areas of the State which have never been mapped.

Forest Soil Relationships

There are approximately 168 different soil series which have been mapped on the forest lands of California alone. The ten most common or "famous" soils in each Forest Practice District are listed in Table 4-2 (Zinke 1979). The Soil-Vegetation Survey legend numbers are listed because soil series names may change, but the numbers will consistently describe the same soil. The first digit of these numbers provides information about the origin of the soil; the second gives information about the vegetation; the final digit(s) provides an identification for the series. These soils can be grouped into classes of profile development and by broad geologic group or parent material as displayed in Table 4-3. The approximate percentage of California forest soils in each profile development group is shown on Table 4-3.

The variety of environmental conditions which exist in California on forested lands make important the understanding that there is a predictable sequence of soil profile development for each parent material. The degree of development can be recognized by obvious field characteristics such as color, clay content, or stoniness and can be related to soil properties affecting forest management such as productivity, soil erosion potential, or road building capabilities. The properties of the soils in the immature soil profile development group are very similar to the parent material. As soils develop, the surface structure becomes stronger (more pronounced visually), the subsurface structure becomes weaker, and the percentage of gravel or stoniness decreases. The subsurface clay content of a soil increases with age, which decreases permeability and infiltration rates, and increases water holding capacity. The higher clay content of more mature soils of all parent materials will, for example, limit road gradients for unsurfaced roads due to decreased traction when the roads are wet (Zinke and Colwell 1965).

Knowledge about the locations and characteristics of soil series is important for the formulation of effective forest management decisions. (Soil erosion is addressed in the section on "Soil/Water Interactions.")

Forest Soil Productivity

The soil, the climate, and certain biotic factors affect the productivity of forest lands. The main soil factors which influence commercial timber (conifer) growth in California are: 1) depth and texture; 2) permeability; 3) chemical characteristics; and 4) drainage or runoff characteristics (Storie and Wieslander 1948). In the Coast Ranges, the best timber sites are on deep loam to clay loam soils at elevations of 100 to 3,000 feet, lying inland from the effects of the ocean, and with at least 40 inches annual rainfall. The best redwood sites are on the deep loamy alluvial soils along large rivers. The best Douglas fir sites are on deep Hugo and Melbourne soils on lower canyon slopes with north aspects. In the Sierra Nevada and Cascade ranges the best sites are on deep loam to clay loam soils with at least 40 inches annual rainfall, depending on latitude. In the mid-elevation zone of the timber belt, the vegetation of the best sites is a mixed commercial conifer type of ponderosa and sugar pine, and white and Douglas fir (Colwell, 1979).

The soils with moderate profile development are overall the most productive timber soils (Colwell, 1979). However, there are certain soils in the other profile development groups which are capable of producing Site I timber. Obviously, factors other than soil alone, such as seed distribution, climate, and slope, will influence timber productivity.

TABLE 4-2

THE TEN "FAMOUS" FOREST SOILS, IN ORDER OF AREA, OF EACH FOREST PRACTICE ACT DISTRICT IN CALIFORNIA

SERIES NAME	SOIL-VEGETATION SURVEY LEGEND	AREA[1]
NORTHERN DISTRICT		
Cohasset	717	223
Sheetiron	820	144
Aiken	711	77
Josephine	815	69
McCarthy	7124	67
Boomer	7118	61
Mariposa-Marpa	827-811	51
Sites	816 and 816m	50
Chalx-Chawanakee	7158-7129	47
Neuns	728	29
COASTAL DISTRICT		
Hugo	812	1,498
Josephine	815	354
Larabee	914	129
Masterson	821	121
Mendocino	915	63
Orick	813	52
Sites	816 and 816m	45
Atwell	823	34
Empire	920	34
Sheetiron	820	21
SOUTHERN DISTRICT		
Shaver	7127	
Holland	716	
Musick	7117	
Mariposa-Marpa	827-811	
Chalx-Chawanakee	7158-7129	
Boomer	7118	
Sites	816 and 816m	
Corbett	7121	
Englebright	7153	
Ahwahnee	749	

(1) Areas are in thousands of acres mapped.

Reprinted from "California Forest Soils," Division of Agricultural Sciences, University of California, April 1979.

TABLE 4-3

THE TEN "FAMOUS" FOREST SOILS ARRAYED BY RELATIVE DEGREE OF DEVELOPMENT ON MAJOR PARENT MATERIAL TYPE

PERCENT OF FOREST SOILS	DEGREE OF DEVELOPMENT	PARENT MATERIAL: ACID IGNEOUS (granites, rhyolites, diorites)	BASIC IGNEOUS (basalts, andesites)	SEDIMENTARY ROCKS: hard, well consolidated	SEDIMENTARY ROCKS: softly consolidated	METAMORPHIC ROCKS
58	IMMATURE					
	shallow, stony, or course textured, usually grayish brown to brown	Chalx-Chawanakee(7158-7129)				
		Corbett(7121)				
						Sheetiron(820)
					Larabee(914)	
		Shaver(7127)				
				Hugo(812)		
29	MODERATELY DEVELOPED			Atwell(823)		
			McCarthy(7124)			
						Mariposa-Marpa(827-811)
	deep (4 feet or more), brown to reddish brown	Holland(716)	Cohasset(717)			
					Empire(920)	Boomer(7118)
			Neuns(728)			
				Josephine(815)		Masterson(821)
13	STRONGLY DEVELOPED				Mendocino(915)	
		Englebright(7153)				
		Musick(7117)				
	deep (75 feet), reddish colors, few to zero rocks			Sites(816)		Sites(816m)
			Aiken(711)			

Source: "California Forest Soils," Division of Agricultural Sciences, University of California, April 1979.

THE WATER COMPONENT

STATEWIDE (1972) SUPPLY AND USE OF WATER

An overview of Statewide hydrologic conditions from precipitation to eventual consumption is provided in Figure 4-2. The source of information for this chart was DWR Bulletin 160-74, "The California Water Plan-Outlook in 1974."

In California, the average annual precipitation in the form of rain or snow amounts to about 200 million acre feet of water (an acre-foot of water equals approximately 326,000 gallons). 126 million acre feet are unavailable for human use as a consequence of evaporation from vegetation, ground, and water surfaces, and through transpiration which occurs in all vegetation including agricultural crops. Part of the remaining precipitation percolates into ground water aquifers and recharges ground water reservoirs. The remainder runs off to oceans or interior lakes.

Three sources other than precipitation affect the supply of water. The first is groundwater withdrawal, representing an overdraft in excess of annual replenishment. The second two contributions are from out-of-State sources: inflow from Oregon, and imports from the Colorado River.

All totaled, there are approximately 58.6 million acre feet of water that could be developed for potential use. 32.6 million acre feet of this potential are currently regulated by various federal, State and local water projects to meet the "demands" for water. When one considers decreases and/or increases in this amount due to factors such as loss during transport or increase caused by reuse, the total volume of regulated water used consumptively amounts to approximately 37.4 million acre feet. This is called the "total applied water demand."

The consumptive uses to which water is put include municipal, domestic, industrial, agricultural, power plant cooling, recreation, and fish and wildlife management. Agriculture is the predominant use accounting for about 85 percent of the applied water.

There is no quantification in Figure 4-2 of the total amounts of water which meet instream, predominantly nonconsumptive uses such as the maintenance of fish and wildlife habitat and water quality, and the generation of hydropower. There are numerous agreements between water developers and other parties (often the Department of Fish and Game) that specify conditions requiring maintenance of downstream flows. Often such requirements are made a part of water rights and other agreements.

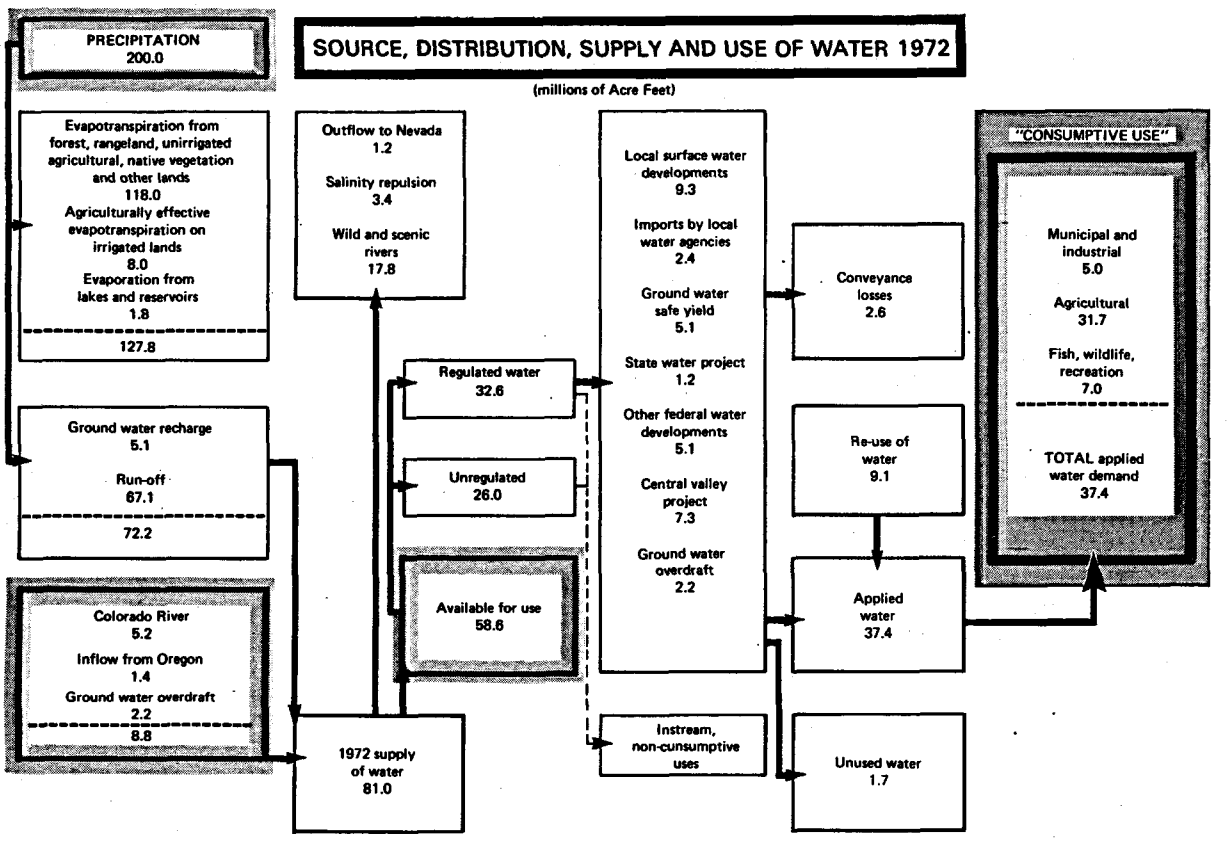
PROJECTED CONSUMPTION AND TECHNIQUES FOR INCREASING SUPPLY

According to 1974 projections of the Department of Water Resources (DWR) consumption of water in 1990 will have increased by 10 to 24 percent above the 1972 level. By 2020, it will be 15 to 49 percent higher than the 1972 level. The amount of the increase will depend on the interaction of several variables.

Reduction of evapotranspiration by the removal or conversion of vegetation, weather modification, and the capture of presently unregulated streamflow are three techniques for increasing the quantity of water available for consumptive use which are likely to occur in forested watersheds of the State. Other techniques are: importation of water, reclamation of waste water, desalinization, and adoption or expansion of conservation measures so that demand begins to decrease.

Water yield from forested areas increases as evaporation, transpiration, and interception losses are reduced

FIGURE 4-2.



ACRE FOOT = The amount of water necessary to cover 1 acre to a depth of 1 foot. This equals about 326,000 gallons.

SOURCE: DWR BULLETIN (60-74)

through the removal of vegetation. Maximum possible increases from forest cutting are obtained by some form of clear-cutting (Anderson 1976). As reflected in Table 4-4, snow accumulation increases up to 34 percent after clear cutting have been reported at the Central Sierra Snow Lab in California. The timing of the run-off is also influenced. Snow accumulates in forest openings and, depending upon the orientation and size of the cut, snow melt is accelerated or delayed, causing increased or decreased peak flows. Controlled burning may also be used to clear vegetation to increase water yield.

Clearing coniferous forests, especially in the snow belt, can have relatively long-term effects on yields of snow and water. Where regrowth is slow or covers only part of the area, increases in water yield can last 20 years or more. Timber harvesting designed to increase water yields offers a comparatively economical means for producing at least a small part of the volume of water needed to satisfy the projected consumption (Anderson 1976).

Weather modification consists of seeding clouds to increase precipitation. In recent years such projects have been undertaken in California by the Department of Interior, the Bureau of Reclamation and DWR. Unfortunately, the processes for evaluating the effects of cloud seeding have been difficult to develop and are not widely accepted. Because changes in precipitation caused by

TABLE 4-4

INCREASE IN MAXIMUM SNOW ACCUMULATION (WATER CONTENT) AFTER CUTTING IN WESTERN CONIFER FOREST

LOCATION AND FOREST COVER	TREATMENT	MAXIMUM INCREASE IN SNOW ACCUMULATION	
		Inches	Percent
Central Sierra Snow Laboratory, California (NE) Red fir	Clearcut	11	23
	East-west strip, 1 tree-height wide	12	26
	Block cutting, 1 tree-height wide	15	34
	Selective cutting; crown cover reduced from		
	90% to 50%	2	5
	90% to 35%	9	19
	Commercial selection cut	7	14
	Wall-and-step forest	19	25

Source: H. W. Anderson; M. D. Hoover; K. G. Reinhart; "Forests and Water: Effects of Forest Management on Floods, Sedimentation and Water Supply," USDA General Technical Report, PSW 18/1976

seeding fall within the range of natural variation, they are difficult to identify. Weather modification involves uncertainties regarding impacts beyond target areas, particularly as they relate to claims of decreased potential precipitation, or costs due to increased water in the form of floods or snow.

Potential water projects which would capture presently unregulated water are affected by all or some of these considerations:

Releases to meet Delta outflow requirements, prior downstream water rights, and navigation flow requirements.

Streamflow releases for fish preservation or enhancement.

Reservoir space to be reserved for flood control.

Maintenance of reservoir storage levels for recreation.

Releases for generation of hydroelectric power.

Maintenance of free flowing streams as required in the California Wild and Scenic Rivers Act.

QUANTITY OF WATER FROM FOREST LANDS

The proportion of the State's annual run-off originating in forested watersheds underscores the importance of these areas to the State's total water supply. The average annual unimpaired

surface run-off for each of California's 12 hydrologic basins is shown on Figure 4-3. These "basins" have been defined by agencies concerned with water quantity and quality. The figures presented span a 53-year period (1894-95 to 1946-47) with slight modifications where necessary to represent events such as the construction of dams. Differences in the mean annual run-off between hydrologic basins reflect the great geographic variability of precipitation in the State. Most of the State's run-off occurs in the north coastal basin, the area which has the highest average precipitation rates in the State. Figure 2-2 illustrates Statewide precipitation rates.

The forest land contribution to the State's total annual surface run-off is shown on Figure 4-4. As presented on this map, forest land or some 21 million acres, accounts for about 70 percent of the State's average annual run-off, or 50 million acre feet. The remaining 11 million acres of forest land generally border these areas and also produce substantial run-off. The total percentage is unknown but it is significantly above 70 percent of the total run-off.

The availability of sufficient water of good quality is of central importance to the well-being of this State. State law mandates that the water resource be adequately protected to ensure its preservation for beneficial uses and the enjoyment of present and future generations of Californians. The relationship of forests to water quantity is clear. Water quality, especially as it is affected by land use practices in the forest, is a second important watershed concern.

SOIL/WATER INTERACTIONS

PARAMETERS OF WATER QUALITY

Many of the physical, chemical, and biological qualities of water can be evaluated. The parameters of water quality currently monitored are turbidity, suspended sediment, pH, dissolved oxygen, temperature and total dissolved solids such as nitrogen and potassium. Other parameters may include coliform bacteria, phosphorous, nitrates, certain heavy metals and chlorides (Board of Forestry 1979).

Impairments to water quality are of two types, point and nonpoint pollutants. In general, point pollutants originate from an identifiable location, such as an effluent discharge pipe. Nonpoint pollutants originate from diffuse sources; identifying the origin of these pollutants is a difficult task.

Although both types of pollution are found in forested areas, the nonpoint type is of far greater significance. Table 4-5 indicates (in millions of pounds per year) the pollutant loads from point and nonpoint sources in the western portion of the North Coastal Basin (NC on Figure 4-3), a predominantly forested area. Annual nonpoint loads are roughly 5 to 1500 times the point loads of comparable pollutants.

On forested watersheds, nonpoint pollution is a consequence of both natural processes and of human activities. The distinction between man-caused and natural nonpoint pollution is often difficult to make because most nonpoint pollutants (sediment, nutrients), usually associated with certain activities undertaken by man, are also naturally occurring constituents of water. Water quality changes caused by human activities are likely to augment or exaggerate changes caused by naturally occurring events.

Point pollution in forested watersheds is almost invariably caused by human activities. The pollutants may consist of substances generally foreign to the stream channel (sewage, toxic metals) or they may be sediment. However, in contrast to nonpoint pollution, it is eas-

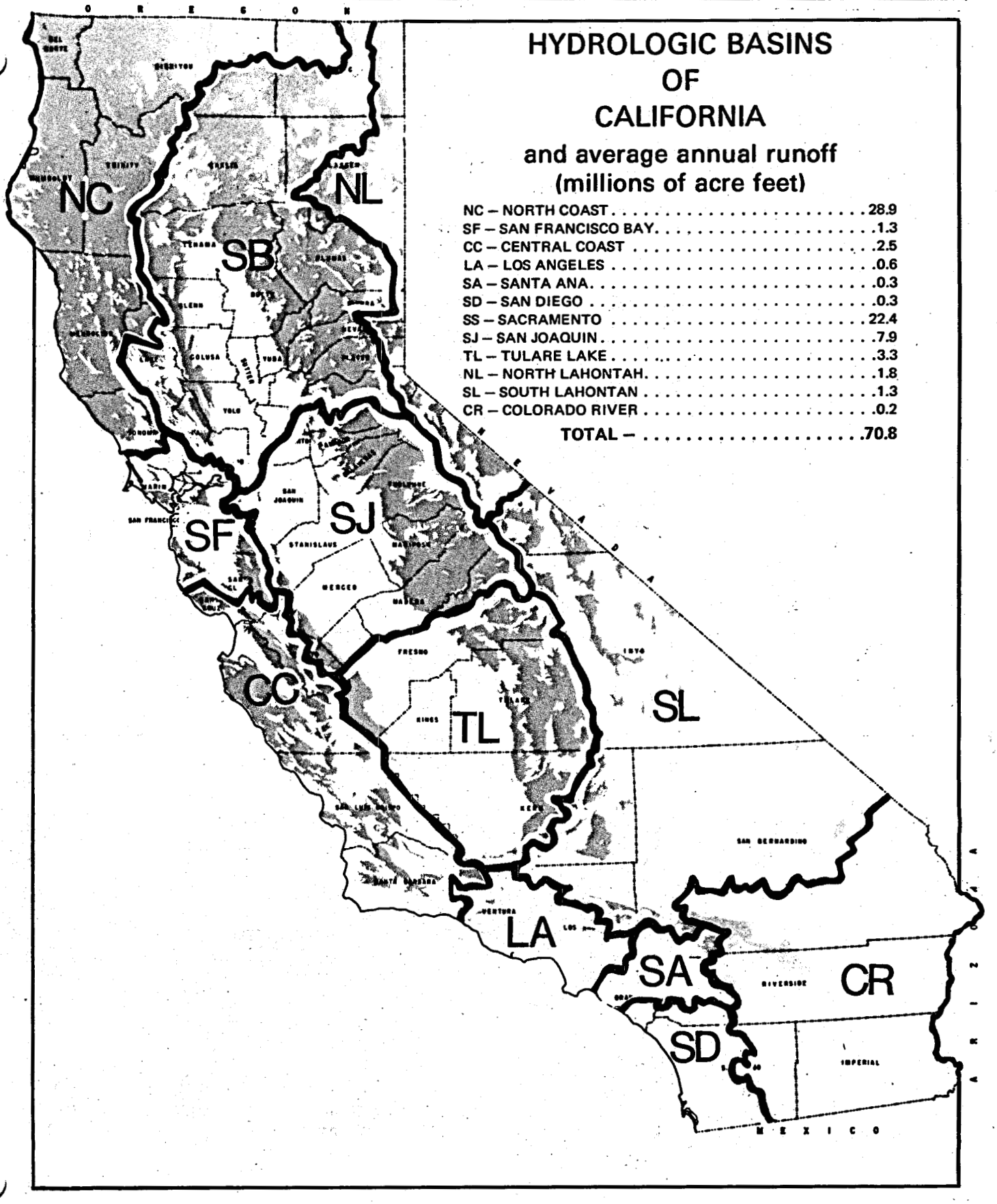
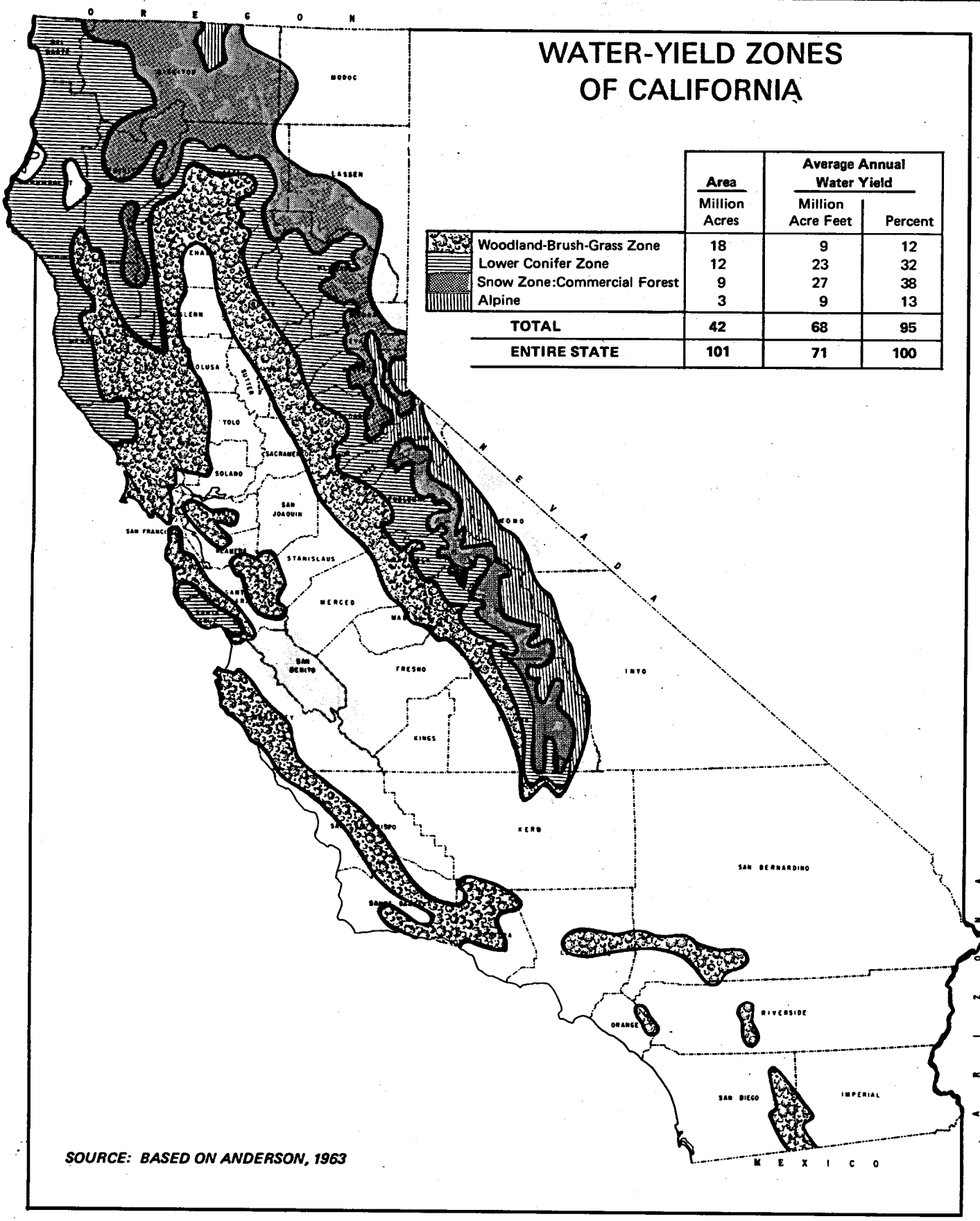

HYDROLOGIC BASINS
OF
CALIFORNIA
and average annual runoff
(millions of acre feet)
NC – NORTH COAST 28.9
SF – SAN FRANCISCO BAY. 1.3
CC – CENTRAL COAST 2.5
LA – LOS ANGELES 0.6
SA – SANTA ANA. 0.3
SD – SAN DIEGO 0.3
SS – SACRAMENTO 22.4
SJ – SAN JOAQUIN 7.9
TL – TULARE LAKE 3.3
NL – NORTH LAHONTAN. 1.8
SL – SOUTH LAHONTAN 1.3
CR – COLORADO RIVER 0.2
TOTAL – 70.8
NC
NL
SB
SF
SJ
CC
TL
SL
LA
SA
CR
SD
OREGON
NEVADA
MEXICO

FIGURE 4-4



WATER-YIELD ZONES OF CALIFORNIA

	Area	Average Annual Water Yield	
	Million Acres	Million Acre Feet	Percent
Woodland-Brush-Grass Zone	18	9	12
Lower Conifer Zone	12	23	32
Snow Zone:Commercial Forest	9	27	38
Alpine	3	9	13
TOTAL	**42**	**68**	**95**
ENTIRE STATE	**101**	**71**	**100**

SOURCE: BASED ON ANDERSON, 1963

TABLE 4-5

ESTIMATED POLLUTANT LOADS FOR NORTH COAST BASIN (1B)
(IN MILLIONS OF POUNDS PER YEAR)

	NONPOINT WASTE LOADS FROM LAND RUNOFF	MUNICIPAL POINT WASTE LOADS
Suspended solids	24,342.8	17.2
Total nitrogen	68.1	2.8
Total phosphorus	5.1	1.0

Source: Water Quality Control Plan Report, North Coastal Basin (1B), Part II, State Water Resources Control Board, April, 1975

ier to identify the origin of point pollution and to measure the discharge.

SOIL EROSION

The passage of time and the action of weathering and gravitational forces on geologic materials creates the drainage patterns and hydrologic characteristics of a watershed. The resistance of different kinds of rocks to weathering and the nature of the forces acting upon them determine the relative rates of soil formation and soil erosion in an undisturbed watershed.

Once a soil has developed, its inherent properties such as structure, texture, organic matter content, depth, and chemical composition affect its erodibility by determining such properties as permeability, infiltration, and water holding capacity. These properties influence the amount and kind of erosion which can occur through interaction with specific external factors such as steepness and length of slope; intensity, duration, and type of precipitation; amount and kind of surface vegetative or litter cover; and treatment of the land. The interaction of the land use practices and the external factors can lead to accelerated erosion.

Table 4-6 (Colwell 1979) shows one set of relationships between soil profile development, parent material and relative erosion hazard ratings. These are average ratings based on the susceptibility to various types of erosion and any one soil within a group or level could vary considerably. As stated earlier soil profile development and parent material can be correlated with the soil properties influencing the basic erodibility of any particular soil. When dealing with specific land use activities each site must be individually evaluated as to specific impacts of the activity on the soil resource. (Erosion hazard ratings are discussed in "Erosion Control of Silvicultural Activities.")

Table 4-6 shows three kinds of erosion and demonstrates that soils can erode differently. Surface erosion refers to "sheet" erosion caused by the movement of water in sheets or as laminar flow over the surface of the soil. Shallow channels called "rills" may be formed.

Surface erosion is perhaps the most insidious form of erosion in that the top layers of soil contain the bulk of soil nutrients. Thus a little soil loss may result in large amounts of nutrient loss.

Immature soils formed on an acid igneous or granitic parent material are most susceptible to surface erosion and display some of the highest surface erosion rates. However, at high elevations most shallow soils from any parent material are highly erodible (Colwell 1979). In the North Coast Region soils that have formed on fractured Franciscan rocks, on steep slopes with high amounts of rainfall are very susceptible to all forms of erosion.

Other forms of erosion which remove more of the subsoil include gullying and mass movement. In gully erosion water is concentrated into deep channels, most often due to topographic effects, although there is influence by soil characteristics such as surface permeability.

TABLE 4-6

EROSION HAZARD RATINGS BY DEGREE OF DEVELOPMENT AND PARENT MATERIAL

		SOIL PARENT MATERIAL GROUPS				
				SEDIMENTARY		
KIND OF EROSION	DEGREE OF SOIL DEVELOPMENT	ACID IGNEOUS	BASIC IGNEOUS	Hard	Soft	METAMORPHIC
Surface	Immature	High	High	Low	High	Low-moderate
	Moderately developed	Moderate	Moderate	Low	Moderate	Low-Moderate
	Strongly developed	Moderate	Moderate	Moderate		Low-Moderate
Deep Gully	Immature	Moderate	Low	Low	High	Low
	Moderately developed	Moderate	Low	Moderate	High	Moderate
	Strongly developed	High	Moderate	Moderate		Moderate
Landslide (Mass movement)	Immature	Low	Low	Moderate	Low	Low
	Moderately developed	Moderate	Moderate	Moderate	Moderate	Moderate
	Strongly developed	High	High	High	High	Moderate

Source: Wilmer Colwell, Jr. "Forest Soils of California" in: "California Forest Soils," Division of Agricultural Sciences, University of California, April, 1979

In general, immature soils on unconsolidated sedimentary rocks are most susceptible to gully erosion. This is especially true of unsurfaced logging and tractor roads, and skid trials on this material. Moderately and strongly developed soils on igneous rocks which have been weathered deeply into the parent material may gully badly when surface soil layers are removed (Colwell 1979).

In the case of mass movement, soil aggregates will move downslope as a large unit carrying vegetation along, either slowly as in creep, or rapidly, as in landslides or mudflows. This normally occurs after periods of intense rainfall when soils become saturated. Moderately and strongly developed soils, with thicker clay or clay loam profiles are much more susceptible to mass movement, especially on steep slopes, than are weakly developed or immature soils.

Gully and mass movement erosion usually remove larger volumes of soil than surface erosion, but much of this soil will be less fertile subsoil or parent material (Rice 1979). When discussing soil erosion impacts on site quality this distinction is important. When discussing water quality impacts the distinction is not as necessary.

Stream bank erosion is a form of sedimentation directly affecting water quality. Soil material is removed from the banks and enters the stream channel. This often occurs due to higher-than-normal flows of water in the channel.

Soil erosion is a degrading process on forest lands not only because of the impact of sediment on water quality, but also because of the loss of site quality which affects forest productivity. Currently there is little information available on the actual magnitude of this latter effect.

NATURAL EROSION AND WATER QUALITY EFFECTS

Certain natural events may accelerate soil erosion processes on a forested watershed with subsequent effects on water quality. These disturbances may lead to dramatic but usually short- lived increases in stream sedimentation. Fire and other events which lead to the destruction of the vegetative cover can influence the dynamics of the watershed in a manner that is eventually detrimental to water quality. The energy of the water flowing through the watershed is equalized throughout the watershed, and affects the geometry of the stream channels. Activities which affect time of delivery or amount of water delivered to the channel will affect the morphology of the channel, causing readjustments, including erosion (degradation) and deposition (aggradation).

Storms with unusually high intensity rainfall, exceeding the infiltration capacity of the soil, can trigger soil erosion events. Almost 60 million tons of sediment were swept past Scotia, near the mouth of the Eel River, in just one day following heavy rains in December 1964 (State Water Resources Control Board 1975). A rainstorm of this magnitude is expected once in a hundred years. These natural events are especially critical in fragile watersheds that are already susceptible to soil erosion.

Water quality within undisturbed forest areas will vary depending upon the interaction of physical parameters. Sediment and turbidity are to be expected in times of extremely high streamflow. In the North Coast area, most of the suspended sediment load passes the gauging stations during only a few days of highest flows. The concentration of total dissolved solids in streams from undisturbed forest areas will vary throughout the year, normally reaching a maximum during periods of low flow, and a minimum during periods of high storm run-off (California Division of Forestry 1972). The dissolved oxygen content is often highest in the winter when temper-

atures are lower. The concentration may be lower and more erratic in the summer as a result of lower oxygen solubility in warm water and greater biological activity (State Water Resources Control Board 1975).

The present annual sediment yield attributed to land use practices and to natural causes (including catastrophic events) has been determined for California River Basins (USDA River Basin Planning Staff 1972). The North Coastal portion, including areas having the highest estimated sediment production in the U.S. (California Division of Forestry 1972), incorporates drainages from the Russian River north to the Oregon border. Included are the Klamath, Trinity, Smith, Eel, Mad and Russian Rivers, those rivers draining the Mendocino area, and Clear Lake. The total area of these watersheds is about 19,750 square miles, much of which is forested (Table 4-7).

According to the USDA 1972 River Basin Study natural erosion accounts for the majority of sediment yielded on an annual basis in the California watersheds of the North Coast. Some 71 percent of the total annual sediment yield, or about 32 to 43 million tons, can be attributed to natural causes (See Table 4-7). The greatest natural (and man-caused) sediment yields occur in the Eel and the Mad River basins. According to Coats (1978) and Dodge (1976), the 1972

TABLE 4-7

PRESENT ANNUAL SEDIMENT YIELD OF THE NORTH COASTAL RIVER BASINS (MILLION OF TONS PER YEAR)

BASIN	AREA IN SQUARE MILES	SEDIMENT YIELD: DIRECTLY INFLUENCED BY MAN	SEDIMENT YIELD: NATURAL	SEDIMENT YIELD: TOTAL
Northern Klamath Trinity Smith*	10,795	4.3 - 5.9	6.2 - 8.4	10.5 - 14.4
Eel and Mad Rivers	4,834	5.5 - 7.6	19.9 - 27.2	25.4 - 34.7
Southern Russian River Mendocino coastal Clear Lake	4,109	3.0 - 4.0	5.8 - 7.9	8.8 - 11.9
TOTAL	19,738	12.8 - 17.5	31.9 - 43.5	44.7 - 61.0

* Includes 88 square miles in Oregon.
Acre feet converted to tons (1 acre foot = 1775 to 2420 tons)
Source: USDA River Basin Staff, 1972

USDA study failed to take into account the role of upstream hydrologic changes in initiating downstream landslides and bank erosion and for this reason the report probably underestimates the human impacts.

Coats (1978) cited C. Wahrhaftig's testimony on the erosion problems in Redwood Creek and stated: "Contrasting the recent rate of erosion in disturbed watersheds with the historic or natural rates suggests that the present rate is at least 2 to 20 times the natural rate. The difference, if we discount the possible role of climatic and geologic fluctuations, may be attributed to human activity."

Several other studies have addressed erosion rates and stream sedimentation, especially on the North Coast. Coats (1978) and Dodge (1976) cite many additional references. It is apparent that there is disagreement among the various studies regarding natural rates of soil erosion and stream sedimentation. Until these rates are more definitively established, it will be difficult to determine the amount of soil erosion, and water quality effects caused by human activities.

Fire, either natural or man-caused, can have extremely adverse effects on water quality by completely destroying the plant cover, litter, humus and the structure in the upper few inches of soil, thereby reducing infiltration and soil water storage capacities. Depending upon the intensity and timing of the subsequent rainfalls, the topography, the inherent erodibility of the soil, and the severity of the burn, the exposed soil surfaces are subject to varying degrees of increased erosion. Peak flows may also be increased. Abnormally large peak flows, bulked with debris from fire damaged lands, can lead to increased surface and streambank erosion. Fire can set the stage for dry ravelling (the movement downslope of debris by gravity) which can lead to sedimentation of streams during the dry season. This is especially true on coarse textured soils on steep slopes (Dodge 1976).

The formation of a hydrophobic (water repellent) layer within the soil is an effect of fire that leads to decreased infiltration and increased overland flow. It may also indirectly affect erosion rates by retarding vegetation recovery. A hydrophobic layer can limit water infiltration to the top 2 to 5 centimeters of soil (Rice 1972). The severity of the condition is positively correlated with burning temperatures (Rice 1972). Water repellency is more severe in coarse textured soils than in fine textured soils (Rice 1972) and is a widespread phenomenon in burned areas of southern California (Krammes 1965) and may be a potential erosion problem on forest lands (Rice 1972).

Fire can also influence the chemical quality of water. The nutrients in the litter and vegetation are converted by high intensity fires to soluble forms contained in the ash. With precipitation and overland flow the potential exists for stream contamination by the readily soluble nutrients. In southern California, for example, ash and leached materials from chaparral fires have rendered water unfit for drinking purposes (California Division of Forestry 1972).

Controlled burning used for slash disposal or for the removal of brush buildup can minimize the effects of uncontrolled fires especially in areas where fire has been suppressed for many years. It is often possible to control the amount of litter consumed, the heat of burn, the amount of soil structure change, and thus the resulting erosion.

The erosional effects of fire are often shortlived and water quality impacts decline rapidly (Rice 1972). Recovery tends to be more rapid in well watered areas and less rapid in high elevation or other areas characterized by slow growth. A study conducted on the Oregon

Coast Range found that a 100 percent clearcut and burned watershed, which had a five-fold increase in sedimentation, was revegetating at a rate that could be expected to return sediment yield to about normal in the fifth or sixth year following the fire. The same study found that understory vegetation on two logged and burned areas in Oregon had returned to near normal in one to four years (Rice 1972). These are not natural situations, but they demonstrate recoverability following fire.

LAND USE PRACTICES AND EFFECTS UPON WATER QUALITY

Land uses which result in degraded water quality have several important characteristics in common. Each removes or modifies the vegetation, exposes mineral soil, and alters drainage patterns. Many land uses strongly motivated by economic expediency (California Region Framework Study Committee 1971). The major land uses carried out in forested watersheds which can lower water quality are: silvicultural operations, including the construction, use and maintenance of required roads; grazing and range management practices; mining; off-road vehicle use; and other forms of recreation, and subdivision development.

Silvicultural Operations Effects

The great majority of silvicultural activities, such as timber harvesting (and general road construction/maintenance), site preparation and reforestation, and maintenance of the subsequent stand of trees, can become nonpoint sources of pollution. Silvicultural point sources include mill storage and processing activities, and sand and gravel operations (EPA 1977a).

The most important effects generated by silvicultural activities include increased water temperatures due to tree removal (Anderson 1976), and pollution from sediment, debris, and chemicals, including those in the form of nutrients and pesticides. Soil nutrients normally absorbed by vegetation can enter streams if the vegetation has been removed. "Research to date indicates that clearcutting does not increase volumes of dissolved solids enough to lower water quality below drinking water standards. However, nitrogen discharge may frequently, though temporarily, exceed the concentrations necessary to increase the growth of algae" (Anderson 1976). Decomposition of logging debris within stream channels, especially in combination with warm water temperatures, may reduce the stream oxygen and result in the release of substances affecting water taste or odor. The origin of the pollutants is generally related to more than one of the activities of the total silvicultural operation. Considering all the potential pollutants, an increase in sediment is the most common occurrence (EPA, March 1977a).

Timber Harvesting

Most of the literature on forest land uses and water quality deals with the timber harvesting components of silviculture and the road access systems that are developed in support of these activities. "The activities associated with timber harvesting constitute the most important human impact on forested watersheds" (Rice 1972). Timber harvesting includes the logging operation (felling trees and moving them to a landing) and removal of the logs from the watershed.

Removal of the vegetation exposes bare soil to raindrop impact which can cause puddling of the soil surface, decreased surface infiltration rates, and increased overland flow of water. If the upper layers of the soil profile are removed soil horizons more susceptible to erosion may be exposed. On vegetated hillsides slope stability is enhanced by the binding effect of tree roots and humus in the soil and the continuous removal

of soil water by transpiration. Exposed, saturated slopes, lacking a network of roots, are more prone to soil creep, landslides and other forms of mass wasting. Rice (1972) cites several studies which report an increase in both the number and acreage of landslides about five years after logging operations cease, a time interval sufficient for root decay to occur.

The operation of yarding and skidding equipment may compact the soil surface and reduce infiltration rates. Increased surface flow with the potential for soil erosion can result. Cut and fill slopes that result from the operation of yarding equipment can erode. In general, as slopes increase, the amount of disturbance necessary for a tractor trail, road, or landing increases proportionately (Hauge 1979). Both Anderson (1976) and Rice (1972) conclude that tractor yarding has the potential for disturbing the most area. There is normally a large amount of excavation creating ground disturbance and compaction, and skid trail patterns tend to concentrate water runoff. Tractor yarding is followed by cable systems in which some part or all of each log is dragged on the ground surface (ground lead). Cable systems in which the logs are lifted entirely off the ground disturb less area than the other two (high lead).

A study by Wallis and Anderson (Board of Forestry 1979) that measured sediment discharge, independent of the effects of road building and increased stream flow, found that "good" logging operations in California showed no detectable increases in the discharge of sediment. "Poor" logging on similar watersheds, however, showed sediment levels to be very dependent on the area treated: sediment increases of about 19 percent for each percent of the watershed area logged. This is a clear indication that the techniques used by the equipment operators or the care they exercise can influence amounts of erosion.

According to Rice (1972), the most important determinant of disturbance and erosion leading to impacts on water quality is the difference in equipment operator performance. Regulation of certain activities carried out in forested areas is an attempt to protect the public's interest in water quality by limiting the operator's discretion. Better education and training of equipment operators in causes and controls of erosion would most likely also improve ground conditions and water quality.

"Of those studies separating erosion into its various causes, several have reported that any changes in sedimentation resulting from logging alone were not significant" (Rice 1972). However, since the potential stream sedimentation may not be realized until years after the logging operation, the contribution made by logging to that sedimentation is likely to be underestimated or even dismissed.

In timber harvest operations, once the felled trees reach a landing, a network of roads is necessary for transporting the material to a manufacturing facility. Some of these roads are permanent, some are temporary. In most cases, these roads are so-called low-volume roads, built primarily for land access where relatively low cost designs are economically mandated (Board of Forestry 1979). While this discussion focuses on roads utilized for timber harvest operations, the potential impacts are equally true for any other road in the forested area, including county, State, and federal roads, and those built on private land.

Road construction can lead to accelerated surface erosion and can initiate mass movement events. Erosion increases exponentially as road density, (miles of road per square mile of area) increases (California Division of Forestry 1972). Surface erosion results from soil compaction and the alteration of natural drainage patterns: the surface flow can

be rerouted and channeled, bringing about a sizeable increase in the water's velocity and erosive power. Subsurface water, intercepted at roadcuts, augments the volume of surface water. Cut-and-fill slopes can trigger mass movement events, particularly when the surfaces are sloped at an angle greater than the angle of repose (60-70 percent). Cuts remove the toes of slopes and create steep surfaces while fills load unconsolidated material onto already existing slopes.

In road construction, the steeper the terrain traversed, and the larger the cuts and fills, the greater is the potential for erosion and sedimentation (Division of Forestry 1972). The extent to which effective erosion control methods are integrated into the design and construction of a road, and the degree to which they are maintained, will influence the amount of erosion which occurs.

The construction and use of roads constitute the primary source of sediment from forested watersheds (Division of Forestry 1972; Anderson 1976; Dodge 1976; Hauge 1977; Rice 1972; Department of Water Resources 1964; Board of Forestry 1979). As much as 90 percent of the sediment produced by erosion on timber sales comes from roads (Anderson 1976). In a study of suspended sediment in 68 northern California watersheds, it was found that dirt logging roads increased sediment by 34 percent for each mile of road per square mile of watershed. Some types of harvest methods may use four miles of road per square mile of operation (Board of Forestry 1979). Roads in steep watersheds show twice as much increase in sedimentation as roads built on moderately sloping watersheds (Anderson 1976).

Reforestation

Reforestation activities, including site preparation and the establishment of new trees, can have both positive and negative effects on water quality. Revegetating a cleared site is one of the most effective means of protecting it from soil erosion. Reforestation activities that may lead to deteriorate water quality include the use of chemicals, the burning of slash, and the removal of brush.

Intensive forest management may include the use of various types of chemicals such as fertilizers, herbicides, insecticides, fungicides, and rodenticides. Excepting fertilizers, these chemicals are collectively referred to as pesticides. Fertilizers are not currently used in any significant amount on California's forest land. Insecticide use is only a small part of the pesticide use on forest lands both in terms of amount applied and acreage covered, according to 1977 data gathered by the U.S. Department of Food and Agriculture. Herbicides are the pesticide most used, with aerial applications being the most common method of treatment. These are all potential nonpoint sources of pollution to surface and ground water.

In the past, reports of general injury to fish and wildlife have been confined to applications of insecticides, principally chlorinated hydrocarbons, in large projects (EPA 1977b). Although there is no reported knowledge of any instance of aquatic ecosystem damage directly attributable to the use of presently registered herbicides, there are many records of detectable concentrations of chemicals left in the environment after applications.

At present there is inadequate evidence for a conclusion that harmful effects (including toxic contamination of streamflows) do not occur from silvicultural use of these pesticides. A significant decline in the aerial application of restricted pesticides (mostly herbicides) occurred in several forested counties of northern California during 1978 (Board of Forestry 1979). Additional information on pesticide use

in California is presently being developed as part of CDF's water quality study.

In early 1979 the Environmental Protection Agency suspended use of the herbicides 2,4,5-T and Silvex (which contains 2,4,5-T) due to the potentially hazardous impact on human health. The suspension will remain in effect until a full review of the herbicide's impacts and benefits is completed. The current controversy over 2,4,5-T underscores the need for additional information on the immediate and long term consequences of all pesticide use on forested watersheds.

Sawmills, Sand and Gravel Operations

Point sources of pollution sometimes are related to the processing and storage of harvested timber at sawmills. Potential pollutants from log decks include sediment which derives from disturbed surface areas, and log debris in varying states of decomposition. These materials may be washed into streams during a rainfall. The decomposition products of the logging debris can kill fish. At smaller mill operations that lack drying facilities moist, freshly cut lumber may be treated with a fungicide which may contaminate the streams due to rainfall, spills, or mill cleanup operations. These fungicides from lumber decks constituted the second highest cause of fish mortality attributed to pesticides during the interval 1961-1976 (Wellman 1979).

Seepage from the few sawmill ponds still in use today may lead to contamination of stream channels by various organic compounds which occur due to the slow leaching and decay of logs in water.

In general, sawmill sites where storage and processing activities are undertaken are not located in forested areas due to the need for access to transportation. In cases where the mill site is upstream from forested land there exists the possibility for significant local effects on water quality within the forest.

Sand and gravel operations are also considered to be silvicultural point-sources of pollution according to the EPA. These operations increase turbidity and sedimentation as stream channels are directly disturbed or rock particles from crushing and washing activities enter streams. Additional water quality problems can occur as the nature of the stream channel is changed when materials are removed or relocated. Former surface flows may subsequently flow below the surface if the ground is permeable, leading to development of an intermittent stream. As water quantity changes, so may water quality. The majority of rock and gravel operations are located in nonforested areas.

EROSION CONTROL OF SILVICULTURAL ACTIVITIES

The Z'berg-Nejedly Forest Practice Act of 1973 and subsequent amendments designate the CDF as the regulatory agency for logging on non-federal forest lands within the State. The Board of Forestry is responsible for adoption of the regulations. The Board divided the State into three Forest Practice Districts and rules have been adopted for each District. The rules address silvicultural operations including restocking, logging, erosion control, stream and lake protection, and hazard reduction. The rules also emphasize the philosophy that careful preharvest planning is the best way to evaluate and mitigate possible adverse environmental impacts of timber harvesting.

The mitigating measures for soil erosion control involve Erosion Hazard Rating (EHR) Systems and Stream Protection Zones. The EHR's are designed to evaluate the susceptibility of a soil in a given location to all forms of erosion.

The minimum size area evaluated is 10 acres. Each Forest Practice District has a different technique for estimating this rating. Table 4-8 shows the factors used in each district for estimation.

In the Coast FPD, where many of the soils have been mapped, the rating is specific to soil series and slope. Where the soils have not been mapped, and the series is unknown, it is necessary to rely upon soil depth or site index, soil texture, and geology. The soil information is combined with a Climatic Stress Factor based on mean annual precipitation fo generate a rating. In the Northern District the rating is derived by multiplication of a Soil Factor based on soil texture and soil depth or site class, and a Slope Factor. This provides an Estimated Erosion Potential. The Southern District does not have a multiplicative rating; one must determine which set of factors is most representative of the site, and then use the designated rating of high, medium, or low hazard for that set of factors.

EHR's are used to influence various logging practices. For example, EHR's and slope determine the distance between waterbars, and extreme or high ratings limit the size of clear-cuts.

Whether the ratings actually reflect the amount of erosion which might or does occur is questionable. CDF's Soil Erosion Study (Hauge 1979) has not found a correlation between the EHR's of the

TABLE 4-8

COAST DISTRICT EROSION HAZARD RATING	NORTHERN DISTRICT ESTIMATED EROSION POTENTIAL	SOUTHERN DISTRICT POTENTIAL EROSION HAZARD RATING
Multiply: 1) Climatic Stress Factors based on mean annual precipitation BY 2) Standard Inherent Erosion Hazard based on specific soil series and slope BY 3) Relative Inherent Erosion Hazard based on slope, geology, soil texure, and soil depth or site index	Multiply: 1) Soil Factor based on soil texture, soil depth or site class BY 2) Slope Factor	Consider: 1) Parent rock 2) Soil texture 3) Precipitation type 4) Vegetative cover after logging
Source: California Forest Practice Rules, 1978.		

Coast District and measured erosion. They feel that the reasons for this might include:

Problem or unstable soils may represent an area less than 10 acres in size and thus will not be rated, but can cause substantial erosion.

Erosion Ratings may be miscalculated.

The factors used to compute the ratings may be unsatisfactorily weighted. For example, in the Coast District, slope may be more important than Mean Annual Precipitation.

All important factors may not be included, such as amount of compacted ground, type of yarding, canopy remaining, etc.

More of the rules should be affected by the Erosion Hazard Ratings. For example, amount of allowable excavation could be limited by the rating.

These last three reasons are part of a larger problem. The Erosion Hazard Rating is calculated when a timber harvest plan is filed, prior to commencement of logging operations. During operations the only major effect the rating has on logging in any District is to limit the size of clear-cuts and in the Northern and Southern district to limit the width of Stream Protection Zones. There are other considerations but they are mainly in the Coast District, and then only on those sites with an extreme hazard rating. Once logging has been completed the same previously calculated rating is used to determine spacing between waterbars based on slope. The same spacing applies regardless of the amount of vegetative cover remaining, amount of ground cover on skid trails, amount of compaction, amount of excavation, number of skid trails, area of exposed subsoil, or changes in drainage patterns. An evaluation of on-site conditions and estimation of erosion potential considering these or other factors following logging operations would probably improve erosion control and provide a higher correlation between ratings and measured amounts of erosion. Initially calculated EHR's could be used to control or limit certain of the above factors where deemed necessary.

Another problem with the rating systems is that different soils are susceptible to different types of erosion, and will not react the same under given conditions. A rating system which evaluates soil properties, specific practices, and tendencies towards a particular kind of erosion would probably provide better erosion control.

Stream Protection Zones (SPZ's) were designed to limit timber harvest activities within the area immediately adjacent (usually within 100 feet) of a lake or stream. There are limitations on stream crossings, debris in streams, vegetation removal, equipment operation, landing locations, etc. There is some evidence that SPZ's are effective in preventing logging debris from entering streams, maintaining soil stability, and preventing sediment movement only when the SPZ has not been significantly disturbed (Hauge 1979). The width of a SPZ can affect its ability to prevent or limit water quality degradation. SPZ's alone are not able to prevent adverse impacts due to the cumulative effects of harvesting many areas within one watershed over a period of time or at the same time, but if they are used in conjunction with effective erosion control measures, SPZ's can be influential in protecting stream water quality.

Other Land Use Practices

Grazing

Grazing by wildlife and livestock may lead to increased stream sedimentation especially where overgrazing occurs.

Overland flows of water increase as the soil is compacted and exposed. In coniferous areas, the effects on water quality of grazing may be limited to forest openings and meadows. As a result, reduced infiltration capacities are less likely to occur in a widespread continuous manner (Anderson 1976). Where conversion of woodland to grassland for livestock has occurred, water quality problems are usually detectable (State Water Resources Control Board 1975). While about nine million acres of forested rangeland are found in California, the significance of water quality problems from the overgrazing of this land is unknown.

Recreation

The most serious water quality problems related to the pursuit of forest recreation appear to involve the use of motorized vehicles. Off-road vehicles have caused damage by crushing vegetation, cutting ruts and trails, and starting fires with sparks or heat from exhaust systems. Motorized traffic has destroyed many erosion control mechanisms such as water breaks and drains on logging roads and tractor trails. The consequence of all these impacts is that soil erosion can be initiated or accelerated, leading to increased stream sedimentation. Contamination by human sewage is another recreation-related water quality problem in some forested areas.

Mining

Active and abandoned or inoperative mines on forested watersheds may constitute point and nonpoint sources of pollution. Direct drainage from adits is a point source whereas percolation of surface or ground water through mine tailings and runoff from exposed surfaces are nonpoint sources. The pollutants include acids, heavy metals (copper, lead, iron, zinc, mercury, arsenic, etc.) and sediment. Generally, the pollutant load generated at a mining site is proportional to the available water expressed as annual rainfall (Central Valley Regional Water Quality Control Board (CVRWQCB) 1978). Thus, practically all mine-related water quality problems are seasonal. In addition, variations in streamflow, water composition, toxicity of constituents, and biotic susceptibility all contribute to the effect of mine discharges upon water quality.

As identified by the CVRWQCB (1978), there are about 30 inoperative mines located in forest areas that are contributing varying amounts of pollution to receiving streams. The study indicates that of the 30, eight have been designated as "high problem areas," three as "moderate problem areas," and 14 as "low problem areas." Pollution from two of the mines is limited to sediment and the remaining three have not yet been ranked.

While active mines pose a potential problem to water quality, they are regulated by the Regional Water Quality Control Boards and are subject to the adoption of waste discharge requirements.

CUMULATIVE IMPACTS

A watershed is the sum of many parts and processes, and any activity in one area is likely to create effects elsewhere.

Many different types of activities can affect a single forested watershed. Each activity may individually influence water quality, but what is the effect of several activities together? There are very few data on cumulative impacts or effects of multiple activities within watersheds. For example, a single clear-cut timber harvesting operation may be limited to 80 acres, but several such operations may occur in one watershed. What is the effect on water quality due to, say, 800 acres of clear-cut on non-contiguous properties? Vacation homes may be built in a small portion of a watershed. As the area is developed

and roads and more homes are built, what is the cumulative effect on water quality? Currently, there is a lack of information to satisfactorily answer these questions. Hopefully, the development of "Best Management Practices" (as discussed in the next section) for water quality regulation and improvement will help lead to a solution of these questions.

REGULATION OF WATER QUALITY

State and federal agencies are involved with the protection of water quality in forested areas of California. Water quality can be protected from nonpoint pollution through the enforcement of regulations on (1) water quality objectives and standards, and (2) land management activities. The State Water Resources Control Board (SWRCB) and the nine regional water quality control boards are responsible for the protection of beneficial uses of water in California and are authorized to use the first approach. The jurisdictions of the regional boards coincide generally with the hydrologic basins (Figure 4-3).

In response to the mandates of the State's Water Quality Control Act (Porter-Cologne 1969) and the Federal Water Pollution Control Act of 1972 as amended (FWPCA PL 92-500), the regional boards have prepared and adopted Water Quality Control Basin Plans which have then been adopted by the State Board. The SWRCB is the designated lead agency within California for the implementation of Section 208 of the FWPCA, which directs states to identify and develop Best Management Practices (BMP's) to control non-point sources of pollution.

The plans by each of the regional boards with jurisdiction over significant forested acreage (Central Valley, Lahontan, North Coast and Central Coast) contain, in part a list of objectives for maintaining ground and surface water quality. The objectives are of two types: (a) numeric limitations on certain water quality parameters that are not to be exceeded; and (b) narrative limits which prohibit the particular pollutant entirely or in concentrations that "cause nuisance or adversely affect beneficial uses." Most of the objectives (or standards) which serve as criteria for water quality violations are narrative rather than numeric.

The effectiveness of the various nonfederal regulatory mechanisms for dealing with nonpoint pollution due to silvicultural activities has been addressed by the Board of Forestry 208 study (1979). Most of the following discussion is based upon a draft copy of this study.

Water quality standards may be of limited effectiveness when applied to nonpoint pollution problems . In the case of numeric standards some of the reasons for this include:

> A standard is a fixed number and as such cannot account for the periodic and short-term naturally-occurring variation in a pollutant's concentration.
>
> Even though the requirements for such uses are not well known, certain water quality standards have been set to protect specified uses of the water resource.
>
> Many water quality standards are based on existing conditions or on laboratory conditions which may not accurately reflect field conditions.
>
> With regard to pollutants that are the naturally occurring constituents of water, such as sediment, a standard has been set with little information on the contribution due to natural events. (Background levels are seldom well-known.)

Proof of compliance with a narrative standard is based upon a finding that a nuisance exists. Not only is this a subjective decision, but the nuisance concept necessitates that legal proceedings be undertaken for each supposed violation. Effective implementation is therefore likely to be costly and time consuming.

Table 4-9 is a list of the regional turbidity standards. As can be seen, they vary throughout the State. They are often difficult to apply because of the lack of knowledge on natural levels.

Regional boards have the authority to set waste discharge requirements. These are prohibitions on the discharge into water of wastes such as effluent, slash, or other substances associated with human habitation or activies. In the North Coastal Basin, waste discharge requirements have been placed on some timber harvest activities and on certain silvicultural operations involving the use of pesticides. If it is found that violations of the waste discharge requirements, or of the water quality objectives, are occurring or are threatened, due to the discharge or threatened discharge of waste, the actions that can be taken by the State Board include administrative procedures such as the issuance of a clean-up and abatement order, or a cease-and-desist order, and referral to the Attorney General for injunctive relief or civil penalty action. Violations of certain procedural aspects are misdeameanors.

The State Department of Health Services is authorized to establish quantitative water standards to meet its responsibility for the maintenance of safe domestic supplies of water statewide as is spelled out in the Health and Safety Code. This agency is primarily concerned with the quality of the supply at municipal facilities.

REGULATION OF LAND MANAGEMENT ACTIVITIES

Three other State agencies have statutory authority for the protection of water quality in nonfederal forested areas through the adoption and enforcement of regulations on land activities that may degrade water quality: the Department of Forestry and its Board, the Department of Food and Agriculture, and the Department of Fish and Game.

As mentioned earlier, the Z'berg-Nejedly Forest Practice Act (1973), established the authority and regulatory power for the Board of Forestry and CDF to establish and enforce rules dealing with timber harvesting and other silivicultural practices. Previously discussed were the rules dealing with erosion control. The regulations are designed to prevent possible significant adverse environmental impacts due to timber harvesting.

CDF is also responsible for licensing timber operators and approving Timber Harvest Plans (THP). THP's must be prepared by Registered Professional Foresters (licensed by the Board of Forestry) and such plans must be found in conformance with the forest practice rules by the Department's Director. These timber harvesting plans are also reviewed by the State Departments of Fish and Game, Parks and Recreation and the Regional Water Quality Control Boards. In addition to the regulatory authorities authorized by the Forest Practice Act, the Board and Department of Forestry can initiate criminal proceedings for violations of the forest practice rules, and refer violations to the State Attorney General.

Silvicultural activities involving the use of pesticides may be regulated by the Department of Food and Agriculture. State and private land owners must obtain permits for the possession and use of restricted pesticides (herbicides and/or insecticides). If a violation is

TABLE 4-9

REGIONAL TURBIDITY STANDARDS

REGION	STANDARD (SEE BELOW)
North Coast	A
Central Coast	B
Central Valley	B
Lahontan	C
Colorado River Basin	B
Santa Ana	B
San Diego	B

A - Turbidity shall not be increased more than 20 percent above naturally occurring background levels

B - (1) Where natural turbidity is between 0 and 50 Jackson Turbidity Units (JTU), increases shall not exceed 10 JTU

(2) Where natural turbidity is between 50 and 100 JTU, increases shall not exceed 10 JTU

(3) Where natural turbidity is greater than 100 JTU, increases shall not exceed 10 percent

C - Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases in turbidity shall not exceed natural levels by more than 10 percent

Source: State Water Resources Control Board, 1978.

detected during the application of a pesticide, and depending on the nature of that violation, the Department can halt the operation and revoke the permit for the possession and use of the chemical, or initiate criminal proceedings through the district attorney or refer the matter to the Attorney General.

The Department of Fish and Game is responsible for managing the fish and wildlife resources of the State and, as such, is also involved in the protection of the waters that support these resources. Any nonfederal project which would alter the bank or bed of any stream or lake must be approved by the DFG. Department of Fish and Game forms are attached to timber harvest plans where compliance is necessary with Fish and Game regulations on timber harvesting activities. The Fish and Game Code prohibits activities causing water contamination (such as hydraulic mining) or degradation of stream conditions (such as log jams or debris accumulations) which prevent the migration of fish.

A violation of any section of the Fish and Game Code or the rules and regulations adopted pursuant to the Code is a misdemeanor. In addition, the DFG can recover damages in a civil action against any person or local agency which unlawfully or negligently destroys any fish or wildlife. These enforcement authorities are subject to a few exceptions but none of the exceptions are applicable to forested areas.

FEDERAL LAND MANAGEMENT IN FORESTED AREAS

Federal agencies which are responsible for the exclusive management of all activities occurring on land under their jurisdiction must also meet State standards for water quality and must cooperate in State programs to plan regulation of land use practices on all lands for resource protection.

Under contract to the State Water Resources Control Board, the Forest Service and the Bureau of Land Management, which together manage 37 percent of California's land, have compiled a list of all of their land management practices affecting water quality, for use in the State's 208 water quality control program.

EVALUATION OF CURRENT REGULATORY APPROACH

Since within a forested watershed, nonpoint pollution of a stream may be natural, man-caused, or both, establishing liability is often impossible. Water quality sampling data are not necessarily conclusive evidence for showing sources of pollution, making control difficult. The regulation of land management activities represents a more feasible approach to control. The draft report of the Board of Forestry's 208 Study concludes, with reference to silvicultural activities, that "the focus must be on the control of the silvicultural activity rather than on the effluent produced. It is better to prevent problems than treat them after they occur. The 'Best Management Practices' approach to controlling the silvicultural nonpoint sources of pollution reflects this recognition. ("Best Management Practices are discussed in this chapter, in the section on "Development of Best Management Practices.")

Problems with the existing institutional setup for the control of nonpoint pollution due to silvicultural activities are addressed in a State Water Resources Control Board Study (John Muir Institute, Inc. 1979). According to the study, "California has a fragmented approach which allows the Department of Forestry, Regional Water Quality Control Boards, Department of Food and Agriculture, and the Department of Fish and Game regulatory authority over silvicultural activities. Compounding this fragmented approach are the unregulated silvicultural activities such as road

construction outside of timber harvesting plan areas, post-harvest slash disposal, and activities involving site preparation."

DEVELOPMENT OF BEST MANAGEMENT PRACTICES

Section 208 of the 1972 Federal Water Pollution Control Act, as amended, requires that non-point sources of pollution, including those associated with silvicultural and related runoff, be identified and that procedures and methuds, called "Best Management Practices" (BMP's), be set forth to control pollution sources. The State Water Resources Control Board, as the lead State agency in Section 208 planning, has contracted with several agencies for the development of planning processes and best management practices. The agencies in California that regulate activities that occur or may occur on forested land, and the activities for which BMP's are being developed, are as follows:

California Department and Board of Forestry: silvicultural activities on state and private land. A draft of the 208 study was issued in May 1979, and a final report is expected in the near future.

Forest Service: grazing, recreation, vegetative manipulation, timber harvesting, road and building site construction, mining, and other activities on national forest land. A draft report was released in February 1979 and the final report was submitted in May 1979.

Bureau of Land Management: grazing and recreation on BLM administered land. A preliminary report, issued in February 1979, addresses all activities managed by the BLM that are related to water quality and includes a methodology for the development of BMP's. The draft report was issued in May 1979 and contains BMP's for their land management activities in grazing and recreation.

The State Department of Transportation has also prepared a 208 report identifying BMP's for road construction and maintenance.

CONCLUSIONS

Soil erosion is the cause of sediment in water. There are three basic types of erosion, sheet, gully, and mass movement. In addition stream bank erosion may occur in changing water channels. Sediment concentration can vary widely through the course of time and geographically. Sediment may be a point or non-point source of pollution. Non-point pollution is more common in the forested environment.

There is a need for further data on soils such as location, reactions to various land use practices, productivity, natural erosion and formation rates, and so forth. Additional information about the effects of sediment on beneficial uses of water must be determined, i.e., at what point does sediment become harmful or a nuisance for various uses?

It is clear that water quality degradation is the consequence of both natural events and human activities. The presence or absence of man-caused water quality problems is determined by the interaction between the activity and the individual site conditions. Land use practices that can affect water quality all tend to remove or change the vegetative cover, expose bare soil, and modify drainage patterns. Such practices on forest lands include silvicultural activities, grazing, mining, and off road vehicle use, among others. Natural events such as fires or floods may also cause erosion. The effects on water quality are not the only form of environmental degradation occurring due to soil erosion. In addition, forest site productivity is being impacted. How much however, is unknown today.

Sediment is the primary pollutant from silivicultural activities, the most studied activities being timber harvesting and road building. The more disturbed an area is (i.e., the more ground disturbance) the more prone to erosion it is. Steeper slopes create conditions for more disturbance because more cut-and-fill is necessary for road building, contributing to the erosion potential. It is thought that the bulk of sediment from silvicultural activities is due to road building. However, operator performance appears to make a major difference in terms of water quality impacts due to soil erosion. Tractor yarding has the potential for causing more disturbance than other yarding methods.

Other silvicultural activities such as reforestation involve the use of pesticides; the overall effects on water or land quality remain to be determined.

The Forest Practice Act (1973) instituted certain timber harvest controls, including efforts to regulate or control erosion. These consisted of various systems to assess the susceptibility of an area to erosion, erosion control measures, stream protection zones, etc. Further studies are needed to evaluate the effectiveness of these measures.

Within any one watershed, water quality may be impacted by a single activity or by several. Whether the effects due to several activities are simply additive or interact in further ways to cause other impacts represent data voids at this time.

Water quality is currently regulated by the Federal Water Pollution Control Act and the State's Porter-Cologne Act which attempt to control both point and nonpoint pollution. The State Water Resources Control Board is working with various State and federal agencies to establish Best Management Practices (BMP's). Regional Water Quality Boards have established waste discharge requirements and standards, the latter which are difficult to apply in the case of sediment. Certain State agencies have control over various land use practices that can impact water quality and future emphasis is likely to be on controlling these practices through the use of BMP's.

AIR RESOURCE

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INTRODUCTION

The forest ecosystem is subjected to numerous natural and man-caused stresses which favor the development of some organisms and suppress development of others. In general, undisturbed forest lands are not considered sources of air pollution and in fact some cleansing of the air by recycling can be attributed to forest vegetation.

Air is a renewable resource and directly affects and is affected by forest land, however, it, as a forest land resource, was not specified in the 1977 Forest Resources Assessment and Policy Act nor was air considered in the federal Resources Planning Act (RPA). However, air pollutants represent an additional man-made stress in the environment; therefore, to place the role of air pollution in perspective, any study of long-term chronic air pollutant effect must be accompanied by evaluations of impact from other stress factors.

Studies on Statewide air pollution problems conducted by the University of California at Riverside in 1977 reveal that intensity of stress produced by any of these factors varies widely over a period of time. Since plant response is affected by interaction of the stress factors, evaluation of the air pollutant involvement in ecosystem changes becomes a very complex study (a chronology of California air pollution events related to forested land is found in the Appendix, Item III.)

FOREST LAND AIR QUALITY

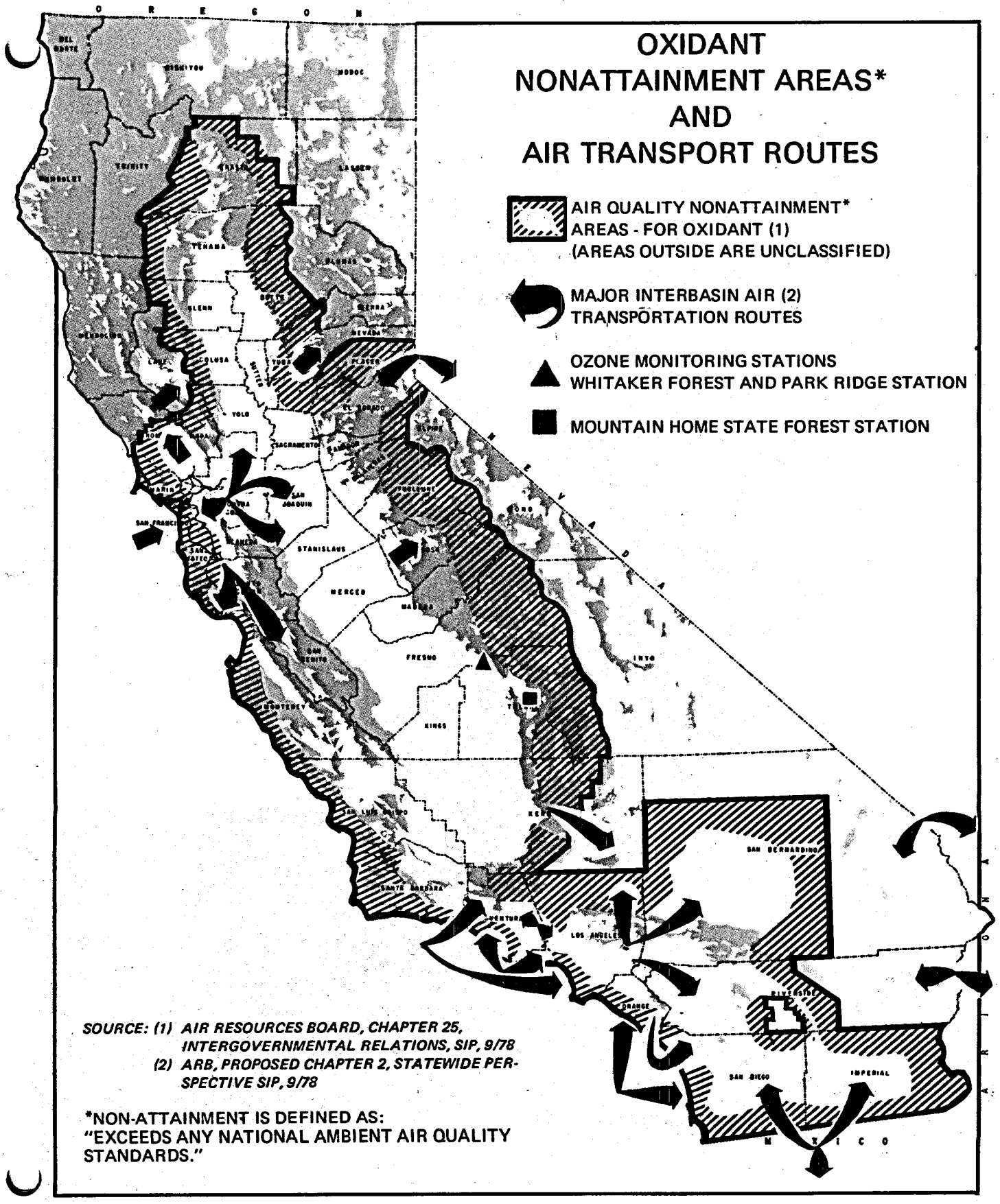
Because of California's air circulation patterns, no area is considered smog free. It is difficult to determine the distance photochemical oxidants and related hydrocarbons and oxides of nitrogen travel. Under ideal conditions they can be carried in excess of 100 miles. Those sections of the State immediately downwind of large metropolitan areas are more severely impacted by transported pollution than the more secluded rural sections (see Figure 5-1 "Oxidant Nonattainment Areas and Air Transport Routes").

Meteorology and topography are factors related to the transport phenomenon. Inversions formed in the Central Valley touch the western slopes of the Sierra Nevada at elevations averaging from 3,000 to 4,000 feet. As a result of transport, oxidants are often collected in high concentrations along this band where the mountains and the inversion layer intersect. Similarly, the surrounding mountains, and the occurrence of strong inversions, are responsible for the pollution accumulation that is so damaging in the South Coast Air Basin (SCAB), according to the UC Riverside Statewide Air Pollution Research Center (APRC) studies.

At present, two components of air are of particular interest relative to California forest lands--particulate matter and ozone. Nonattainment areas for both pollutants are shown on Figures 5-1 and 5-2. Major interbasin air transportation routes are shown on Figure 5-1, and air monitoring station locations in or near forest lands are indicated on Figure 5-3.

("Attainment" means that the area depicted has better air quality than the national standard for that particular air pollutant over a standard time period. Conversely, "nonattainment" indicates the surrounding air quality is worse than the minimum standard set.)

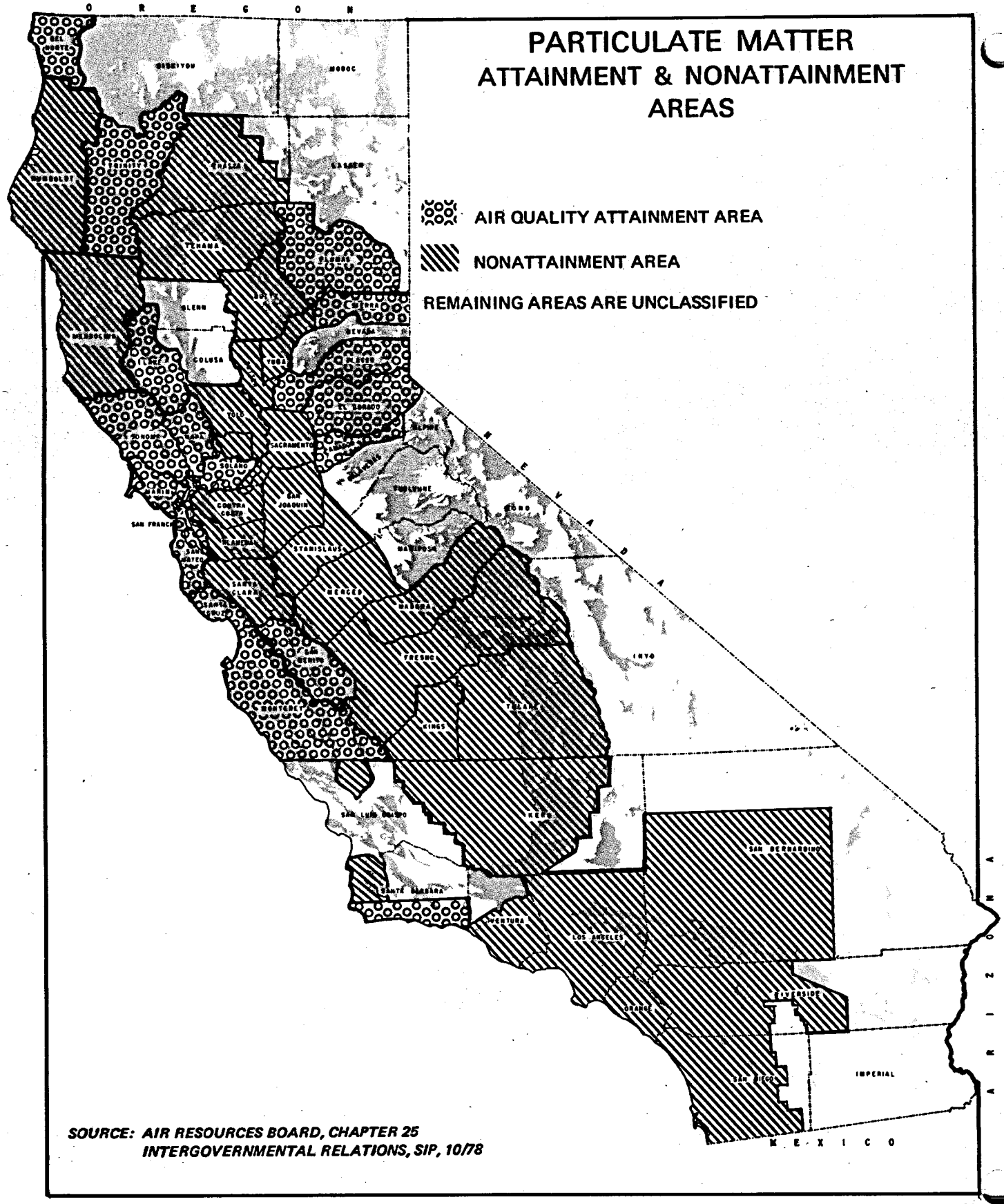
Particulate matter in smoke is a visual problem and a health concern. It is a by-product of forest land management



SOURCE: (1) AIR RESOURCES BOARD, CHAPTER 25, INTERGOVERNMENTAL RELATIONS, SIP, 9/78
(2) ARB, PROPOSED CHAPTER 2, STATEWIDE PERSPECTIVE SIP, 9/78

*NON-ATTAINMENT IS DEFINED AS:
"EXCEEDS ANY NATIONAL AMBIENT AIR QUALITY STANDARDS."

FIGURE 5-2



SOURCE: AIR RESOURCES BOARD, CHAPTER 25
INTERGOVERNMENTAL RELATIONS, SIP, 10/78

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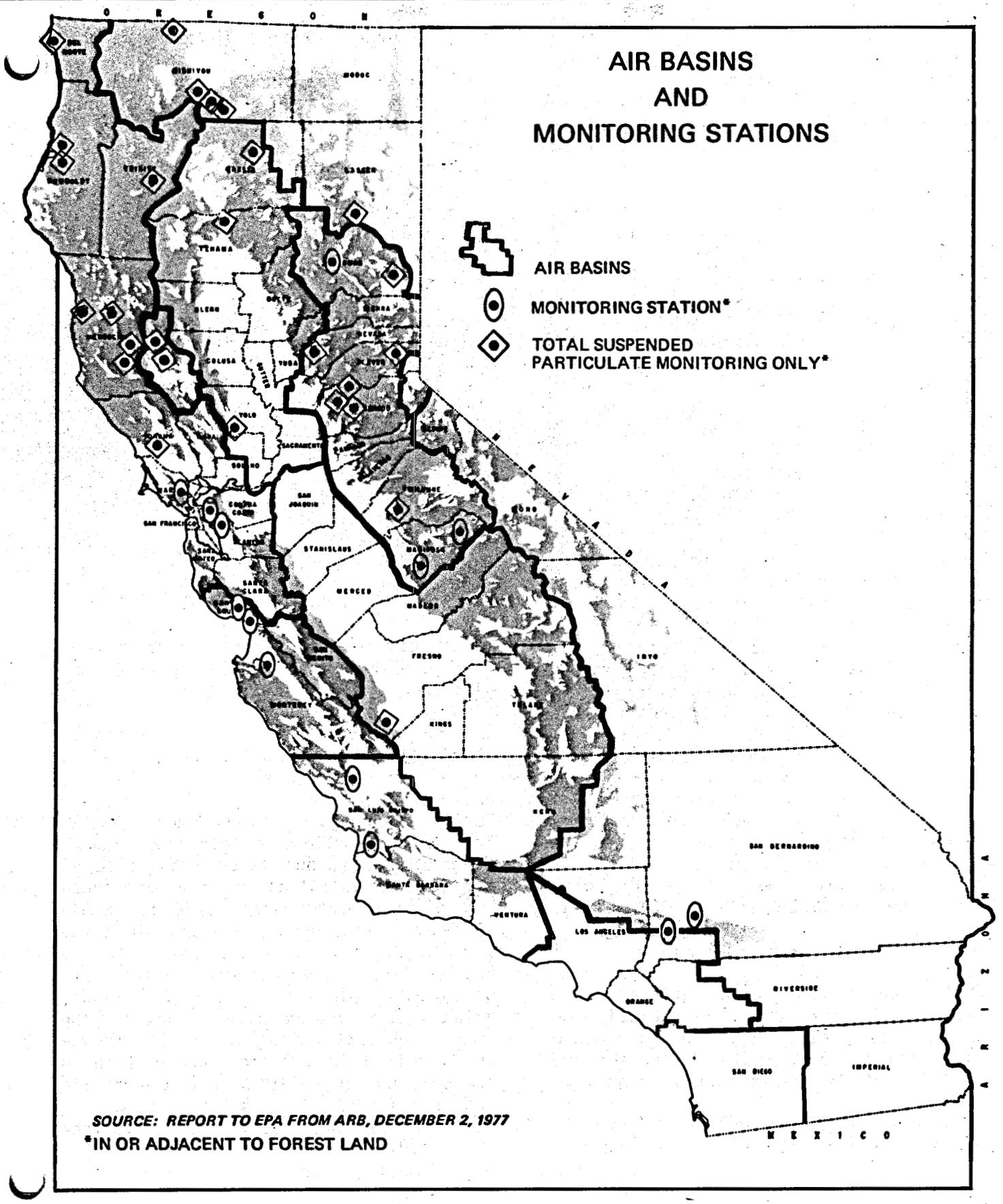


SOURCE: REPORT TO EPA FROM ARB, DECEMBER 2, 1977

*IN OR ADJACENT TO FOREST LAND

created through the burning of logging slash or from vegetative type conversion burning. This is often associated with the conversion of brush fields or hardwood stands to conifer tree production. Particulates are also a by-product of wildfires.

Little is known about the impacts of forest generated particulate matter but a growing store of oxidant information exists. Most studies have been conducted in the southern half of the State where significant oxidant damage to vegetation was first detected and where the greatest amounts of ozone are generated by exhaust emissions interacting with sunlight.

SOUTHERN CALIFORNIA

Most smog in the South Coast Air Basin is generated in the Los Angeles urban area. In the summer, a combination of weather patterns and topography work together to transport the pollutant mass to conifer forest locations as far as 80 miles away from the source. Pollutants forming over the urban Los Angeles metropolitan area in relatively cool marine air are often trapped under a persistent inversion layer of warm air in the upper atmosphere from which they cannot escape. On-shore ocean breezes transport the polluted air mass eastward where it "stacks up" against the lower levels of the San Gabriel and San Bernardino Mountains. During the morning, the inversion layer remains intact and pollutants accumulate, but remain generally below 4,500 feet elevation (USFS 1978).

Photochemical oxidants arrive in relatively undiluted quantities far from their sources because sunlight acts continuously on raw automobile exhaust gases as they move to produce more ozone and peroxyacetyl nitrate (PAN), the end products of the photochemical reaction.

By midday, surface heating of air in contact with mountain slopes tends to break down the inversion layer. When this happens, the heated slopes act as a chimney to vent pollutants up to the forested ridge crests. The smog laden air invades the mountains aided by the continuing on-shore breezes. Additionally, part of the flow of pollutants up the slopes of the San Gabriel Mountains may be injected back into the stable inversion layer in a horizontal direction away from the slope. As a result, the inversion itself may serve as a reservoir for oxidants (USFS 1978).

Pine is the species most susceptible to oxidant damage. Ponderosa and Jeffrey pine acreage in southern California amounts to about three percent of the total conifer acreage Statewide. From a timber loss standpoint the southern California pine loss is not significant, but from a recreational, visual, and watershed standpoint for southern Californians it is significant.

San Bernardino National Forest

The most severe oxidant damage to conifer forests occurs in the San Bernardino Mountains. The San Bernardino National Forest (SBNF) has been exposed to an increasing annual dosage of photochemical oxidants during the preceding three or four decades as industrial and urban development in the South Coast Air Basin expanded at a phenomenal rate. Tree abnormalities, originally thought to be diseases, but later identified as oxidant air pollutant injury, were causing concern in the early 1950's. Similarly, the injury on ponderosa pines was later thought to be associated with hydrogen fluoride and perhaps other air pollutants released by specific industries which were relatively new to the SCAB. Research during the 1950's largely dispelled this theory and implicated the oxidant air pollutants which are the responsibility of a broad sector of man's activities, as outlined in the 1977 study conducted by the APRC on the mixed conifer ecosystem.

The San Bernardino National Forest, located at the east end of the South Coast Air Basin, and forming the principal northern and eastern barrier to the movement of polluted air out of the basin, is subject to an ebb and flow of polluted air from the SCAB due to the alternate diurnal "pumping" of high desert and marine air through the Basin. Typically, during the recognized "smog season," the APRC studies show that the air flow during the early morning is from the east toward the coastal region; and as the day warms, the flow is essentially reversed to deliver marine air laden with oxidant pollutants to the SBNF.

Evaluation of the direct effects of oxidant pollutants in the SBNF has for the most part been confined to the dominant tree species although it is known that a wide variety of species of green plants are adversely affected. These tree species are critical elements in an ecosystem, providing food and shelter for all other organisms in the system. Chronic injury to the green vegetation, may over a period of time, significantly change the source of energy, protection, and general habitat of numerous consumer organisms. We must understand the changes in plant communities suffering from air pollutant injury if we are to predict the fate of an ecosystem impacted by a growing and changing industrial and urban complex.

Loss of ponderosa and Jeffrey pine trees has increased dramatically as pollutant levels have risen and the frequency and length of pollutant attacks have intensified. Pollutant effects on interrelated subsystems of the SBNF ecosystem have been studied in 18 plots established in selected regions of the forest. The plots were selected to represent sites of varying pollutant dosages while retaining as much uniformity of plant species and environment as possible. Data from the plots will be used in a group of linked models to describe pollutant impact on ecologic subsystems. The models should be useful in anticipating or predicting responses in other areas under similar conditions.

Secondary impacts of tree mortality due to air pollution are primarily related to the:

Potential for increased insect and disease activity,

Greater dead-fuel-mass generated; and thereby

Increased potential of more intensive wildland fires.

In 1962, the area of mixed conifer forest damaged by photochemical oxidant air pollution in the San Bernardino Mountains of Southern California was estimated to be 25,000 acres. Ponderosa pine was the most severely injured species; associated species did not then show similar damage symptoms.

In 1969, aerial photography was used to estimate damage to ponderosa and Jeffrey pines (see Figure 5-4). Of 160,950 acres surveyed:

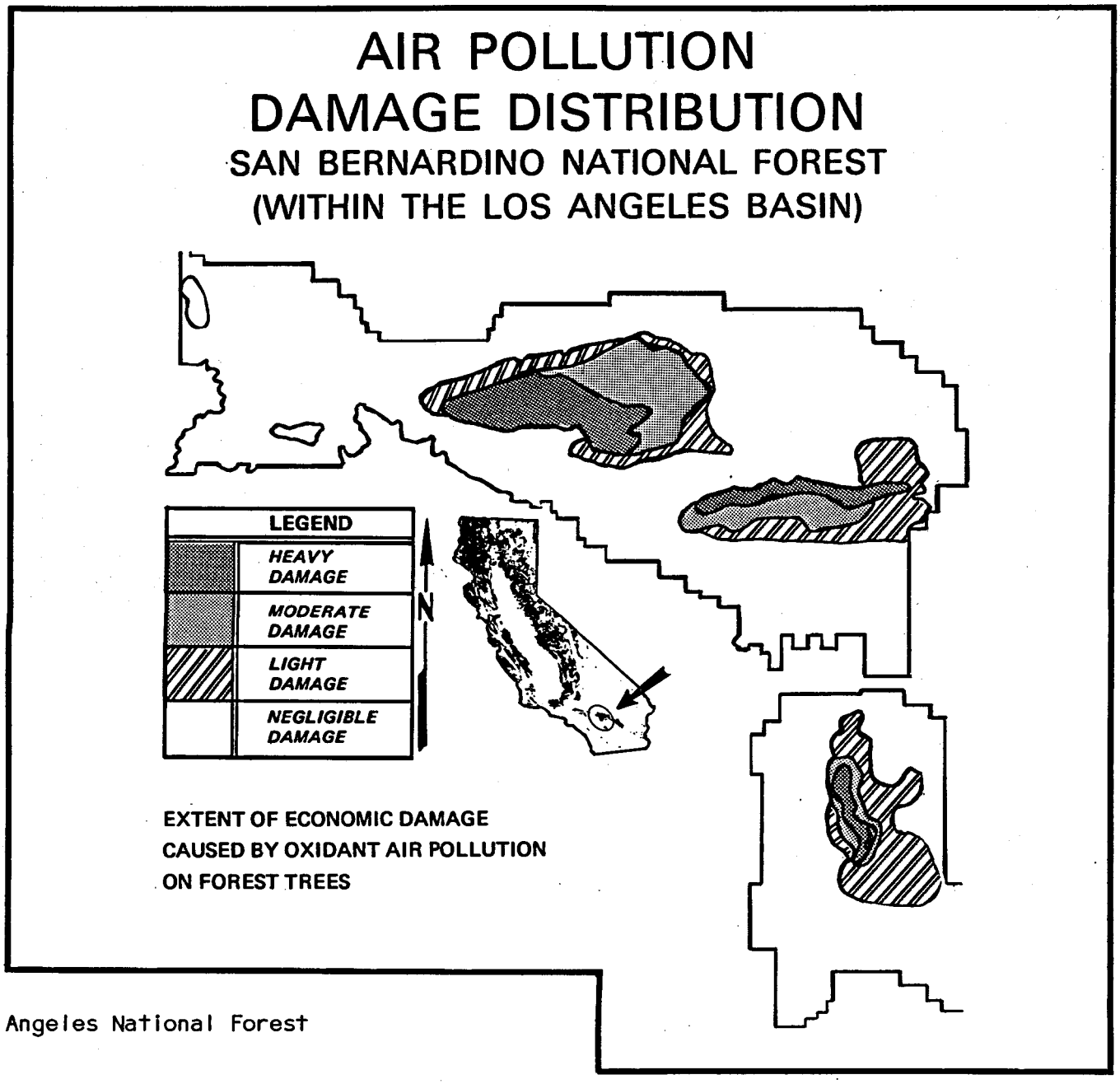
46,230 acres had heavy smog damage

53,920 acres had moderate smog damage

60,800 acres had light or no damage

Since 1972, twelve scientists representing several research disciplines (systems ecology, soils, plant nutrition, forest ecology, forest pathology, wildlife ecology, air pollution technology, and meteorology) have collaborated in integrated studies to determine the chronic effects of photochemical oxidant air pollutants on a western mixed conifer forest ecosystem. An enormous amount of data have been collected which describe the present and past natural conditions of twelve subsystems which comprise the conifer forest ecosystems of the San Bernardino Mountains (APRC 1977).

FIGURE 5-4



Angeles National Forest

Smog damage to the conifer forests of the Angeles National Forest is believed to be less severe than in the San Bernardino although it is still a serious problem in some areas. Much less research work has been directed toward quantifying damage on this forest than on the San Bernardino National Forest. Nevertheless, the results of a 1970 aerial reconnaisance survey indicated that 260,689 pines were affected by oxidant air pollutants on 40,000 acres. Of the affected trees, 20.1 percent were severely damaged and about 79.9 percent were moderately damaged (USFS 1978).

Cleveland National Forest

Ozone injury symptoms have been detected on the Cleveland National Forest, but the extent of damage has not been thoroughly assessed.

Los Padres National Forest

In recent years, the Los Padres National Forest has been subjected to air pollution from two separate sources. One is the steady and increasing encroachment of smog from the Los Angeles Basin as overall air pollution levels from that source increase. A second and more recent development has been the invasion of smog from the Bakersfield-San Joaquin Valley Region on the northeastern perimeter of the forest. An extensive damage survey has not yet been made (USFS 1978).

Because of its location north of the Southern California air basin, the Monterey District of the Los Padres is probably the only area within the Southern California National Forests which is relatively free of the threat of smog injury, according to the Timber Management Plan data.

SOUTHERN SIERRA NEVADA

Ozone injury symptoms on pines in the Sierra Nevada Mountains of central California were first reported in 1971. Due to the heavy ozone damage in southern California, the Forest Service became concerned about the current status and potential threat of ozone injury in the forests that border the San Joaquin Valley air basin (Pronos 1978). In 1974, the Forest Service Insect and Disease Management Staff began to describe and assess the air pollution situation in the southern Sierra Nevada. Evaluation efforts have included ozone injury ground surveys, ozone injury trend plots and ozone dose monitoring. Initial roadside surveys in 1974 identified sites where ozone symptoms were present, but did not rate the level of injury nor record the presence of other insect or disease pests (Pronos 1978).

In 1975, there was no season-long ozone dosage information available for a forested site in the Southern Sierra Nevada. In 1976, the Forest Service established an ozone monitoring station at Whitaker's Forest (elevation 5400 feet) some 50 miles due east of, and downwind from, Fresno. The 1976 data from that station's monitoring effort confirmed the presence of ozone in sufficient seasonal dosage to account for the symptoms observed on ponderosa and Jeffrey pines in the general area. The seasonal dose was approximately one-fifth to one-quarter of the dosage recorded in the highest ozone areas of the San Bernardino Mountains. The highest maximum hourly average for 1976 was 14 parts per hundred million (pphm). The federal standard of eight pphm in 1976 was exceeded on more than half the days from mid-July through September (Smith 1977). The Federal Standard for ozone was revised upward by the EPA in February 1979, from eight to 12 pphm, which could significantly reduce the number of days when this new standard is exceeded. The California standard for oxidant (in this case ozone) is 10 pphm.

Ozone monitoring of the San Joaquin Air Basin by the California Air Resources Board in 1976 showed that the highest ozone concentrations were occurring downwind from the urban centers and the highest seasonal dosages were found 30 to 60 miles downwind in the foothills and mountains of the Sierra Nevada (Smith 1977).

In 1977 an ozone injury survey was conducted on the Sierra and Sequoia National Forests. The survey was designated to identify sites where ozone symptoms were present or absent on ponderosa and Jeffrey pines, and to determine the actual extent of oxidant injury. Only these two pine species were included because they are the conifers in California which most readily indicate ozone injury. The results showed that on 68 percent of the plots at least one tree out of 10 had ozone injury symptoms. The worst injury found was considered to be at a "moderate" level and accounted for less than six percent

of the plots. The most seriously affected plots were all located between 4000 and 7000 feet on the Sierra Nevada's western slopes adjacent to the San Joaquin Valley, or along major river drainages (Pronos 1978).

Two trend plots, located approximately 50 miles east of Fresno, were visited and rated for injury each year since 1974. According to Pronos neither plot showed any consistent increase or decrease in smog injury ratings between 1974 and 1978.

Monitoring stations were also established at Park Ridge Lookout (elevation 7500 feet), two miles north of Whitaker's Forest, and at Mountain Home State Forest (elevation 5900 feet), thirty-five miles south of Whitaker's Station. The locations of these monitoring stations are indicated on Figure 5-3.

During 1977, the Forest Service Insect and Disease Management Staff monitored ambient ozone levels at Whitaker's Forest, Park Ridge Lookout, and Mountain Home State Forest. Ozone doses and exposure times in excess of the federal standard of 12 parts per hundred million (pphm) were greatest at Whitaker's Forest. Comparison of August ozone readings between 1976 and 1977 at Whitaker's shows an increase greater than two pphm in the average daily maximum ozone level. Ozone data collected from Shaver Lake south to Mountain Home suggest that day-to-day fluctuations and overall trends in ozone levels are similar throughout this area and are not just peculiar to Whitaker's Forest (Pronos 1978).

Although smog symptoms are found on ponderosa and Jeffrey pines throughout most of the Sierra and Sequoia National Forests, the exact level of damage being done to these trees is unknown.

It was concluded that:

> Ozone symptoms are common and wide-spread in much of the southern Sierra, but ozone is not causing moderate or worse injury on a forest-wide basis.
>
> Although few in number, localities with moderately injured pines do exist.
>
> The worst injury found was located on front range mountains adjacent to the San Joaquin Valley or along major river drainages.
>
> Ozone-sensitive trees will probably suffer continued injury as past seasonal ozone doses recur.
>
> The level of injury has not consistently increased or decreased since 1974.
>
> Ozone concentrations sufficient to cause injury to pines can be measured from Shaver Lake south to Mountain Home State Forest (Pronos 1978).

Given the present levels of ozone and of ozone injury to pines at widely scattered sites, and the possibility that ozone doses may increase, the present condition in these two National Forests appears to be one of great potential rather than actual damage (Pronos 1978). Experience in Southern California suggests that trees now classed as "sensitive" in the Sequoia and Sierra National Forests will continue to show a visible decrease in vigor if annual doses remain about the same (Miller 1979). Sufficient information has been collected to show that there are large areas of these forests where ozone injury is absent or so low as to be inconsequential (Smith 1977). Forest Service monitoring and trend plot evaluation in the southern Sierras are currently active and continuing programs (USFS January 1979).

NORTHERN CALIFORNIA FOREST LANDS

No regular oxidant damage surveys have taken place on forest lands in the more northern parts of the State and on the east side of the Sierra Nevada range. The Forest Service plans to make spot checks on National Forest land throughout the central and northern Sierras to define the geographical distribution of ozone injury symptoms within National Forest lands. From Figure 5-1 it could be assumed that some damage to pines may result from Central Valley oxidant transport easterly into the mountains.

A March 1979 ARB publication reported that ozone which formed in the Sacramento area during the June-October 1978 survey period was carried by the prevailing northeast wind flow in an elliptical pattern about 55 miles long and 35 miles wide. Typical-day ozone transport did not reach the Tahoe Basin from the greater Sacramento area.

Excessive automobile traffic such as occurs in the Lake Tahoe area may result in decreased visibility and in the production of ozone. Ozone damage on pines has been observed downwind from Lake Tahoe toward Luther Pass. Heavy particulate-laden wood smoke may also occur in areas with large numbers of recreation camp fires (USFS January 19, 1979).

The California Energy Commission is encouraging an increase in the production of electricity from geothermal powered plants. These kinds of plants may produce moderate to high amounts of sulfur in the form of hydrogen sulfide (H_2S). This pollutant could cause forest damage depending on the amount of H_2S released, the closeness of the forest, the topography, and the meteorological conditions, according to the Forest Service.

There are plans for building fossil-fuel powered electricity generating plants in the Central Valley of California. These coal and oil burning plants could produce large quantities of sulfur dioxide (SO_2) which, if released, would be distributed in patterns similar to the ozone distribution from the central valley southeastward into the forest. In high enough quantities, SO_2 would cause damage to the forest vegetation. An "acid rain" situation might also result from these facilities unless adequate measures were taken to prevent such emissions.

In those mining activities in which the initial processing of the ore is accomplished on forest land, there is the potential for release of heavy metals and sulfur compounds into the atmosphere. Both groups of these compounds damage a wide variety of plants, including trees. One example of this is occurring at a tungsten mine on the east side of the Sierra Nevada (USFS 1979).

FOREST MANAGEMENT, RESULTING AIR IMPACTS AND CONTROLS

Forest land management activities which will generate air pollutants can be placed in four categories:

Cultural treatment by prescribed burning to remove or reduce undesirable species or control species density; to prepare land for reforestation.

Chemical spraying of pesticides and herbicides to control insects, diseases, and undesirable vegetation.

Resource protection by broadcast burning to reduce fuel loads.

Logging activities such as road building, unpaved road use, and log skidding which cause dust (particulate) emissions.

PRESCRIBED BURNING

Smoke from burning woody fuels, brush and ground litter is the primary air pollutant generated by timber management practices and type conversion. Currently nearly all such material burned is in the form of piled slash or brush resulting from tree removal or reforestation projects though some range management burning contributes to air contaminants (USFS 1978).

Air pollutants released through burning forest vegetation are substantially different in character from those generated by industrial or automotive sources. This can be attributed to the relatively low temperatures attained, and the nature of the material burned. According to the California Air Resources Board (ARB) pollutants resulting from the burning of forest fuels are harmful when produced in quantity or added to an already polluted atmosphere (see Table 5-1).

Particulate matter produced by forest fuel combustion (smoke and ash) is probably the most objectionable feature of prescribed fire, especially in the creation of small particulates which are identified as a health hazard. Smoke lessens visibility, and is considered esthetically and physically displeasing by many people. However, emissions from the burning of natural fuels are unique in many respects when compared to fixed continuous industrial sources or automotive sources. The Forest Service, 1978 Timber Management Plan points out these unique properties which include:

Composition--chiefly particulates, carbon dioxide, water vapor.

Timing--seasonal and annual.

Duration--usually less than 24 hours.

Nonpoint sources (in comparison to most industrial sources).

Can be managed to minimize impact on air quality.

Though chaparral is not a forest vegetative type, it is closely associated with and can be intermixed with trees. Chaparral management can have an impact

TABLE 5-1

THE APPROXIMATE RANGE OF FOREST FUEL AND GASOLINE AIR EMISSIONS WHEN ONE TON OF EACH FUEL IS BURNED

	Forest Fuel 1)	Gasoline 2)	
		Controlled	Uncontrolled
Carbon dioxide (CO_2)	2,000-3,500	---	--- lbs/ton of fuel
Water (H_2O)	500-1,500	---	---
Carbon Monoxide (CO)	20- 500	305	915
Particulates (TSP)	17- 67	3.3	6+
Hydrocarbons (HC)	10- 40	35	90
Nitrogen Oxides (NO_x)	2- 6	25	38

1) Source: EPA, October 1978
2) Burned in a controlled and uncontrolled emissions, 15 miles per gallon, light-duty vehicle (source ARB, 6/78)

on adjacent forest land, particularly on air quality.

Vegetation management by prescribed burning in the chaparral types offers an opportunity for improvement of air quality. Wildfire in this type of vegetation is inevitable, particularly in Southern California. Wildfires in the chaparral type are frequently catastrophic in terms of air quality deterioration, loss of watershed values, and off-site damages resulting from flooding and associated debris movement. Timberland burned-acreage has increased in the last decade. Whether this trend will continue is unknown, but such wildland fires add significantly to air pollution during the summer season. Substantial reductions in these adverse effects, including air quality degradation, can be achieved through prescribed burning. Prescribed burning programs can result in managed air quality effects and substantial reductions in other resource losses. The inevitability of fire in the chaparral type makes the continuation of prescribed burning an important consideration in the development of air quality management policies.

PESTICIDES

The portion of pesticide spray that is moved away from the target area by wind or other meteorological factors is known as "drift." Part of this drift may come to rest outside the target area, and part is dispersed into the atmosphere. Drift can be minimized by spraying under controlled climatic conditions with minimal wind and high humidity and by ground rather than aerial applications. Pesticide formulations are also used to reduce drift of aerial sprays. These are classified as (1) invert emulsions, (2) spray thickeners, (3) particulating agents, and (4) foaming agents. These reduce drift by increasing droplet size, by increasing viscosity of the spray solution, or by producing a larger particle or globule that contains the pesticide (TMP, April 1978).

According to the ARB (Lockett February 5, 1979) current research indicates that in some areas of the State, certain pesticide applications may contribute significantly to total reactive organic emissions, such as hydrocarbons, depending on the types and amounts of carrying agents used. Research in this area is just beginning; therefore, the effect on forestland vegetation has not yet been determined (see Chapter Seven, "The Forested Rangeland").

LOGGING

Preliminary search did not produce data on the amounts of dust particulate matter introduced into the air within logging areas and from vehicles travelling unpaved logging roads. Generally, unpaved roads are watered or are treated with dust abatement materials during logging operations. If not treated, logging or recreation or other traffic can produce clouds of dust which will settle out at varying distances from the roadway, coating nearby vegetation and allowing wind dispersion of particulates.

CURRENT INTERGOVERNMENTAL INVOLVEMENT

In 1967 the California Air Resources Board was created by Senate Bill 490 (Mulford-Carrell) in response to a growing awareness of air quality problems. The ARB and the closely related Air Resource Control Districts (ARCD) interact with many governmental agencies in the field of air quality improvement and control (see Appendix item II).

Within the forested areas of the State, the ARB and the ARCD's (generally formed on county lines) coordinate with the CDF and the Forest Service, particularly with regard to the management of fire, which in turn relates to controlled and uncontrolled fire with its attendant suspended particulate matter and visibility problems.

ARB and ARCD local agriculture burning rules regulate agriculture, range, land

improvement, and forest management burning. The ARB and fire management or control agencies cooperate in administering the State agricultural burning program and the ARCD's issue permits for agricultural burning based on ARB designation of "burn days" (ARB October 1978). ARCD's may issue burn permits on ARB "no burn" days if an economic hardship exists.

State and local rules pertaining to particulate matter and visible emissions are explicit for urban areas. Various exceptions are provided for under State law, e.g., fires set by public officers for fire hazard abatement, to save life or valuable property, and for certain disease and pest prevention when no other reasonable alternatives are available (Section 41801, Public Health and Safety Code).

The most significant relationship between the State of California and the federal government, in the area of State Implementation Plan development and that Plan's implementation, exists between the ARB and the Environmental Protection Agency (EPA) (ARB, October 1978).

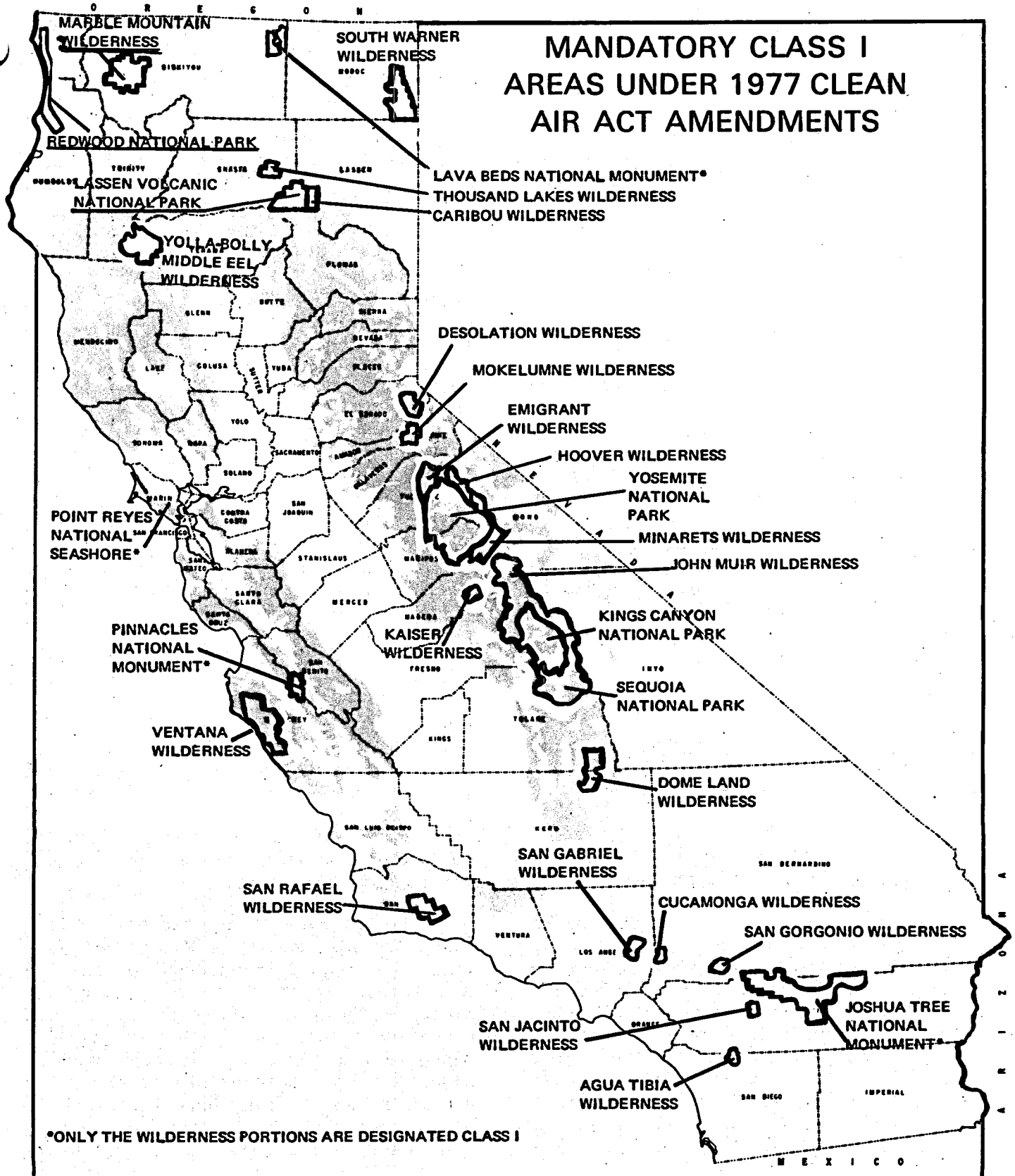
In October 1977, the regional directors of the Bureau of Land Management, Forest Service, and National Park Service having responsibility in California, issued a policy statement in which were set forth air quality goals to:

> Minimize the impacts of their respective land management activities on air quality.
>
> Manage lands in a manner consistent with State and federal air quality laws and regulations.
>
> Prevent off-site air pollution from adversely influencing use of federal lands.
>
> Actively seek cooperation of federal, State, county and local agencies.
>
> Weigh the benefits of certain land management activities against possible air quality deterioration.
>
> Continue studies on air pollution damage to forest and range resources.

The policy statement was included in a letter to the Air Resources Board indicating that the statement would serve as a basis for decision making regarding any activities which would affect air quality on lands administered by the agencies. The ARB, along with these agencies, finds that much of the land under federal agency jurisdiction deserves special protection to insure the attainment or maintenance of superior air quality.

The 1977 Clean Air Act amendments established as a national goal "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I federal areas where such impairment results from man-made air pollution." These Class I areas include all international parks, wilderness areas, and national memorial parks over 5,000 acres, as well as all national parks over 6,000 acres. All of these areas in existence on August 7, 1977 (Figure 5-5) have been so classified. Two pollutants, particulate matter and sulfur dioxide, according to the Act, shall not be allowed to increase over baseline concentrations by specific amounts (which are different for Class I, II, or III) as measured in micrograms per cubic meter. Concentration limits for certain other pollutants, e.g., carbon monoxide, photochemical oxidants, lead, and nitrogen oxides must be set and regulations for their control are to be promulgated within two years after the enactment of the Clean Air Act Amendments.

Restrictions could be expected upon management practices which create visibility impairment, in Class I areas, in-



*ONLY THE WILDERNESS PORTIONS ARE DESIGNATED CLASS I

SOURCE: AIR RESOURCES BOARD, CHAPTER 25, In INTERGOVERNMENTAL RELATIONS, SIP, 10/78

cluding prescribed and slash burning (Lockett May 17, 1979).

In California, the Air Resources Board is developing a program termed the Air Conservation Program (ACP) which will implement as well as supplement the Clean Air Act Amendment mandates. The goal of the Air Conservation Plan is to maintain superior levels of air quality in areas that already experience relatively clean air (TMP, April 1978).

If the current proposal is implemented, areas of the State would be classified in one of four categories (Class A, B, C, D), ranging from areas where very little deterioration of air quality would be permitted (Class A) to areas where moderate to substantial deterioration would be allowed (Classes B and D). Class C (agricultural and silvicultural areas) is intended to serve as an identification of areas where vegetation (such as timber resources) will be protected to prevent unacceptable economic losses (Lockett, February 5 and May 17, 1979).

Class A areas would be equivalent to Federal Class I areas; very little if any air quality deterioration would be allowed except by unavoidable circumstances, such as wildfire (see Figure 5-5. At this point, the ACP is a proposal only. Several years will be required to classify all areas and develop regulations to protect clean air areas.

Class I or A designations for parks and wildernesses will not automatically ensure their pure air status because meteorological transport of polluted air from lower classification areas will continue to invade these areas, particularly in the southern part of the State. Also, when comparing Figures 5-2 and 5-5, inference should not be made that the wilderness and park lands in 5-5 are islands of pure air in a sea of unacceptable air quality. The nonattainment planning process also applies to the Class I areas which do not meet current air quality standards.

The Forest Service and the Park Service are preparing written air quality goals which consider ongoing management programs in their respective wilderness areas. The EPA will use these goals during the development of methodologies to provide objective measurements of visibility. Until these technical methodologies are perfected, visibility related control regulations will certainly be subject to challenge. Several studies have been initiated to generate the basic data that must precede announcement of regulations. The hope is that cooperation and accurate data will result in regulations that protect the air while accommodating forest users (Day, August 1978).

Statistics on prescribed burning as a range improvement measure do not differentiate between a forest-brush range vegetative type and a grass-brush ecosystem. Much range improvement work occurs in the interface areas between the two ecosystems. This topic is discussed in greater depth in Chapter Seven.

The CDF received a high of 117 applications for controlled burning permits in 1974 and a low of 63 applications during 1977. There is an increase in the number of smaller burns conducted during the winter and spring seasons throughout California.

The Forest Service has recently established an Air Resources Management System. These guidelines require managing all burning operations to prevent or minimize the penetration of smoke into populated areas. Under the Air Resource Management System, heavily populated or high use areas susceptible to excessive accumulations of emissions into the air as a result of concentration sources, and climatic and topographic restraints on ventilation, have been designated as Smoke Sensitive Areas (SSA). The SSA's

include the air space to a ceiling of 3,500 feet above the ground surface (TMP, April 1978).

Only limited burning is permitted when smoke will disperse in air that is moving toward an SSA. No burning will be permitted if the smoke will reach the sensitive area at elevations below the area's specified ceiling when the fire is less than 30 miles away. Limited burning is permitted if the smoke will be dispersed through a deep layer extending above the SSA ceiling.

Only under special conditions will unlimited burning be permitted. This may occur when smoke will be blown directly away from SSA's or, if toward, only when the nearest such area is no closer than 100 miles downwind, or if the smoke rises into the base of a precipitating cloud system.

The Forest Service's Pesticide-Use Coordinating Committee (PUCC) reviews all proposed pesticide applications within National Forests. The PUCC works in conjunction with the Environmental Protection Agency, the State Departments of Food and Agriculture, Fish and Game, and the County Agricultural Commissioners to ensure that all regulations and requirements are met. In accordance with the National Environmental Policy Act of 1969, Forest Service Regional policy requires all proposed pesticide uses to be accompanied by an Environmental Analysis Report (EAR) (USFS, January 19, 1979).

In 1978, an EPA-sponsored group consisting mostly of researchers from the Berkeley and Riverside campuses of the University of California, the Pacific Southwest Forest and Range Experiment Station, and the Statewide Air Pollution Research Center was established. This group's initial goal is to establish coordination between study projects of forest succession in oxidant-damaged stands and the forest managers carrying out the forest management processes.

CONCLUSIONS

Research and field survey information on the adverse impacts on forests of air pollution is a relatively new science. What information is available has been generated principally in the southern part of California where the oxidant decline and mortality among certain pine trees was first recognized.

Future oxidant and pesticide damage to forest land is dependent on the adequacy of controls exercised by federal, State, and local agencies.

Air pollution impacts, particularly from smoke particulate matter originating on forest lands, are a matter of regulation and there must be trade-offs between economics and environmental purity.

Wildland fuel buildup on forest, brush, and rangeland leads to periodic mass uncontrollable fires, which produce vast quantities of objectionable air pollutants. The drift of this material is also uncontrollable and would easily violate the pristine air quality in Class I areas scattered about the State. Smoke management by prescribed burning would lessen this uncontrolled adverse impact.

Current air standards and regulations are so tight and controlled burn costs so high that an acceptable solution to the problem Statewide is unlikely unless realistic goals are formulated and compromise regulations, standards, and procedures established to which all parties (ARB, EPA, CDF, USFS, NPS, etc.) involved can agree. Much research needs to be done to truly ascertain the true picture of air pollution and its effect on forest land management.

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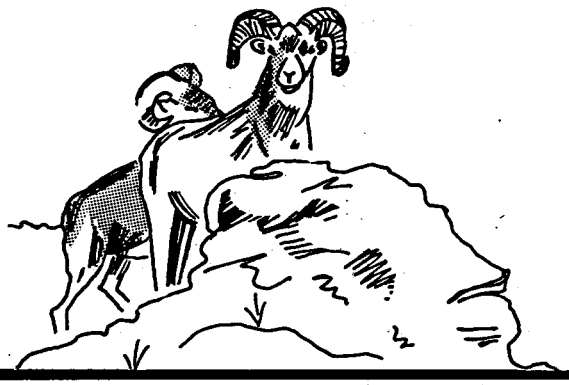


INTRODUCTION

Conservationist Aldo Leopold pointed out that there is an ethical aspect to the preservation of fish and wildlife. A "land ethic," in Leopold's words, "affirms their right (plants and animals) to continued existence, and, at least in spots, their continued existence in a natural state" (Leopold 1947).

FRAPA includes a provision to evaluate opportunities to improve wildlife and wildlife habitat management on the forest lands of the State; and to assess and analyze the present status of the fish and wildlife resources of forested lands.

As California's human population increases, the opportunities for using and enjoying fish and wildlife are changing. More and more people want to fish, hunt, and enjoy wildlife in the outdoors. The current pace of human community growth and development in California is such that only a commitment to a "land ethic" will enable fish and wildlife resources to remain as an important attribute of this State. This becomes more apparent as demands for wood and energy increase and the management of forest lands is intensified. The opportunity still exists, however, to conserve, and even to enhance, the fish and wildlife resources on the forested lands of California.

OVERVIEW

THE VALUE OF FISH AND WILDLIFE RESOURCES

The fish and wildlife resources of California have direct and indirect economic values as well as aesthetic and natural values. The direct economic values derive from fish and wildlife support of commercial industries. For example, in 1977 the fur trapping industry netted $895,600; and in 1975 the commercial salmon industry netted 6.9 million dollars. Both of these industries rely to some degree upon forest land habitat.

Indirect economic values accrue to business and rural communities as a result of over six million people participating annually in hunting and fishing activities, together with other wildlife-related recreational pursuits, support major tourist and recreational industries throughout the State. Through a special excise tax on sporting arms, ammunition, and fishing tackle, hunters and fishermen support most of the State's fish and wildlife management programs.

More and more people are choosing to sightsee, birdwatch, and photograph wildlife in natural surroundings. These aesthetic pursuits are increasing so rapidly that conflicts exist between the consumptive users (hunters and fishermen) and nonconsumptive users (birdwatchers, photographers, etc.).

The scientific value of fish and wildlife resources also necessitates their protection. The natural diversity of wildland plants and animals provides a repository for yet-to-be-discovered "scientific breakthroughs." It is impossible to predict what species of fish, wildlife, or plant life, perhaps presently obscure, will provide some clue to human health and survival...in the tradition of the discovery of mold as a source of penicillin; the use of the Klamath beetle for control of the Klamath weed; or the use of the native plant, meadow foam, (Limnanthes) as a possible alternative for sperm whale oil.

Ecological systems should be maintained as close to natural diversities and

balances as possible because we do not truly understand them well enough to do away with these natural components.

PRESENT SUPPLY OF FISH AND WILDLIFE RESOURCES ON FORESTED LANDS

MAMMALS

At least 209 species of mammals reside in California; many of them associated with forested lands. The exceptions are marine mammals, and species endemic to the Sacramento-San Joaquin Valley and the California desert. Some of the mammals found in California's forested lands are considered endangered, rare, or threatened under guidelines established both by the State and federal governments, (see Table 6-1) or are species of special concern according to the criteria established by the State Department of Fish and Game (see Table 6-2). Table 6-3 lists those mammals which are considered "sensitive species" by the Forest Service. About 30 percent of the forest wildlife, many of which are listed in the previous tables, inhabit old-growth forest. Successional stages of vegetation are habitat for the remaining 70 percent of the forest wildlife. Such species as deer, mice, rabbits and quail prefer this type of habitat.

Big game animals inhabiting forested lands in California include deer, black bear, elk, bighorn sheep, mountain lion, and wild pig. Deer and black bear have received considerable attention over the years because of their visibility and importance to the State's hunting program. Other species such as tule elk and bighorn sheep have become more visible because of the efforts of the Department of Fish and Game to transfer and relocate these mammals to establish new populations.

TABLE 6-1

ENDANGERED, RARE AND THREATENED SPECIES ON FORESTED LANDS OF CALIFORNIA

1. SPECIES CLASSIFIED AS ENDANGERED

   A. California condor (also federal classification)
   B. American peregrine falcon (also federal classification)
   C. Southern bald eagle (also federal classification)
   D. Blunt-nosed leopard lizard (also federal classification)
   E. San Francisco garter snake (also federal classification)
   F. Shortnose sucker
   G. Lost River sucker
   H. Unarmored threespine stickleback (also federal classification)

2. SPECIES CLASSIFIED AS RARE (STATE CLASSIFICATION ONLY)

A. California Bighorn
B. Peninsular Bighorn
C. San Joaquin kit fox (endangered under federal classification)
D. Wolverine
E. Alameda striped racer
F. Southern rubber boa
G. Siskiyou Mt. salamander
H. Limestone salamander
I. Shasta salamander
J. Kern Canyon slender salamander
K. Tehachapi slender salamander
L. Modoc sucker
M. Rough sculpin

3. SPECIES CLASSIFIED AS THREATENED (FEDERAL CLASSIFICATION ONLY)

A. Lahontan cutthroat trout
B. Paiute cutthroat trout
C. Little Kern golden trout

TABLE 6-2

SPECIES OF SPECIAL CONCERN

1. SPECIES OF SPECIAL CONCERN (AS NOTED BY CALIFORNIA DEPARTMENT OF FISH AND GAME ON FORESTED LANDS OF CALIFORNIA)

A. MAMMALS

1. Fisher
2. Marten
3. Sierra red fox
4. White-eared pocket mouse
5. Yellow-eared pocket mouse
6. Red-backed tree vole
7. Northern flying squirrel
8. Mountain beaver
9. Mt. Pinos lodgepole chipmunk

B. BIRDS

1. FIRST PRIORITY

a. Barrow's goldeneye
b. Harlequin duck
c. Swainson's hawk
d. Merlin
e. Great gray owl
f. Willow flycatcher

2. SECOND PRIORITY

   a. Cooper's hawk
   b. Osprey
   c. Spotted owl
   d. Long-eared owl
   e. Short-eared owl
   f. Purple martin
   g. Yellow warbler
   h. Yellow-breasted chat

3. THIRD PRIORITY

   a. Goshawk
   b. Sharp-shinned hawk
   c. Golden eagle
   d. Prairie falcon
   e. Ruffed grouse
   f. Black swift
   g. Black-capped chickadee
   h. Marbled murrelet

TABLE 6-3

SENSITIVE SPECIES CLASSIFIED BY U.S. FOREST SERVICE
ON FORESTED LANDS OF CALIFORNIA

A. MAMMALS

   1. Tule Elk
   2. Nelson bighorn sheep
   3. Mt. Pinos chipmunk*

B. BIRDS

   1. Prairie falcon*
   2. Osprey*
   3. Spotted owl*
   4. Golden eagle*
   5. Goshawk*
   6. Mt. Pinos blue grouse

C. AMPHIBIANS

   1. Red-legged frog

D. FISHES

   1. Dolly Varden trout
   2. Redband trout
   3. South Fork Kern golden trout

*Also included on State's list of species of special concern.

Deer

Four of the six subspecies of deer found in California, the Columbian black-tailed, the California mule deer, the Rocky Mountain mule deer, and the Inyo mule deer, are associated with forested lands. The other two, the burro and southern mule deer, are not associated with forest lands. Favorable habitat for deer occurs on 56 million acres or 56 percent of the State. Deer habitat must include vegetation suitable for hiding, feeding, fawn rearing, and thermal protection. Figure 7-2 in the chapter on forested rangelands illustrates the distribution of deer herds in the State.

The deer herds, of which there are approximately 109 recognized Statewide, peaked in size beyond the long-term carrying capacity of their ranges during the 1950's and the early part of the 1960's because of favorable habitat conditions as a result of prescribed burns, conversion of land for grazing, and timber harvesting. Since the mid 1960's, many of the deer herds in California have declined 60 percent. This population reduction can be attributed to the loss of habitat due to such things as second home subdivisions, water impoundments and road construction; effective fire suppression activities within the forested areas which has halted large scale creation of suitable successional habitats. The historic overpopulation of deer itself have also contributed to the decline. Many of these activities have taken place on the winter ranges, making these habitats a limiting factor insofar as the future possibility of increasing deer numbers. When a deer population exceeds the long-term carrying capacity of its range, severe damage to existing preferred forage occurs. There can be little doubt that deer themselves have been responsible for a major share of the depletion of their own habitat and in consequence their subsequent decline in numbers (Longhurst et.al. 1976).

Approximately 31,000 deer were reported harvested in California in 1978. About 33 percent of the deer harvest takes place in the northern counties of Humboldt, Del Norte, Trinity, Shasta, Modoc, Lassen, and Siskiyou. Most of the remaining harvest is from the Sierra Nevada and Coast Range mountains. The present deer population is estimated at 500,000 animals (see Chapter Seven, "The Forested Rangelands," for further discussion of forage outputs on deer range).

The Statewide deer population has remained static since 1975. Some areas have shown a slight increase in deer numbers since then. This increase may be attributed to range recovery and better fawn survival during the mild winters of 1976 and 1977. The recovery of California's deer herds is a major program and priority of the Department of Fish and Game (CDFG 1976). The plans will be developed cooperatively with public and private land managers. The Department of Fish and Game is presently developing individual herd management plans for the deer herds in California. Thirty of these plans are expected to be completed by 1979 and the remainder by 1981.

Bear

The black bear is the only species of bear extant in California, even though there are brown, black, cinnamon, and blond color phases within the species. The grizzly bear, once native to California, was extirpated from the State by 1922.

Black bears are creatures of the forest and adjoining woodlands; they require timber stands and berry producing brushfields in their habitat. Because the exact status of the black bear population in California is unknown, the Department of Fish and Game in 1978 initiated a three-year study to determine that. It appears that the Statewide

bear population is fairly stable, since numerous national parks, State refuges, and wilderness areas provide either total protection or limited human access into bear habitat. An estimate of the bear population is not available, however, in 1978, 655 bears were reported harvested from forest lands. The reported harvest could underestimate actual legal harvest by 20 to 30 percent.

Sheep and Elk

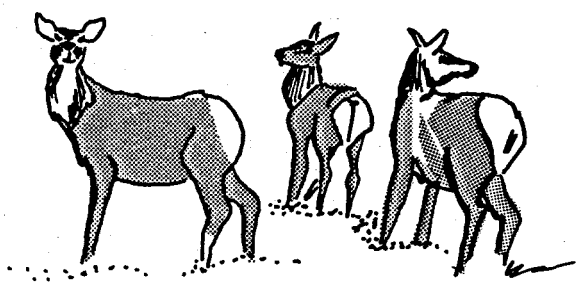
Bighorn sheep have been protected in California for over 100 years. Three subspecies associated with forested lands are the California, Peninsular, and Nelson bighorn. The California bighorn, with an estimated population of 275 animals, ranges along the crest of the Sierra Nevada in the vicinity of Mt. Baxter and Mt. Williamson in Inyo County. The Peninsular bighorn sheep occupy a range within the Santa Rosa Mountains in Riverside County and the Anza-Borrego Desert State Park in San Diego and Imperial Counties. The population is considered stable at approximately 1,100 animals. Both subspecies are listed as rare on the State's list of rare and endangered animals, shown on Table 6-1. The Nelson bighorn is associated with the forested lands in the San Gabriel, San Bernardino, and White mountains. The State population is approximately 2,600 animals. Human encroachment, competition for forage with feral burros and horses, vegetation changes, and diseases are considered to be limiting current populations.

Three subspecies of elk are associated with forest habitat in California. Two subspecies, the Roosevelt and tule elk, are native; the Rocky Mountain elk were introduced. Tule elk are being relocated from the Owens Valley herd to suitable habitat in-State to establish new herds and comply with the Legislative directive which states that the minimum population of tule elk will be at least 2,000 animals. The present estimated number of tule elk is 800 animals. The Roosevelt elk population on the North Coast of California is remaining stable at 2000 animals. Introduced populations of Rocky Montain elk are located in Shasta, Kern, and Monterey Counties. The Statewide population is estimated at 1,200 animals. No elk were harvested in 1978. (Figure 7-1 in Chapter Seven, "The Forested Rangelands," illustrates the Statewide distribution of elk and sheep.) The amount of suitable grassland habitat and intraspecific competition are the major factors constraining elk populations.

Other Mammals

Department of Fish and Game personnel believe that mountain lions have increased in numbers since abolition of the State's trapping program and bounty system in 1963. Estimates place the population at approximately 2,400 cats. They are found throughout the State except in the Sacramento and San Joaquin Valleys. The main food item for these animals is deer, thus making this species highly dependent on the forest ecosystems which produce those animals. Current law prohibits the sport harvest of mountain lions. Legislation has recently been introduced to have a limited harvest on the cats. Limiting factors on lions may include the deer prey base and the spatial requirements of lions themselves.

Wild domestic and introduced European pigs are widely scattered throughout the oak woodland-oak grassland communities in California. Little data are available on the wild pig populations in



California and little is known regarding the extent of their range and population densities. Pigs are a significant big game species, with an estimated annual harvest ranking second only to deer. They can also cause severe depredation problems for agriculture and forestry.

Furbearing mammals are a group of animals characteristic of the forested lands of California. Species such as the pine marten, fisher, and wolverine are particularly adapted to the old-growth coniferous forests. California legislation has classified the following as furbearing mammals:

pine marten	red fox
fisher	raccoon
wolverine	beaver
mink	badger
river otter	muskrat
gray fox	ring-tailed cat

Those mammals which are fully protected are the:

pine marten
fisher
wolverine
river otter
red fox
ring-tailed cat

The wolverine has been classified by the California Fish and Game Commission as rare. Its range extends from Del Norte and Trinity Counties eastward through Siskiyou and Shasta Counties and southward through the Sierra Nevada Mountains to Tulare County. Because of its secretiveness the wolverine is only rarely seen. Since 1950, 87 sightings have been recorded; 27 of which have been reported since 1970. Available information suggests, however, that the numbers of wolverine are increasing in California, according to DFG (see Figure 6-1).

Several other animals found in California's forests important to the fur industry are the coyote, bobcat, striped skunk, weasel, and oppossum.

Very little is known about the biology and distribution of furbearing mammals on forested lands, particularly on the private forested lands. Much more emphasis, however, is being placed on the study of these animals.

Information is lacking on many other mammal species within forest ecosystems because they are not economically or aesthetically important. Numerous species of voles, deer mice, squirrels, chipmunks, bats, moles, and shrews, etc., on which population levels and density information is not available or is widely scattered as unpublished reports, are associated with forested lands. Information is also lacking on the interactions of these animal species at the ecosystem level.

BIRDS

Approximately 530 species of birds have been observed in California. The Forest Service wildlife habitat relationship study for the Western slope of the Sierra Nevada alone lists 209 species associated with forest lands. When additional habitat relationships are developed for the remaining regions of the State, a more complete list of the birds on forested land will be available.

Birds associated with forest lands can be grouped into the broad categories of:

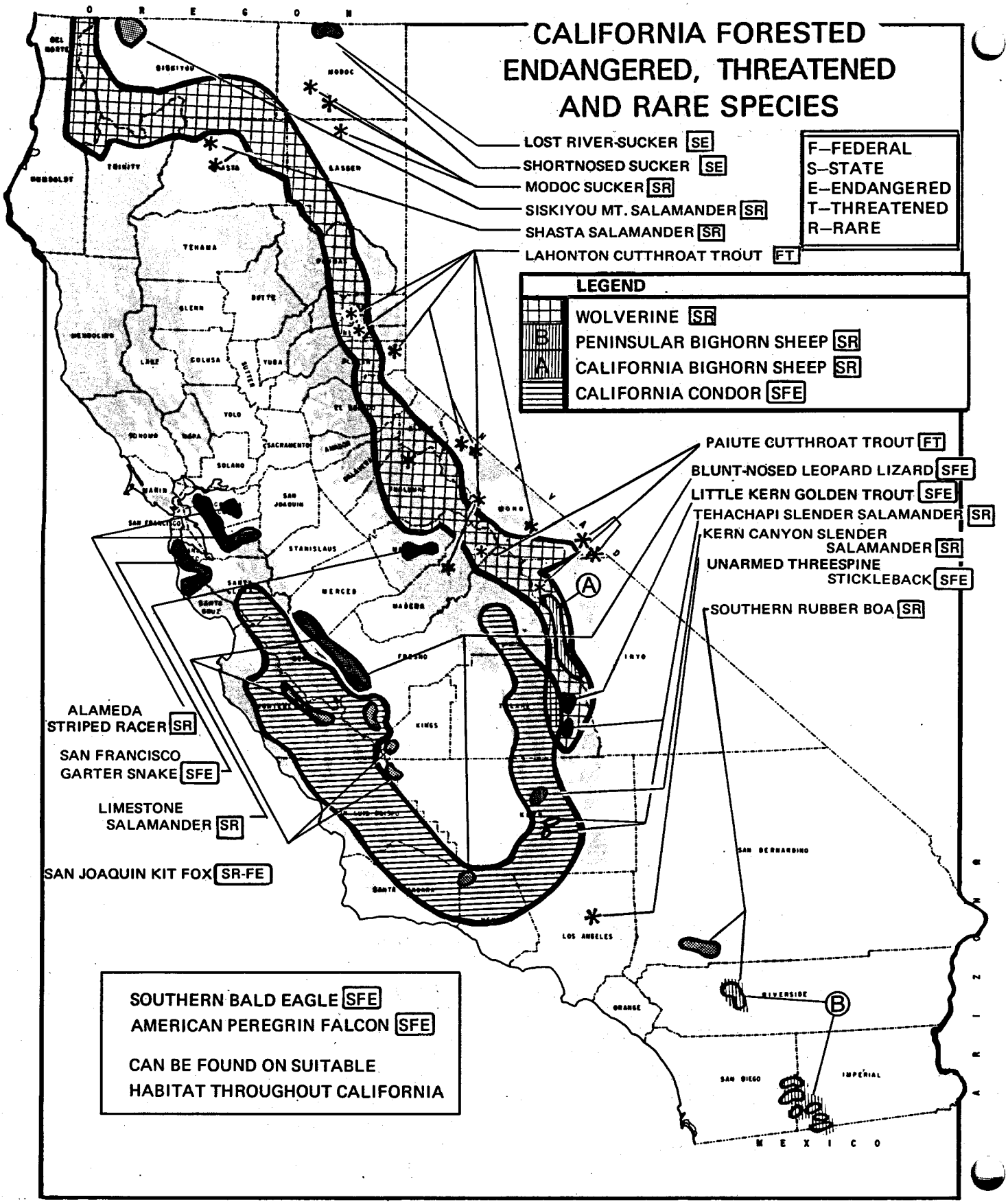
waterfowl
raptors
upland game
all other birds

Waterfowl

Many species of waterfowl including ducks, geese and swans are associated with waters which are surrounded to some degree by forested lands.

Waterfowl species, such as the wood duck, merganser, and goldeneye, depend on cavities in trees adjacent to lakes or streams in the riparian forest envi-

FIGURE 6-1


CALIFORNIA FORESTED
ENDANGERED, THREATENED
AND RARE SPECIES
LOST RIVER SUCKER SE
SHORTNOSED SUCKER SE
MODOC SUCKER SR
SISKIYOU MT. SALAMANDER SR
SHASTA SALAMANDER SR
LAHONTON CUTTHROAT TROUT FT
F–FEDERAL
S–STATE
E–ENDANGERED
T–THREATENED
R–RARE
LEGEND
WOLVERINE SR
PENINSULAR BIGHORN SHEEP SR
CALIFORNIA BIGHORN SHEEP SR
CALIFORNIA CONDOR SFE
PAIUTE CUTTHROAT TROUT FT
BLUNT-NOSED LEOPARD LIZARD SFE
LITTLE KERN GOLDEN TROUT SFE
TEHACHAPI SLENDER SALAMANDER SR
KERN CANYON SLENDER SALAMANDER SR
UNARMED THREESPINE STICKLEBACK SFE
SOUTHERN RUBBER BOA SR
ALAMEDA STRIPED RACER SR
SAN FRANCISCO GARTER SNAKE SFE
LIMESTONE SALAMANDER SR
SAN JOAQUIN KIT FOX SR-FE
SOUTHERN BALD EAGLE SFE
AMERICAN PEREGRIN FALCON SFE
CAN BE FOUND ON SUITABLE HABITAT THROUGHOUT CALIFORNIA
A
B
OREGON
NEVADA
MEXICO
SISKIYOU
MODOC
TRINITY
SHASTA
LASSEN
HUMBOLDT
TEHAMA
PLUMAS
GLENN
BUTTE
MENDOCINO
LAKE
COLUSA
YUBA
YOLO
SONOMA
NAPA
SACRAMENTO
SOLANO
MARIN
SAN JOAQUIN
SAN FRANCISCO
STANISLAUS
MONO
MERCED
MADERA
SANTA CRUZ
FRESNO
INYO
KINGS
SAN BERNARDINO
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL

ronment for nesting sites. Many other species utilize lakes and reservoirs surrounded by forest land as a place to rest. The water developments and impoundments in northeastern California are particularly important for nesting waterfowl. The Forest Service in conjunction with the Department of Fish and Game have developed an extensive program to improve wetland habitat in northeastern California. Much of the Canada Goose nesting which takes place within California occurs within the juniper forest area which fits this description. Duck production on forested wetlands is mainly constrained by unregulated cattle grazing of nesting cover vegetation (Salwasser 1979). Very little is known regarding population trends for waterfowl on forested lands. Most of the data regarding waterfowl populations have been collected on birds during migration into the Sacramento and San Joaquin Valleys.

Raptors

Raptors, the term applied to those birds with raptorial or grasping feet such as hawks, owls, vultures, and eagles, include the California condor, the American peregrine falcon, and the bald eagle. Recent studies indicate that many raptor species populations have declined in recent years in California (Mallette and Schlorff 1978).

The endangered California condor once ranged over much of western North America from British Columbia to lower California. Its numbers are now reduced to 30 birds confined largely to the Coast Range, Sierra Nevada, and Transverse Range mountains bordering the San Joaquin Valley. Condors do not breed until they are five or six years old; females lay but one egg every two years and incubation and brooding require a period of six months. The population is dwindling because of decreasing numbers of young, human disturbance and habitat losses. The present habitat for these birds is shown on Figure 6-1.

The endangered American peregrine falcon breeds in-State along the coast and in mountainous northern California. In the 1940's the breeding bird population in California was 100 pair. In 1970, this population was estimated to be only five pair, of which two pair produced four young. In 1978 the DFG reports that 23 nesting territories were documented; from the 16 nests which were monitored 22 young fledged. Nesting failure due to food chain contamination by persistent pesticides, illegal taking by falconers, human disturbance, and occasional shooting are contributing to its decline.

Nesting habitat for the bald eagle is limited to the Sierra Nevada, Cascade, and Klamath mountains. A significant influx of northern birds occurs in winter months. Wintering bald eagles occur Statewide, particularly along the coast and in interior California adjacent to lakes, reservoirs, and wetlands. Large winter roosts consisting of a couple of hundred eagles is not uncommon on Klamath Lake in Siskiyou County. The decline is caused by shooting, removal of nest trees, human encroachment into nesting and feeding areas, power line electrocution, environmental pollution, and contamination of the food chain by persistent pesticides. Approximately 42 nesting territories were occupied in California in 1978, with 18 young fledged.

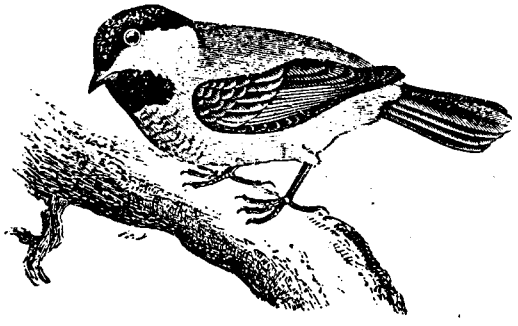
Many other species of raptors, such as the Swainson's hawk, merlin, Cooper's hawk, osprey, goshawk, sharp-shinned hawk, golden eagle, great grey owl, flammulated owl, spotted owl, and saw-whet owl are associated with the forest ecosystem. The goshawk, great grey owl, and spotted owl depend on mature, old-growth forests for habitats. While species such as the merlin and Cooper's hawk need the riparian forest ecosystems. Very little information is available concerning their present status or distribution.

Upland Game

Upland game birds, aside from their aesthetic value, provide recreational hunting for approximately 767,000 sportsmen in California. Blue grouse, mountain and California quail, and band-tailed pigeon are particularly adapted to the forest ecosystem. There have been numerous studies and data gathered associated with these species, mainly because of their popularity as game birds. Wild turkeys, also associated with forest lands, are commonly found in the oak-grassland vegetative community. Although wild turkeys are not native to California, recent introductions have established a population throughout most suitable turkey habitat within the State.

Blue grouse need tall fir trees for winter roost, and mid seral brushlands of berry producing shrubs and forbs for summer habitat. Mountain quail prefer successional stages of forest vegetation that follow logging or a fire. On the other hand, band-tailed pigeons require hardwood forests with mast producing oaks and berry producing madrones.

While turkey populations are still expanding, quail populations tend to fluctuate yearly depending upon the weather conditions or the successional stage of the forest. The migratory band-tailed pigeons tend to fluctuate depending upon their breeding success in Oregon and Washington and the availability of their food supply.



All Other Birds

This group includes such common species as blackbirds, sparrows, jays, finches, warblers, flycatchers, thrushes, crows, orioles, swifts, hummingbirds, and woodpeckers. The habitats for these species range from riparian corridors to chaparral woodlands, alpine meadows to the canopy of virgin red fir.

The population levels of most of these species will probably never be known and it will be some time before the habitat relationships and distributions are fully understood for many of these forest species. A list of the studies presently being conducted is included in this chapter.

FISHES

The fishery resources on forested land in California can be categorized into four broad areas: coldwater, anadromous, warmwater, and nongame fishes. The majority of the popular game fishes such as the striped bass, black bass, catfish, shad, brook trout, and brown trout are not native to California, but were introduced during the last 100 years. Salmon supports an important sport and commercial fishery while trout are an important sport fishery.

Coldwater Fishes

The coldwater fishery is a collective name applied to fish belonging to the family Salmonidae. There are four groups in the Salmonidae family: the trouts, chars, salmons, and whitefish. All these species typically inhabit the colder streams, lakes and reservoirs within the forested land of California. In fact approximately 65 percent of the available coldwater fishery habitat lies within the national forests.

In the inland waters of California, trout are by far the most widespread and most numerous of the Salmonidaes. Sev-

eral species of trout, salmon, and mountain whitefish make up the inland fish group. Generally, they require water temperatures less than 70° F and dissolved oxygen of five parts per million or more. They occur naturally in many waters and have been planted in almost all other suitable places. It is the current policy of DFG not to plant catchable fish in salmon and steelhead habitat in order to prevent hybridization of the natural populations.

Trout are thought to be undergoing a rapid evolution in California. Historically they formed many local races or subspecies in waters that have been isolated long enough for this to happen. Years of indiscriminate planting have resulted in a crossbreeding which has led to the endangerment of several native subspecies such as the Lahonton and Paiute Cutthroat. Hatchery stocks, which now supplement much of the State's fishing program, are now of somewhat uncertain ancestry. In California there are four species of true trout (brown, cutthroat, golden, and rainbow) and four species of the similar and closely related chars (Dolly Varden, bull trout, brook trout, and lake trout). The only species native to California are the cutthroat, golden, rainbow, Dolly Varden, and bull trout.

The Lahontan and Paiute trout populations have been restricted to isolated locations in the Sierra Nevada (see Figure 6-1). Both subspecies have been classified as threatened by the federal government. Species considered to be sensitive and in need of further study are the Dolly Varden, South Fork Kern golden trout, Little Kern golden trout, and the redband trout.

Hatchery fish have been used to augment natural trout production for many years. Stocking streams and lakes with put-and-take fishing, supported by plants of catchable sized trout, has been a major program of the DFG since World War II in order to supplement recreational fishing. Annual hatchery production is about 12,300,000 catchables. The trend is towards producing a larger sized catchable rather than increasing total numbers. Because most of the trout fishing in California is associated with forest lands, it is important that water quality and watershed management be an integral part of the forest fishery management plan.

Anadromous Fishes

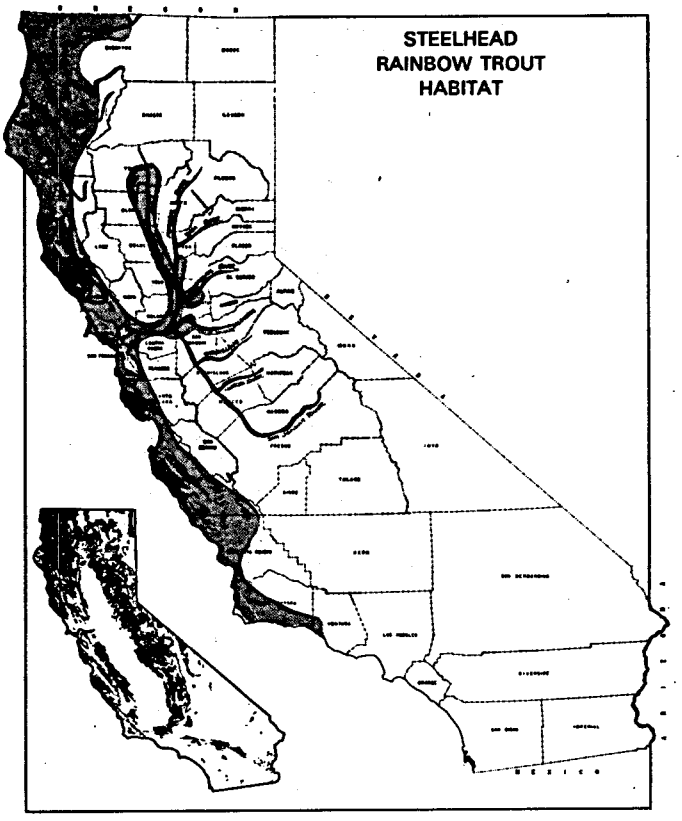
Some species of fish migrate to the ocean to mature but must return to their fresh water origins to spawn. Many of these spawning grounds are in forestland streams and rivers, many of which are hundreds of miles upstream in the interior mountains. Among these species, known as anadromous fish, are salmon which are not land-locked, the migratory rainbow trout known as steelhead, and other sea-run species of trout (Figure 6-2 illustrates the habitat of these species).

King (Chinook) salmon and silver (Coho) salmon are the only salmons which enter California rivers in significant numbers to spawn in streams and rivers within the forest area. The coastal rivers contain virtually all of the silver salmon habitat and slightly less than half of the king salmon habitat in the State. Since the turn of the century salmon and steelhead populations have declined approximately 65 percent. Salmon, which support a commercial and recreational industry, produced a catch of 841,000 fish in 1978; the steelhead catch approached 122,000.

The Klamath River system, largest of the coastal California rivers, presently supports approximately 66 percent of the king salmon and 15 percent of the silver salmon that spawn in California's coastal rivers. The 3,600-square-mile Eel River system is second among California's coastal streams as measured by average annual runoff. Most of the

drainage for the Klamath River and portions of the Eel River is within the national forest. Estimated annual spawning populations in the Klamath River system in 1965 were 168,000 king salmon and 15,400 silver salmon (California Fish and Game 1965). Tag and recovery estimates of king salmon were made in 1976 and 1977. Estimates were 260,000 and 203,000 salmon in 1976 and 1977 respectively, entering the mouth and prior to operation of river fisheries (Taylor 1978). These figures are not representative of the actual number that reach the spawning grounds.

The numbers of salmon passing Benbow Dam Fishway on the Eel River in Humboldt County have declined dramatically since counting was begun. Average counts during the first 10 years of operation (1938-1947) were 11,869 king salmon and 14,327 silver salmon. During the 10 years from 1966 to 1975 average annual counts were 4,714 king salmon and 1,846 silver salmon. The most recent of these



counts indicate that king salmon runs are relatively stable but silver salmon runs are continuing to decline. In 1975 only 509 silver salmon were counted going upstream past the dam.

The best historical data on salmon populations on the Eel River are annual fish counts conducted from 1938 through 1964 at the Sweasey Dam Fish Ladder in Humboldt County. The counts which range up to 3,139 king salmon and 3,580 silver salmon per year indicated that after 1951 both king and silver salmon populations above Sweasey Dam declined dramatically. King salmon counts increased in the early 1960's. Data have not been collected during the 1970's.

In areas where recent monitoring has been accomplished to assess current status and trends, figures show that populations have declined since the 1960's. The declines can be attributed to major water developments, depletion of water supplies, diversion of water for agriculture, sedimentation as a result of logging and road building, fishing mortality, stream blockage, and lack of spawning gravels. Man's activities on the North Coast have been the major reason for the decline of the Coastal salmon population.

The Sacramento-San Joaquin Valley river systems support the remainder of the salmon and steelhead fishery in the State. Most Central Valley salmon spawn in the Sacramento system, which is made up of the lower Sacramento, Feather, Yuba, American Rivers and numerous smaller tributaries. King salmon are the only salmon of any importance in this system. Four different runs or races of king salmon spawn in the Sacramento each year: the spring, fall, late fall and winter runs. Because dams block most of these river systems at relatively low elevations, the effects of changes in the forestlands on salmonid populations would be much less than in the major coastal streams.

Estimates of the spring spawning salmon runs have fluctuated since 1970, when the first counts became available, from a high of 70,000 in 1971 to a low of 25,000 in 1974 (Hallock 1978). Late fall runs have fluctuated greatly since counts were first started in 1971. Numbers of spawning fish counted in the late fall have ranged from a high of 32,000 in 1972 to a low of 6,000 in 1974. Similarly, data gathering for the winter runs of spawning salmon began in 1970; spawning counts range from 53,000 salmon in 1971 to 19,000 salmon in 1974. In the Sacramento River system problems affecting salmon populations have been identified as the loss of spawning gravels through sedimentation, the lack of gravel supply, heavy metal contamination, and stream flow manipulation, and/or fluctuation. Construction of dams which block access to spawning grounds has also adversely affected salmon populations in the Sacramento River. Other factors control or limit natural salmon populations, most noticably predation and loss of young between the time eggs are deposited and the time young enter the ocean, and the numbers removed from the ocean either as catch or hooking mortality (Hallock 1978).

Warmwater Fishes

Warmwater game fish, although not usually considered species with a close relationship to forested lands, are quite common at lower elevations in many of the ponds, lakes and reservoirs on forest lands. Of the 19 species now present 18 were introduced, mostly during the late 1800's. Examples of warmwater fishes include: largemouth and smallmouth bass, bluegill, crappie, sunfish, and catfish. Most of these populations are static with variations arising from water and nutrient supply fluctuations.

Nongame Fishes

There are a large number of nongame fish species found in close association with forest lands. They run the gamut

from the secretive sculpin to the large, piccivorous squawfish. Other nongame fishes are the suckers, shiners, hitch, chubs, sticklebacks, and minnows. Suckers and minnows comprise the largest group of nongame fish in California's inland waters. Approximately 65 species of fish are classified as nongame in California.

Suckers inhabit almost every kind of fresh water habitat in California. Because of habitat changes and the competition from introduced species, many of the native nongame fishes have become very rare, and one, the thicktailed chub, is probably extinct. The shortnose and Lost River suckers, two species associated with forested lands, have been declared endangered by the California Department of Fish and Game. The unarmored threespine stickleback has been classified as endangered by the State and federal government, while the Modoc sucker and rough sculpin are on the State's rare list (See Figure 6-1).

Habitat protection is the most important factor in protection and preservation of the various nongame fishes within the forest ecosystem. Because of the close association between game and nongame fish in most waters, efforts to protect and enhance game fish habitat will, in most cases, benefit nongame fish.

AMPHIBIANS AND REPTILES

Amphibians and reptiles on forested lands are as varied and widely distributed as the mammalian and avian fauna. These groups include such animals as the salamanders, frogs, toads, lizards, and snakes. The previously discussed Forest Service report on habitat relationships for amphibians and reptiles on the western slope of the Sierra Nevada lists 53 species inhabiting forested lands. Data on the population levels and habitat requirements for many of these species are incomplete or lacking. Once the habitat relationships are completed for the other forested areas of California, a better understanding of the status of amphibians and reptiles will be available. The present trend and status is also unknown. Two species on forest lands, the San Francisco garter snake and the blunt-nosed leopard lizard are classified as endangered by the State and federal governments. Species associated with forested lands which are considered rare by the State are the Alameda striped racer, southern rubber boa, and the Siskiyou Mountain, Limestone, Shasta, Kern Canyon slender, and Tehachapi slender salamanders. Their habitats are illustrated on Figure 6-1. Most of the rare salamander species are located in small isolated populations associated with wet seeps or limestone deposits.

ENDANGERED, THREATENED, RARE, AND SPECIES OF SPECIAL CONCERN

FISH AND WILDLIFE

In 1970, the State Legislature expressed its concern over California's disappearing wildlife and authorized the Fish and Game Commission to establish a list of what animals in California are considered rare or endangered. As a result of the California Endangered Species Act of 1970, the Fish and Game Commission has declared 49 animals endangered or rare.

The State has classified eight species as endangered and 13 species as rare that are found on forested lands as illustrated by Figure 6-1 and listed in Table 6-1.

There are numerous endangered or rare species of fauna associated with the riparian habitat along the Colorado River. However these species are not within the forested areas considered under the FRAP project.

Congress enacted the Endangered Species Act of 1973 which provides federal jurisdiction over endangered and threatened wildlife and plants and makes it a federal offense to take plants or wildlife so classified. The "threatened" designation is comparable to the State's "rare" classification. The federal and State lists contain some of the same species but the lists do not coincide.

The federal government has listed 36 species as endangered in California, of which seven are associated with forested lands. Seven species of fish and wildlife are listed as threatened, of which three fish species are found within the forest ecosystem (see Table 6-1).

The status of the various endangered and rare wildlife is discussed in a section of this chapter about the present trends of the fish and wildlife resource on forested lands. In addition to the endangered, threatened or rare species, the Department of Fish and Game has noted several "species of special concern." This proposed list of species has no special legal status, but some may be candidates for listing as endangered, rare or threatened species (see Table 6-2). The Forest Service uses the term "sensitive" as a similar classification (see Table 6-3). These are species about which very little may be known regarding their distribution and population levels within the forested lands of California.

Many of the species listed in Tables 6-1, 6-2, and 6-3 are associated with old- growth forests. In fact about 30 percent of the forest species tend to inhabit this forest type. Reductions of this habitat may thus be of considerable concern. Most species of forest wildlife exist at acceptable levels; however, significant population shifts of any species should serve as a warning of potential problems.

PLANTS

Congress, in passing the federal Endangered Species Act of 1973, enacted legislation to protect endangered plants. However, it was not until December 1974, when the Smithsonian Institution's report on threatened and endangered plants was published, that a list of the nation's candidate plant species was available.

In that same month the California Native Plant Society issued Special Publication No. 1, "Rare and Endangered Vascular Plants of California." While the lists provided a basis for the director of the U.S. Fish and Wildlife Service to adopt an official listing of endangered and threatened plants to comply with the federal act, there was no comparable authority for the State to do likewise.

Lack of such State authority prompted the California Native Plant Society to seek State legislation to extend to plants a program similar to that for endangered animals (Rae July-August 1978).

On September 30, 1977 Governor Brown signed SB 308, the Native Plant Protection Act, and on January 1, 1978 California's endangered plant program became a reality. This legislation declares that it is the policy of the State to preserve, protect, and enhance endangered and rare native plants.

The Department of Fish and Game is directed to inventory the native plant species, and submit a biennial report to the Legislature on its findings including the measures being taken to preserve and enhance those plants declared endangered or rare by the California Fish and Game Commission. The act also provides for issuance of permits for taking any rare or endangered native plants and notification of landowners of the location of these plants (Rae 1978).

The program will initially evaluate the 704 species, subspecies and varieties contained in the California Native Plant Society's 1974 publication and other data collected by universities and plant ecologists.

The endangered plant program is in its first phase of data collection, taxonomic reviews, drafting of distribution maps, and compiling lists of candidate species. Within the next two years a comprehensive account of the State's native plants will be available. The California Fish and Game Commission has classified 29 plant species as rare or endangered. The only such plant presently known within the defined forested areas of California is the Lake County dwarf flax (Hesperolinum didymocarpon). This rare plant is found on the rocky hill slopes of serpentine soil in association with grassy areas and scattered digger pines in Lake County.

Additional information available on the status of native plants on forested lands is an inventory list compiled by the Forest Service in California Region 5. Approximately 300 plants are listed as sensitive species within the national forest boundary. A listing of the sensitive plant species on national forest lands is included in the Appendix (see Appendix Item IV).

PRESENT AND PROJECTED USES OF FISH AND WILDLIFE RESOURCES

RECREATIONAL USES

Hunting and fishing are the main recreational appropriative uses of wildlife resources in California.

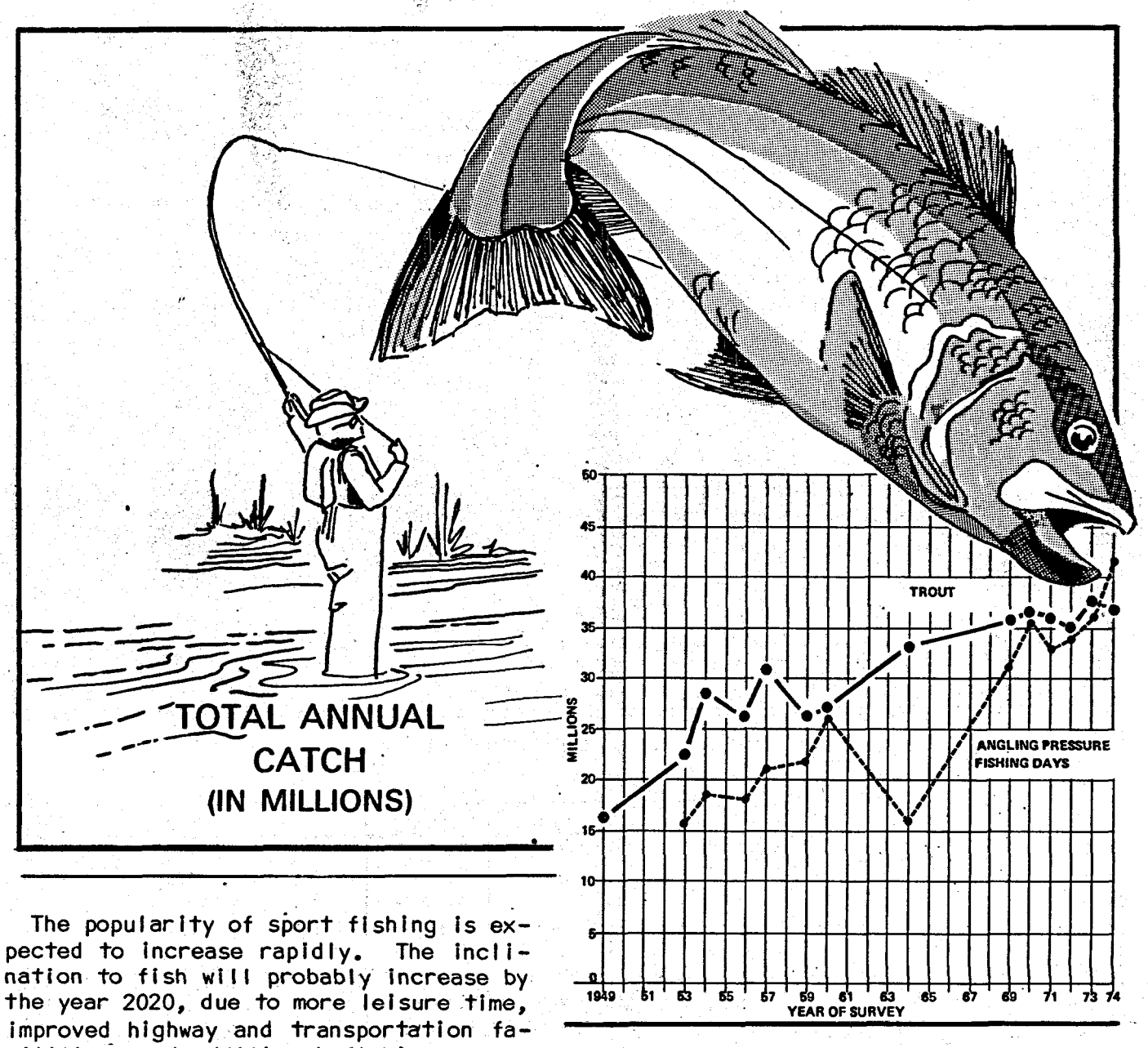
Fishing

Fishing is the most popular recreational consumptive use of wildlife in the State. In 1977 California led the nation with the sale of 2,166,649 sport fishing licenses.

Trout are the primary target for 45 percent of the California anglers. For the past 10 years the annual catch of trout has been fairly stable at approximately 37 million fish with an average annual catch of 39 fish per fisherman (see Figure 6-3).

It is not possible to distinguish the amount of fishing on forested land; however, a vast majority of the coldwater fishing for trout in California takes place within such land. In 1977 1.4 million trout stamps were sold.

It is interesting to note that since 1936 the annual catch of trout has more than tripled from 12 million to 37 million; however, the average number of fish per fisherman per year has declined from 80 to 39 fish. During this period the number of trout fishermen has increased sevenfold (Lal 1979).



The popularity of sport fishing is expected to increase rapidly. The inclination to fish will probably increase by the year 2020, due to more leisure time, improved highway and transportation facilities, and additional fishing access areas.

However, recent energy constraints may tend to alter these projections. At present the predicted trout angler days per year are closely following actual survey data. Most studies conducted in the early 1970's projected a consumption rate of 25 to 27 million trout angler days per year by 2020 (see Table 6-4). It is highly likely that the streams and rivers will not support such an increase in angling pressure.

Angler use, as outlined in the Comprehensive Framework Study for the California Region (Fish and Wildlife, Appendix XIII) is expected to stabilize at about 18-20 million trout angler-days per year after 2000 due to decreased fishing space per angler, and increased competition with other forms of recreation.

The ability to provide for increased angling will be difficult without acceleration of fish management programs.

Water development projects and timber harvest programs will continue to have an impact on stream habitat even though present Forest Practice Rules are affording better protection to stream habitat. The greatest potential for meeting trout angling needs appears to be in reservoir angling. Intensive lake and reservoir management utilizing catchable-sized trout could provide a greater share of the consumption.

The catchable trout program provides approximately one-third of the trout for California anglers. The vast majority of these fish are released within lakes, streams and rivers on forested lands. The production of catchable trout has remained fairly stable at approximately 12,300,000 fish.

Several management tools are available to increase fishing opportunities. The Comprehensive Framework Study included an accelerated fish hatchery production program, construction of spawning channels and rearing ponds, rehabilitation of stream spawning areas, improvement in stream flows, chemical control of non-game fish species, introduction of forage species, development of access and maintaining flexibility in harvest regulations, and bag limits.

There have been efforts in the past to discontinue stocking fish within the national park system. The rationale has been that this would help reduce fishing pressure and human disturbance and thus return the mountain lakes to a primitive ecosystem. If this comes about, addi-

TABLE 6-4

CONSUMPTION AND PROJECTED CONSUMPTION FOR TROUT ANGLING IN CALIFORNIA

(ANGLER DAYS PER YEAR IN MILLIONS)

	1970	1980	1990	2000	2020
Comprehensive Framework Study (1)		13.7		19.7	27.3
Water Quality Planning Project (2)	10.0	13.2	14.9	16.2	
1974 State Angling Survey (3)	12.5				
1976 State Angling Survey (4)	15.0				
Fishery Demand Studies (5)			16.0	25.0	

(1) Comprehensive Framework Study, California Region, Appendix XIII, Fish & Wildlife, 1971.
(2) Department of Fish & Game, Present and Future Human Demand for Fish & Wildlife, 1972.
(3) Telzman R., Department of Fish & Game, 1973.
(4) Lal, K., Department of Fish & Game, 1979.
(5) Tharratt, R. C., Department of Fish & Game, Fish Demand Study, 1971.

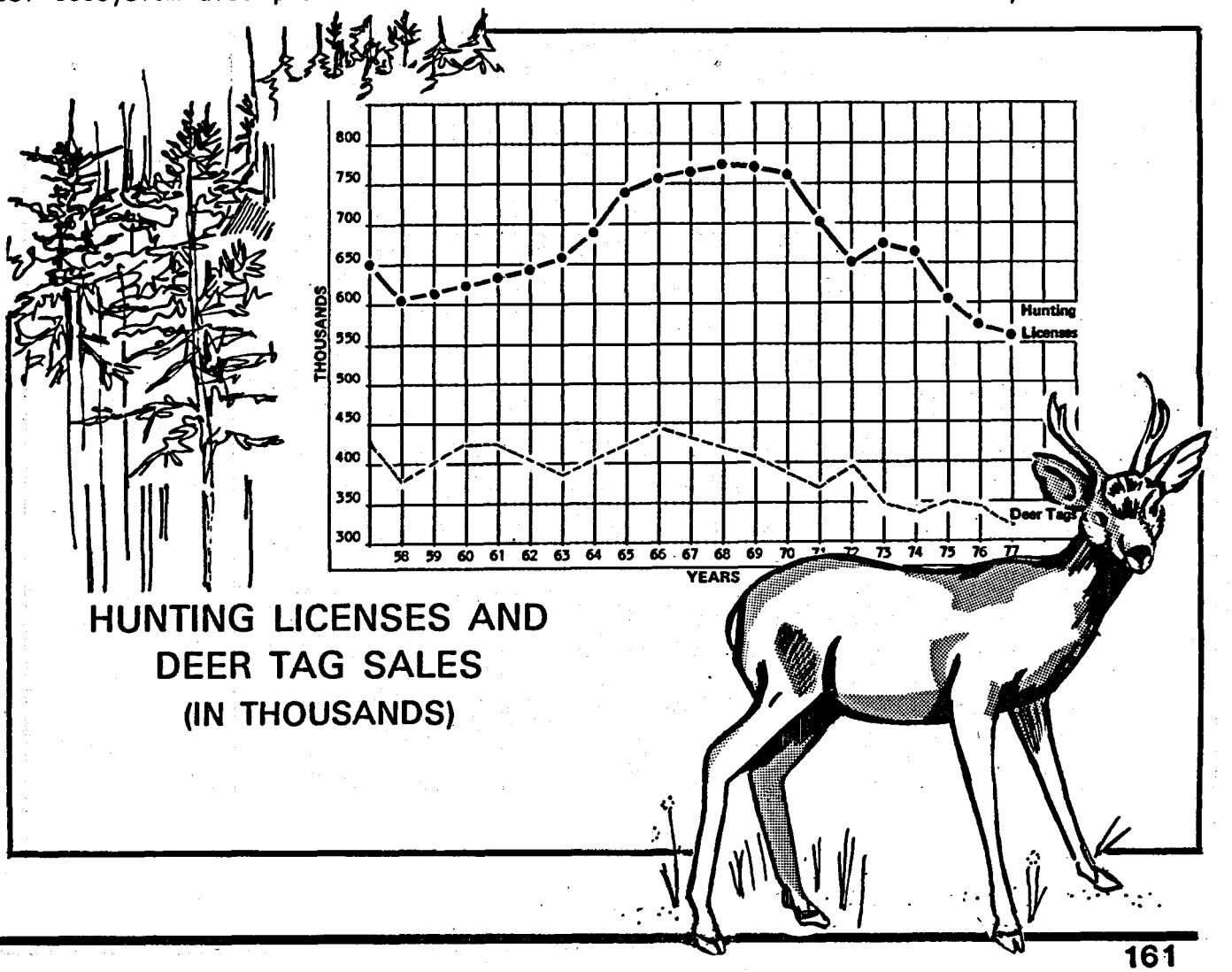
tional pressure will be placed on other existing fishery resources outside of the National Parks.

The present demand for nongame fishes is relatively low. There is a minimal amount of recreational, scientific or commercial use of these resources, and likewise a great void of information about the life histories of many nongame fishes. Future demands for these resources are also expected to be low.

Hunting

Hunting is a popular and important recreational activity on forested lands in California. Practically all of the hunting for deer, bear, tree squirrel, blue and ruffed grouse, mountain quail, wild turkey, and band-tailed pigeon takes place within the forest. The forest ecosystem also provides habitat for other huntable species such as rabbits, California quail and, to a limited degree, waterfowl.

Approximately 557,000 hunters bought hunting licenses in California in 1977, a 27 percent decrease from the record high of 764,000 licensed hunters in 1970. During the same seven-year period, approximately 325,000 licensed hunters also bought tags to hunt deer in California. The decrease in the number of licensed hunters is directly correlated to the number of individuals buying deer tags as Figure 6-4 illustrates. The significance is that if there were more deer, there would be more hunters, and therefore more recreational opportunity. The sale of deer tags would undoubtedly improve if there were more deer to harvest and hunter success was higher. The numbers of deer (population size) and the availability of deer to



HUNTING LICENSES AND DEER TAG SALES (IN THOUSANDS)

the hunter (weather, time of season, length of season) fairly well determine hunter success. At present only 10 percent of those who hunt deer are successful. Rather than encouraging additional deer hunters, the State Department of Fish and Game indicates that recent thoughts are to maintain a population of approximately 300,000 hunters, and strive to increase individual hunter success to 20 percent.

The Comprehensive Framework Study (1971) and the Water Quality Planning Report (1972) projected an increase in hunter days through the year 2020. The projected increase in hunter days from 1970 to 1980 was 16 percent as Table 6-5 shows.

At the present time, looking at 1977 hunter survey data collected by the Department of Fish and Game, it is obvious that the projected increases will fall short of 1980 predictions. Statewide hunter use data for 1977 was approximately 8,357,000 use-days. This compares with a prediction of 11.3 to 12.2 million use days or a 26 to 32 percent decrease (See Table 6-5).

The decrease in hunter use-days is a reflection of society's changing attitudes toward hunting. The 1970's have been a decade of increased environmental awareness and a move towards preservation as opposed to conservation. The consumptive use of the State's wildlife resources was discouraged, particularly

TABLE 6-5

CONSUMPTION AND PROJECTED CONSUMPTION
FOR HUNTING IN CALIFORNIA
(HUNTER DAYS IN MILLIONS)

	HUNTER DAYS		
	STATEWIDE	BIG GAME	UPLAND GAME
1. 1970 Hunter Survey[1]	9.7	3.5	5.0
2. 1977 Hunter Survey[2]	8.4	2.9	4.0
3. Comprehensive Framework Study, 1980 Projection[3]	11.3	4.2	5.8
4. Water Quality Planning Project, 1980 Projection[4]	12.2	3.5	6.6

[1]California Department of Fish and Game, Report of the 1970 Game Take Hunter Survey

[2]California Department of Fish and Game, Report of the 1977 Game Take Hunter Survey

[3]Comprehensive Framework Study, California Region, in Appendix XIII, Fish and Wildlife, 1971

[4]California Department of Fish and Game, Water Quality Planning Project, 1972

with a large segment of the preservationist population located in the large urban centers of the State. These groups have had legislation introduced to put game species on the State's protected list.

There has also been a decrease in the hunting activity for big game species within the forested lands of California due to changes in the hunter-success pattern. It is probably a conservative estimate that 85 percent of all the big game hunting takes place on forested lands. The 1977 hunter survey recorded 2.9 million hunter days in the pursuit of big game. The projected hunter days for big game in 1980 were 3.5 to 4.2 million, again a decrease of 19 to 31 percent from the anticipated hunter days per year (see Table 6-5). Interest in hunting is sufficient to harvest substantially more deer if California desires to produce them.

Meeting the projected demand for big game hunting will be difficult. Harvesting surplus antlerless deer and improving deer habitat to produce more deer are two means by which the consumptive level can be increased. However, public acceptance of doe hunting, prescribed burning, use of herbicides, and other means of improving habitat are necessary if significant increases in deer numbers are to be achieved. Other means to increase hunting opportunity on both public and private lands include adjustment of deer seasons to permit hunting in areas normally closed due to high fire hazards, and opening game refuges established by the Legislature. Although more public access may be needed in some areas, the Comprehensive Framework Study indicates that roadless areas should be retained in order to maintain a high quality hunting experience. Additional big game hunting could be provided by providing incentive programs for private land owners who make their land available for hunting.

Unless some of these activities are accomplished on an accelerated schedule, demand will equal supply and remain fairly constant at three to four million hunter-days per year for big game through the year 2000.

The amount of upland game hunting will depend largely on how private landowners manage their land. The establishment of incentive programs such as cost sharing, technical assistance, education, taxation benefits, etc., could lead to the availability of additional hunting on private lands.

Public enjoyment of wildlife, is not limited to hunting. For every day expended by hunters in pursuit of game, one and one-half days are spent on such diversified recreational activities such as bird watching, wildlife photography, and nature studies. Anadromous fish spawning areas and fish hatcheries also support an unknown amount of similar use. Wildlife plays an important role in the total biotic community and contributes to the pleasure and well-being of many people.

COMMERCIAL USES

Trapping

The current role of trapping in California is in doubt because of the controversy surrounding the taking of furbearing or nongame animals for their fur. By law, fur-bearing mammals are muskrat, beavers, raccoon, gray fox, red fox, cross fox, silver fox, kit fox, mink, martin, fisher, wolverine, badger, ring-tailed cat, and river otter. However, the only fur-bearers for which there is an open trapping season are beaver, muskrat, mink, badger, raccoon and gray fox. The wolverine and ring-tailed cat have been declared fully protected mammals by the Legislature.

Historically a number of mammals have been taken for fur, including the coyote, bobcat, striped skunk, weasel, and oppossum. A season was established on

the bobcat in 1974 because its pelt value skyrocketed in response to fashion demands for spotted cat fur. Coyote, fox and raccoon are popular for the same reason.

Legislation enacted in 1974 required that every person who traps fur-bearing or nongame mammals for profit purchase a trapping license. The California Department of Fish and Game is responsible for administering and monitoring the trapping program in California.

In the 1976-77 fur trapping season 1,692 trapping licenses were sold. This is an increase of 82 percent from the 931 licenses sold in 1975-76. The number of pelts reported sold was approximately 82,300 and represented a value of $895,603. The forested counties of Shasta, Siskiyou, Modoc, and Lassen account for approximately 20 to 25 percent of the fur pelts harvested in California.

Habitat losses, through the loss of riparian and old-growth forests may result in a general decline of many furbearers. However, the Comprehensive Framework Study reports that little change in economic conditions is anticipated, and the importance of fur trapping is expected to remain relatively constant to 2020 unless it is legally restricted.

The Department of Fish and Game feels that a very small portion of the furbearing population is currently being harvested. However, data on population levels needed to maintain furbearer numbers are not available. Trapping data are not specific to forested lands.

Commercial Fisheries

The predominant commercial fishery dependent upon forested land and related forest habitat is the salmon industry. There are two important species of commercial salmon in California: king salmon and silver salmon. In 1975 salmon ranked 13th in total pounds of fish landed in California ports. In dollar value salmon ranked second behind the major species of yellowfin, skipjack and, albacore tuna, with the total value in 1975 placed at $6,972,000. Approximately 62 percent of the commercial salmon catch is harvested commercially along the North Coast, as measured by landings at Fort Bragg and Eureka. Value wise, salmon are the single most important species of fish landed at either port.

The present rate of consumption of salmon in the sport and commercial fisheries is expected to continue through 2020. Although the ocean catch is apparently holding its own, it appears that in order to take the same quantity of salmon it now takes about four times the effort (Hallock 1978). In spite of decreased natural spawning runs in California artificially raised fish in hatcheries and supplies from Oregon and Washington have kept the commercial fishing fairly stable. The ability to maintain present consumption levels or to increase production will necessitate new hatchery management and release techniques, stream habitat restoration, revised water quality standards and more efficient fishing laws and regulations to insure protection of the fishery resource.

Increases in the production of hatchery raised salmon might have a great input upon the fishery without a great expansion of present facilities. Measures such as: (1) elimination of the Sacramento River Chinook Disease-Virus and other diseases, (2) release of all fish at 90 per pound or larger to ensure better survival, and (3) elimination of down stream migration losses by trucking more fish to the Delta.

The Brown Administration has recently proposed a program called the Renewable Resources Investment Fund to increase California's salmon population. On a Statewide basis, the 10-year goal of the

salmon restoration proposal is to add four hundred thousand adult salmon to the annual runs, thus doubling the present Statewide total. The cost to the State is expected to be 70 million dollars.

In conjunction with the State's program a new State-federal cooperative program to restore the salmon and steelhead fisheries of the Klamath and Trinity Rivers has been endorsed by the Resources Agency, Department of Interior, and Department of Agriculture.

PROTECTION AND ENHANCEMENT OF FISH AND WILDLIFE RESOURCES ON FORESTED LANDS

Most publicly owned forest lands, particularly those within the national forests, are managed, under the concept of multiple use. Timber, watersheds, livestock, recreation, and wildlife supposedly receive equal management emphasis. In a few key places the production of deer and other forest wildlife has received priority over that of sawlogs and pulpwood according to Dasman in his book "If Deer Are to Survive."

The principal concern of forest management, however, has been to grow trees. If the wildlife manager, the sportsman, and general public wish to develop a broader and more cooperative attitude among foresters, they will have to support wildlife populations at levels that can be carried without serious conflict with silviculture. Conversely, foresters charged with the responsibility of managing the public lands must deliberately seek to create greater public benefits on the lands that they administer (Dasman 1971).

WILDLIFE HABITAT REQUIREMENTS

On much of the forested lands of California, opportunities exist to improve wildlife habitat through cultural methods.

Species diversity can be improved by increasing what is known as the "edge" --edges occur where different plant communities come together. The species richness of any given edge is affected by the interspersion of plant communities that consist of a variety of successional stages. Edges may be natural in origin as from fire, flood or wind or they may be of human origin such as those which occur during logging operations, brush conversion projects, prescribed burning, herbicide treatments, or timber stand improvement projects. Habitats which vary in structural and vegetative characteristics support a larger variety of animal species than do monotypes.

There are several components of the forest ecosystems which are particularly important for species diversity. They are the riparian zones, oak and hardwood interspersions, snags and cavity-containing trees, and meadows.

Riparian zones, those areas associated with water, are the single most important wildlife habitats on forested lands. These areas are extremely variable and may include the habitat associated with streams, ponds, seeps, rivers, lakes, springs, bogs, and wet meadows. Because riparian habitat is associated with water, it provides one of the three basic requirements necessary to sustain an animal population: water, food, and shelter. Oftentimes the riparian zones also supply the necessary habitat for shelter and food. But they are also areas where wildlife resources are often in potential conflict with logging, grazing, and recreation. Riparian zones are usually quite sensitive to management or human activities and need to be very cautiously and carefully managed. The Department of Fish and Game and the Forest Service presently are inventorying most of the riparian resources in the State. Their report will be available in 1980 or 1981. The Forest Practice Rules contain protective measures for riparian habitat on private commer-

cial timber lands. The effectiveness of these rules is presently being evaluated by the Department of Forestry.

Oaks dispersed within the forested lands provide a diversity of habitat important to wildlife. There is a greater variety of wildlife species in oak-conifer habitats than in coniferous monocultures since a mixture of hardwood species and conifers creates a horizontal and vertical edge affect. Several wildlife species are dependent on hardwoods for food and cover. Oak mast (acorns, twigs, and leaves) is an important food item for deer, wild pigs, tree squirrels, scrub jays, acorn woodpeckers, band-tailed pigeons, wild turkeys, and many other species of wildlife.

With increased efforts toward using wood as an alternate energy source, oaks and other hardwoods will be in greater demand. Proper management of these resources is needed to insure adequate food and habitat for wildlife. Particular attention needs to be directed towards the old and mature oaks which produce the heaviest acorn crops and the best nesting and den cavities.

Dead or deteriorating trees accommodate approximately 49 species of birds in California which use them as nesting sites by excavating nesting holes, inhabiting cavities resulting from decay, or using holes created by other species. Such trees, commonly called snags, have often been considered undesirable by forest managers because: (1) they are a major source for lightning strikes and sparks for spreading fire during wildfires; (2) they occupy space that could otherwise be utilized by live trees; (3) they may harbor insect pests; (4) they are a safety hazard during logging operation especially if located close to a road; and (5) they are not aesthetically pleasing. In the past, snags were eliminated from the forest during a timber harvest. As a result, in some areas few nesting sites were left for cavity-nesting birds and mammals such as tree squirrels, woodpeckers, swallows, wrens, nuthatches, owls, and chickadees.

Forest managers now are more aware of the importance of snags to cavity-nesting birds and mammals. In 1977, the Forest Service established a national policy covering snags which requires all forests under their jurisdiction to develop guidelines to provide habitat needed to maintain viable, selfsustaining populations of cavity-nesting and snag-dependent wildlife species. The State forest practice rules for private timberlands were revised in 1976 to provide for snag retention for wildlife. However, there is still the need to periodically review snag policies on privately managed timber lands. Some hard snags (merchantable, dead trees) should be retained for the future of cavity nesting animals. A snag 25 or 50 feet tall which does not present a fire or safety problem should not automatically be removed.

Meadows, often associated with riparian zones, are very important wildlife habitat. In the past meadows have been used as recreational sites, livestock gathering pastures, timber hauling roads and many other uses that have tended to degrade these natural ecosystems. The edge between the meadow and forest provides a diversity of habitat attractions to many species of wildlife. Raptors hunt for mice and voles, deer graze, and swallows and flycatchers gather insects within the meadow ecosystem.

Timber harvesting can have a dramatic impact on wildlife habitat. If well planned and executed, silvicultural practices can also serve wildlife needs. Forest management practices can be used to produce or insure diversity and stability of both plant and animal communities, or to provide better habitat for selected animals. Practices such as those listed below offer the most practicable broadscale approach to alteration of the forest habitat that is available to wildlife managers to

achieve a diversity of wildlife species (Arvola 1978):

Choose a cutting system that favors variety of habitat. Group-selection-cutting, small clearcuts of about 80 acres that are well spaced, and fairly heavy single-tree harvesting result in diversity of wildlife habitat.

Retain streamside cover and protect meadows.

Harvest trees in ways that create the most edge effect.

Reserve some patches of brush within or adjoining the forest for edge effect and habitat diversity.

Save some live trees which have hollow trunks and limbs for such animals as raccoon, opposum, squirrel, chipmunk, woodduck, owl, sparrow hawk, woodpecker, insect-eating, and song birds of various kinds.

Keep some hardwoods, especially oaks, as a source of food for many birds and mammals.

Keep snags that are not hazardous for fire and safety reasons, or any snag that contains nesting birds of valuable species, e.g., eagle, osprey.

Protect and develop water sources for wildlife.

Conduct prescribed burns to produce habitat diversity. See Chapter Seven for additional information on prescribed burning on forest lands.

FISHERY HABITAT REQUIREMENTS

Stream habitat within the forest ecosystem consists of clear, cool water. Gravel size, velocity of the water, and quality of water within the river or stream are also important in maintaining a fishery.

A major impact on the fishery habitat within the forested areas of California is logging and logging-related road building. This is particularly true along the North Coast where the loss of spawning habitat has contributed to a 60 percent decline in the salmon population.

Damage due to logging falls into two main types: physical destruction of portions of the stream itself, and sedimentation of the gravels resulting from accelerated erosion. The major causes of damage to fish and fish habitat from roads are:

Roads located too close to streams and crossing streams without adequate structures for fish passage.

Siltation from unstablized slopes and road damage.

Landslips triggered by poorly located, constructed, or maintained roads.

Removal or disturbance of too much tree and other vegetative cover along streams, causing higher water temperatures, bank erosion, and diminished food supply

Habitat restoration programs have the potential for immediate benefits to

freshwater streams and rivers. Rehabilitation measures such as stream clearance (removing logs and debris), gravel replacement or rehabilitation, and sediment control could increase salmon and steelhead populations. Many water quality factors also affect fishery habitat. Toxic metals and sedimentation pollute rivers and streams.

The removal of stream side shade can raise water temperatures to lethal levels for fish; this removes portions of the stream from production and creates thermal barriers for passage of resident and migrating fish. Forest Practice Rules currently provide for the leaving of at least one-half of the shade producing canopy along streams.

Aside from maintaining the quality of water in a particular river, the quantity of water available during the spawn migrations is important. As is often the case, water releases are minimal during fall migrations which leaves spawning riffles exposed. Additionally, "dumping" large volumes of water for flood control during the winter has frequently resulted in washing away fish eggs deposited in the gravel.

The Forest Practice Rules also provide for stream side protection zones (SPZ's). For example in the North Coast District the rules provide for at least a 50 foot buffer zone on streams where fish are absent and a 100 foot buffer in streams where fish are present. There is still the need to periodically review the rules regarding SPZ's to ensure that minimum distances are adequate to protect stream habitat, particularly on timber soil which have a high or severe erosion hazard rating.

Anti-pollution regulations have been established by the various Regional Water Quality Boards of the California State Water Resources Control Board. In addition, the Fish and Game Code Section 1601 and 1602 contains regulations dealing with water pollution, and with streambed and streamflow modifications. The overall effectiveness of the State in controlling point-source water pollution depends largely on the stringency of institutional standards and the cooperation of forest users. The California Forest Practice Act provides for formulation and enforcement of forest practice rules on private timber lands and public non-federal timberlands. As a result, timber harvest operations on private lands have improved. More effective rules and better enforcement measures, however, are still needed on privately-owned and public forest lands to improve water quality and stream habitat. Section 208 of Public Law 92500 (1972) will eventually result in procedures for control of non-point sources of pollution for forests in California watersheds. The study will evaluate the rules in relation to shade canopy, stream protection zones, and siltation due to road construction (see Chapter Four, "The Watersheds," for further discussion of Section 208).

FISH AND WILDLIFE PLANNING

CALIFORNIA FISH AND WILDLIFE PLAN

The Department of Fish and Game is in the process of rewriting the 1965 California Fish and Wildlife Plan. The plan consists of three volumes and is scheduled for distribution on July 1, 1980.

Volume 1 contains the primary DFG planning document which sets forth primary objectives, major programs and authorities and philosophies of the Department. The Fish and Wildlife Plan, in addition to guiding DFG programs during the next ten years, will also communicate to other public agencies and to the private sector DFG's concerns for the resource as the State's population increases and its lands are developed.

Volume II includes species plans for wildlife, inland fisheries, anadromous fisheries, and marine resources. The objectives and programs of DFG for individual species or species groups are presented to the year 1990. No effort is directed towards long range planning to the years 2000 or 2020.

Approximately 300 plans will be developed which will describe what DFG intends to do regarding individual species such as deer, red fox, and condor; and for groups of species such as ducks, geese, and flycatchers. The strategic programs described for species/groups are designed to guide DFG for the next 10 years.

The treatment of nongame species will be more refined in the 1980 plan than in the 1965 version. In the latter plan, five nongame plans were prepared covering raptors, land associated nongame birds, miscellaneous mammals, furbearers and related species, and water associated nongame birds. In the 1980 effort, approximately 53 plans will be presented for nongame animals.

The level of detail of the plans presented will vary considerably. Species actively sought by man, for any number of reasons, have been more thoroughly studied in the past. Until recently, there has been little interest in nongame species other than from the academic community.

Information needed for proper management of nongame animals is generally lacking. Many of the objectives and programs are, therefore, designed to improve the level of knowledge so that adequate management programs can be developed. The species plans will include much of the following information:

Population and land and water use changes.

Impacts of projected population and land and water use changes on wildlife resources.

Existing and projected human use of species/groups.

Areas of special biological importance.

Volume III of the plan will describe the fish and wildlife resources within a county. The report will identify, through use of individual county maps, the terrestrial and aquatic habitats which are of importance to fish and wildlife. Special attention will be given to areas of special biological importance.

The completion of the Fish and Wildlife Plan by the Department of Fish and Game should greatly assist in future management of important wildlife resources of the forested lands of California.

FOREST SERVICE HABITAT RELATIONSHIPS

The federal Draft Assessment of the Forest and Range Land Situation in the United States has been completed and includes California's input into the national assessment of fish and wildlife resources. The computer printout from this program identifies 14 forest range type ecosystems for California. Such information as species adaptability, specialized habitat needs, importance of timber size and the importance of range condition are delineated for each species. The information is useful on a national or Statewide level; however, for the land manager, more specific and detailed information is necessary.

The Forest Service's recent efforts to classify vegetative communities and develop wildlife habitat relationships is a step towards providing a data base for the management of fish and wildlife resources on a local level. Thus far, wildlife habitat relationships have been compiled for forested lands on the west slope of the Sierra. The material is, as of July 1979, in draft form waiting final printing.

The goal is to complete habitat relationships for the Great Basin, North Coast and Southern California Regions. When completed, wildlife habitat relationships and a wildlife matrix will be available for approximately 90 percent of the forested lands in California. Much of the effort being put forth by the Forest Service can be extended to private lands; however, the remaining ten percent (forest lands on the North and Central Coast) will need to be completed by an independent survey.

RESEARCH PROGRAMS

PRESENT RESEARCH PROGRAMS

Numerous organizations and agencies are conducting fish and wildlife research on the forest lands of California. Table 6-6 outlines known research projects by the Department of Fish and Game, Forest Service and the Pacific Southwest Range and Experimental station. Not available at the time of this publication are data from the colleges and universities which collectively produce much of the research on forest lands.

FUTURE RESEARCH NEEDS

Wildlife

Continued studies to determine the value to the forest ecosystem are needed of the life cycles of various mammals and birds and of their role in the forest environment. Animal damage and its effect on forests is also discussed in Chapter Ten, "The Timber Resource."

Especially needed are studies to:

Learn how intensive management can be applied to wildlife so as to achieve harmony with other forest needs; determine how to increase the population and quality of various animal species while, at the same time, enabling the construction of roads, the harvesting of timber, and use of the land by recreationists.

Determine the ideal conditions for the habitat of various species of wildlife throughout their annual life cycles in different parts of the State; give special attention to migratory wildlife; determine the ecological role of the wildlife on the various wildland environments; and define habitat requirements, especially for endangered and potentially endangered species of birds and animals.

Learn how the habitat requirements for various species of wildlife may conflict with other desirable uses of the forest.

Identify potential conflicts for forest forage between wild animals and domestic livestock.

Identify the effects of bird populations on controlling insects which damage valuable timber species.

Appraise the damages created to forest vegetation by various species of wildlife and determine how to control the extent of these damages at an acceptable level.

Continue to revise habitat relationships to determine the effects of timber harvesting on various species of wildlife during successive stages of the timber's life cycles; study especially the effects on food and cover required by different species of wildlife.

Determine the effects of forest taxation and the economics of forest use on the maintenance of wildlife habitat.

TABLE 6-6

PRESENT RESEARCH PROGRAMS ON FOREST LANDS

	SUBJECT	AGENCY	DATE OF COMPLETION (WHEN KNOWN)
1	Fish & Wildlife Plan	California Fish & Game	July 1980
2	Riparian Study	California Fish & Game, U. S. Forest Service	1980 1981
3	Black Bear Study	California Fish & Game	1981
4	N. Kings Deer Study	California Fish & Game, U. S. Forest Service	1982
5	Grindstone Habitat	California Fish & Game, U. S. Forest Service	1981
6	Wildlife Habitat Project Relationships	U. S. Forest Service, Pacific Southwest	
7	Brown Trout Spawning Preferences	U. S. Forest Service, Inyo NF & San Bernardino NF	
8	Oak Survival & Growth Study	U. S. Forest Service, Angeles NF	
9	Bighorn Sheep, Habitat & Behavior	U. S. Forest Service, Inyo NF	
10	Yosemite & Black Toads	U. S. Forest Service, Inyo NF	
11	Fishes Distribution	U. S. Forest Service, Humboldt State	
12	Bald Eagle Habitat Parameters	U. S. Forest Service, Shasta-Trinity NF & CFG	1979
13	Spotted Owl Vocalization Study	U. S. Forest Service, San Bernardino NF & PSW	
14	Modoc Sucker Spawning Study	California Fish & Game, U. S. Forest Service & Modoc NF	
15	Modoc Wetland Study	U. S. Forest Service, Modoc NF, PSW & UC Berkeley	December 1979
16	Condor Activity Study	U. S. Forest Service, Los Padres NF & Santa Barbara Co.	January 1980
17	Southern Rubber Boa Distribution & Habitat	U. S. Forest Service, Los Padres & San Bernardino NF	
18	Review of Essential Habitat for Sea Otter, San Joaquin Kit Fox, Peregrine Falcon & Leopard Lizard	U. S. Forest Service, Los Padres NF	
19	Black Bear Habitat & Distribution	U. S. Forest Service, Tahoe NF	
20	Pine Martin Radio-telemetry Habitat Study	U. S. Forest Service, Tahoe NF & Sacramento State	September 1979

TABLE 6-6 (continued)

	SUBJECT	AGENCY	DATE OF COMPLETION (WHEN KNOWN)
21	Riparian Snag Study	U. S. Forest Service, Six Rivers NF	
22	Snag Habitat Relationships	U. S. Forest Service, PSW & San Bernardino NF	
23	Slump Pond Study	U. S. Forest Service, Six Rivers NF	
24	Blunt-nosed Leopard Lizard Distribution & Habitat	U. S. Forest Service, Los Padres NF	1979
25	Oak-Mast Study	Department of Fish & Game	
26	Deer Management Plans	Department of Fish & Game	4 implemented in 1979 8 implemented in 1980
27	Avifauna of Grazed & Ungrazed Habitats in Foothill Woodlands of the Sierra Nevada Mts.	PSW	June 1979
28	Avian Community Responses to Logging-Related Habitat alteration in the Mixed Conifer Zone of the Sierra Nevada	PSW	August 1980
29	Long-term Fire Suppression on Vegetation Dynamics in the Range of the California Condor	PSW & UC Santa Barbara	March 1979
30	Past & Present Distribution of the Brown-Headed Cowbird in the Sierra Nevada Mts.	PSW & UC Santa Barbara	January 1979
31	Cowbird Occurrence, Local Movements & Potential Impact on Breeding Success of Song Birds in Sierra Nevada Mts.	PSW & UC Santa Barbara	January 1980
32	Feasibility of Individual Recognition of Spotted Owls	PSW & Occidental College	June 1980
33	Methods of Sampling Avian Riparian Communities	PSW & California State University, Fresno	September 1979
34	Avian Community Composition of Mixed Conifers & Red Fir Forests Before & After Logging in the Sierra Nevada Mts.	PSW	Study in Planning Stages, Expected to last at least 10 yrs.
35	Great Gray Owl, Statewide Survey	Department of Fish & Game	October 1979
36	Swainson's Hawk, Statewide Survey	Board of Land Management, Department of Fish & Game	September 1979

Fisheries

The characteristics and quality of aquatic life in California's inland streams depends to a large extent upon the quality of the terrestrial environment through which the streams flow. Through wise management of the inland fisheries, there is considerable opportunity for increasing the recreational opportunities for all types of fisheries and fishermen, for increasing economic gains, and for creating new fisheries or improving existing forest fisheries.

Needed research should:

Identify methods and study the economics of providing a variety of fishing experiences to meet the demands and needs of sports fishermen and commercial fishermen.

Relate the location, range, and fluctuation of water temperatures and volumes to the management of inland fisheries; learn how to manipulate the forest environment so as to provide water quality and flow which is favorable to the stream environment.

Determine how much shade canopy from trees and other vegetation is needed to maintain fisheries in streams located in different parts of the State; study how this shade can best be achieved through the establishment and maintenance of particular riparian vegetative types.

Determine the drain on fish populations from sports fishing, commercial fishing, and ocean predators.

Determine how to control the detrimental effects on spawning grounds caused by road construction, logging, mining, recreation, and other land uses in the forest.

Identify the characteristics of prime stream environments required for fish habitat and determine the effects of various land-management practices on them; develop land management practices which will obtain optimum productivity from the inland fisheries while sustaining desirable aquatic ecosystems.

Determine the effects of various types of timber harvesting on stream environments; evaluate characteristics of stream side habitat needed to protect streams under different conditions of vegetative cover, slope, soil type, and climate.

Determine the specific requirements of threatened and endangered species of fish and learn how to provide these requirements while, at the same time, meeting other needs of the stream environment.

CONCLUSION AND POLICY FOCUS

The fish and wildlife resources in California's forests are more varied than elsewhere in the United States. Early to mid-successional stages of forest vegetation enhance populations of deer, mountain lion, bear, quail, voles, mice, and raptors. In fact about 70 percent of the wildlife species which inhabit forest lands favor these vegetational stages. The remaining 30 percent of our forest wildlife species tend to inhabit old-growth or late successional stands. Typical species are fisher, marten, spotted owl, yellow-rumped warbler, pileated woodpecker, and goshawk. Reductions of old-growth habitat may thus be of considerable concern. Substantial acreages of this habitat exist in wilderness and park acres and much of the remainder is also in public ownership. Most species of forest wildlife exist at acceptable levels; however, significant population shifts of any species should serve as a warning of potential problems.

The 60 percent decrease in the deer population since the mid-1960's can be attributed to the loss of suitable habitat. These losses have resulted from the growth of rural sub-divisions, urbanization, road construction, water developments, maturing browse (which is unsuitable for deer), and the gradual crowding out of browse by young stands of timber. Immature brush which often results from logging has the opposite effect. Without extensive habitat restoration programs deer populations are expected to remain stable through the 1980's.

Certain species of fish and wildlife generate greater interest than others because they support such activities as sport fishing and hunting and commercial fishing and trapping. Most trout fishing and practically all deer and bear hunting takes place on forested land. Approximately 37,000,000 trout, 31,000 deer, and 655 bear were harvested in 1978. Salmon, which supports a commercial and recreation industry, produced a catch of 841,000 fish in 1978; the steelhead catch approached 122,000. Over half of these fish are dependent on forest ecosystems for spawning.

Since the turn of the century salmon and steelhead populations have declined approximately 65 percent. Along the North Coast water development projects, timber harvesting, road construction, debris accumulations, siltation of spawning gravels, and unfavorable water levels and temperatures have contributed to the reduction of the natural production of salmon and steelhead. The numbers of salmon and steelhead are not expected to increase unless substantial measures are taken to improve spawning habitat and increase hatchery production.

There are federal and State laws to protect endangered, rare or threatened plants and animals, however, there is overlap and the two jurisdictions have generated lists of animals that do not coincide. Forests provide key habitat for many of these species.

The fish and wildlife issues confronting society concerning management on forest lands is the desire to produce more fish (see "Salmon" issue) and more wildlife (mainly deer) and at the same time harvest more timber (see "More Timber, More Game - Complementarity" issue). The amount of timber harvested could double while providing only a 5 to 10 percent increase in deer populations. However, with a 70 percent increase in timber production and encouraging successional stages of brush conducive to deer, one could expect a 50 to 100 percent increase in deer population.

With present investments and under present management substantial increases in salmon populations are not expected; however, the Resources Agency has proposed investments of 50 to 70 million dollars over a 10 year period to increase the number of salmon presently entering California streams and rivers. Funds would be used to improve spawning habitat and to increase hatchery facilities.

CHAPTER SEVEN

THE FORESTED RANGELANDS

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INTRODUCTION

Before the arrival of the white man in California native ungulates such as antelope, elk, and deer grazed on grasslands which were dominated by perennial bunch grasses.

In 1769 the first Spanish settlements in the State were established in the vicinity of San Diego. According to the "Survey of California Deer Herds, Their Ranges and Management Problems," a game bulletin published by the California Department of Fish and Game in 1952, the Spanish settlers were few in number and restricted in the area they occupied. Nevertheless, they dramatically impacted the terrain, particularly as a result of their introduction of domestic cattle, sheep, horses, and goats.

Along with the European livestock came European annuals; grasses, and forbs which generally replaced the original perennials throughout the foothills of the Central Valley and coastal plains. Today, as a result, most of California's rangeland is dominated by introduced Mediterranean annual plants such as wild oats, soft chess, red brome, various fescues, bur clover and filarees.

Domestic herds were large and roamed over thousands of acres of rangeland. It is estimated that in 1825 there were one million head of sheep as well as extensive herds of cattle and horses.

By 1830 the Los Angeles Basin and the coastal areas were showing signs of overgrazing. The first widespread overstocking occurred during the early 1850's and was quite general in many portions of the State until the herds and flocks were depleted drastically in the droughts of the 1860's (Burcham 1957). By 1876 numbers had rebuilt to where there were 6,000,000 head of sheep in California and equally large numbers of cattle and horses. Meadows and grasslands could not support this number of animals and severe overgrazing again occurred.

Today much of the original range area, especially in the Central Valley and in southern California, has been altered by urbanization and farming. Grazing activity still continues on much of the forested land of California and is intensified on the grassland and woodland ecotones at lower elevations.

THE NATURAL RANGELANDS OF CALIFORNIA

DESCRIPTION OF THE RANGELAND RESOURCES

In June 1979 the Board of Forestry's Range Improvement Advisory Committee proposed the following definition of rangeland: rangeland is land on which the existing vegetation, whether growing naturally or through management, is suitable for grazing or browsing use. Rangeland includes any natural grasslands, savannas, shrublands, deserts, woodlands, and wetlands which support a vegetative cover of native grasses, grass-like plants, forbs, shrubs, or naturalized species. Rangeland is land that is dominated by vegetation other than trees. Many woodlands including pinyon, juniper, chaparral, and oak woodlands are included in rangelands, because their response to range management principles and activities are similar to those of other shrubby ecosystems.

Also included are those lands that have been seeded to non-native forage but are managed as native ranges. The key elements in the definition of range,

therefore, are (1) forage for grazing or browsing animals is produced by native plants, and (2) if the forage is produced by introduced species, the plants are managed as if they were native species. Thus, the lands commonly designated as improved pastures, cropland pastures, irrigated pastures, and grazed cropland are excluded from the forest land and rangeland base used in this Assessment because they are dominated by non-native species and are routinely cultivated, seeded, fertilized, or irrigated. Rangelands are those lands which produce forage for livestock or wildlife.

In California, rangeland is land on which forage is produced within the commercial timber zones, the deserts and the grass steppes. Species composition and production are the result of natural phenomena including soil, climate, topography, fire, floods, insects, and use by grazing animals. Management is accomplished mainly through the regulation of grazing and browsing livestock and native ungulates.

Rangelands in the State supply about 61 percent of the total feed required for meat animals produced annually on California farms and ranches. Approximately 36 million acres, or 36 percent, of the land area of California is classified as rangeland (Reed 1974).

Most of the open range and low-lying portions of the oak-grass woodland are used for the production of green feed in the winter and spring. Along the coast and in southern California much of the rangeland covered with annual grasses is grazed year-long with some additional feed coming from irrigated pastures and crop residue. At higher elevations and along the northern coast where fall rains start earlier, range provides some winter feed, but green feed is produced principally during the spring and early summer months. Grazing at higher elevations, particularly on the national forest lands, occurs usually between the months of June and October.

It is also interesting to note that in a state where 47 percent (47 million acres) of the land area is public land, only one-third of the rangeland (13 million acres) is in federal ownership while two-thirds (23 million acres) is privately owned (see Table 7-1, "California Rangeland Ownership"). Private rangeland is even more important when productivity, as measured by animal unit months (AUM's) rather than acreage, is considered. (An AUM is usually defined as the amount of forage necessary to sustain a cow or steer, or five sheep for one month, or 1,000 pounds of forage.) Then it becomes apparent that 94 percent of the livestock production on rangeland comes from private land while the remaining six percent comes from grazing on federal lands (see Table 7-2, "California Rangeland Production." This ratio does not hold true for all areas within California since ranch operations on the eastern side of the Sierra Nevada and Cascade Mountains obtain from one-fourth to one-third of their feed supplies from federal lands (Clawson 1978). In California the price ranchers pay per AUM is extremely variable. In 1979 the price of an AUM on Forest Service lands was $2.03. This was a 24 percent increase from the 1978 figure. On the Spenceville Wildlife Area, east of Beale Air Force Base and managed by the Department of Fish and Game, bids received on several allotments ranged from $16.25 to $20.00 per AUM.

Much of the area classified as rangeland is not suited for more intensive agricultural use because of rocky conditions, steep slopes, poor soil, low rainfall, temperature extremes, etc. This does not diminish its importance. Grazing or browsing by herbivores is the most practical and feasible means of converting range vegetation into food and fiber useful to man. In addition to food, forage, and fiber, rangelands provide other resources and services neces-

TABLE 7-1

CALIFORNIA RANGELAND OWNERSHIP (IN THOUSANDS OF ACRES)

AREA	PRIVATE	USFS	BLM AND OTHER PUBLIC	TOTAL	REGION AS A PERCENT OF TOTAL
North Coast	2,733	160	8	2,901	8.1
North Central	1,130	1,279	160	2,569	7.1
North East	1,247	1,699	1,337	4,283	11.9
Central Coast	4,866	106	299	5,271	14.6
Sacramento Valley	2,439	194	33	2,666	7.4
San Joaquin Valley	5,993	343	839	7,229	20.1
Eastern Sierra	223	553	1,834	2,610	7.3
Western Sierra	1,650	401	102	2,153	6.0
Southern California	2,930	269	3,087	6,286	17.5
	23,211	5,004	7,753	35,968	100.0

Source: "The Contribution of Rangeland to the Economy of California," University of California, June 1974.

sary for man's well-being. These include supplying wildlife habitat, acceptable water quality, recreation, natural beauty, absorption and breakdown of pollutants, degradation of organic wastes, cycling of nutrients, and maintaining a beneficial balance of gases in the atmosphere (USDA September 1978).

LIVESTOCK

Sales of livestock products in California accounted for 10.6 percent of the total farm income in 1977. In that year, cash receipts from the sale of cattle and calves alone was $987 million.

Typically, beef production tends to follow a 10- to 14-year cycle in response to market prices, and is so long because it can take up to four years from the time a cow/calf producer decides to increase his breeding herd until the extra meat arrives at the market. The 1976-77 drought coupled with the liquidation phase of the last beef production cycle has resulted in the current declines in the numbers of cattle marketed.

On January 1, 1978 there were an estimated 4.4 million head of cattle in California. The total number of cattle in the State, however, is not indicative of cattle use on rangeland. A more accurate correlation would be the estimated beef cattle and the number of stocker cattle on rangeland. On that same date in 1978 there were an estimated 966,000 beef cattle and approximately one million stockers on rangeland. An estimated 69 percent of the forage for stocker cattle is produced on rangeland (Reed 1974).

Approximately 29 percent of the beef cattle and 50 percent of the stocker

TABLE 7-2

CALIFORNIA RANGELAND PRODUCTION IN ANIMAL UNIT MONTHS (AUM)
(IN THOUSANDS OF AUMS)

AREA	PRIVATE	USFS	BLM AND OTHER PUBLIC	TOTAL	REGION AS A PERCENT OF TOTAL
North Coast	1,163	7	1	1,171	8.4
North Central	406	69	15	490	3.5
North East	528	121	120	769	5.5
Central Coast	3,654	39	58	3,751	26.9
Sacramento Valley	1,380	12	2	1,394	10.0
San Joaquin Valley	3,409	60	99	3,568	25.6
Eastern Sierra	129	42	46	217	1.5
Western Sierra	1,359	31	8	1,398	10.0
Southern California	1,072	27	96	1,195	8.6
	13,100	408	445	13,953	100.0

Source: "The Contribution of Rangeland to the Economy of California," University of California, June 1974.

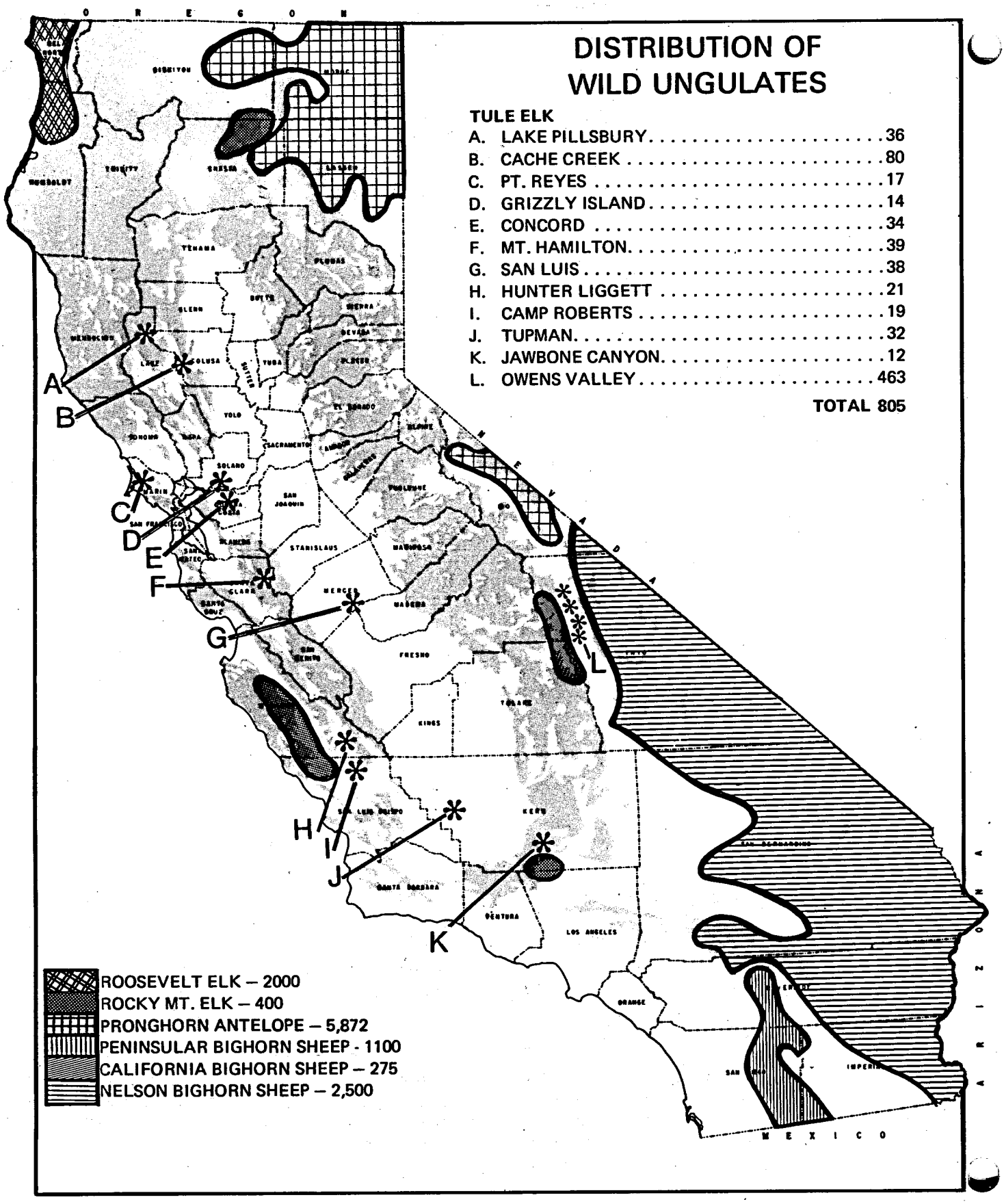
cattle in California are raised in counties adjacent to the San Joaquin Valley. Other counties which produce a significant number of beef or stocker cattle are Humboldt, Siskiyou, Lassen, Modoc, Tehama, Monterey, San Luis Obispo, and Santa Barbara (California Livestock Statistics 1977).

Sheep production is also an important factor in the State's livestock industry In January 1978 it was estimated there were 915,000 sheep in California; a reduction of 23 percent from the 1,185,000 inventoried in 1970. Sheep production is highest in the San Joaquin Valley where 40 percent of the total number is produced. The Sacramento Valley is second with 29 percent. Humboldt, Mendocino, Sonoma and Kern Counties combined provide 46 percent of the range forage for sheep (Reed 1974).

WILDLIFE

Prior to the advent of Europeans in California, the predominate species of big game wildlife utilizing the range resources were pronghorn antelope, bighorn sheep, deer, and elk. Today antelope are fairly well restricted to northeastern California and the elk populations are contained in small herds in the Owens Valley, Humboldt and Del Norte Counties, Cache Creek in Yolo, Colusa, and Lake Counties and other smaller populations presently being reestablished throughout the State by the Department of Fish and Game. The combined antelope-elk population in California approximates 8,000 to 9,000 animals. Figure 7-1 shows the present distribution of antelope, bighorn sheep, and elk in the State.

FIGURE 7-1


DISTRIBUTION OF
WILD UNGULATES
TULE ELK
A. LAKE PILLSBURY.....36
B. CACHE CREEK.....80
C. PT. REYES.....17
D. GRIZZLY ISLAND.....14
E. CONCORD.....34
F. MT. HAMILTON.....39
G. SAN LUIS.....38
H. HUNTER LIGGETT.....21
I. CAMP ROBERTS.....19
J. TUPMAN.....32
K. JAWBONE CANYON.....12
L. OWENS VALLEY.....463
TOTAL 805
ROOSEVELT ELK – 2000
ROCKY MT. ELK – 400
PRONGHORN ANTELOPE – 5,872
PENINSULAR BIGHORN SHEEP - 1100
CALIFORNIA BIGHORN SHEEP – 275
NELSON BIGHORN SHEEP – 2,500
OREGON
NEVADA
ARIZONA
MEXICO

Further discussions in this Assessment of range use by wildlife will be limited to deer, keeping in mind that numerous other species of herbivorous animals are sustained on seeds and grasses. These include mice, voles, gophers, rabbits, ground squirrels, finches, quail, sparrows, and meadowlarks, many of which are important links in the food chains of other animals.

Deer are the most visible wildlife users of forage on the rangelands of California. According to information developed by Longhurst in 1952 approximately 56 million acres, or 56 percent of the State, are occupied by deer as shown on Figure 7-2. Deer occupy most of the forested woodland and chaparral range ecosystems within the State.

The present growth trend of the deer herds in California is downward. Populations in 1978 were estimated at 500,000 animals, a decrease of 60 percent from those of the early 1960's.

The primary factors which have contributed most to this apparent decline, which started about 1960, are thought to be a diminishing food supply and the loss of habitat. Changes in the patterns of burning, logging, and grazing plus a shift from the grazing of sheep to cattle on rangelands have all contributed to a lowering of the production of deer food plants (Longhurst 1976).

Deer thrive best on rangelands where early successional stages of vegetation predominate. Young brush with a mixture of grasses and forbs appears to be the ideal deer habitat. Mature brush and climax forest with little understory and few openings normally support few deer.

Various influences have the potential in California to affect large areas of deer range in terms of successional trends in vegetation (Longhurst 1976):

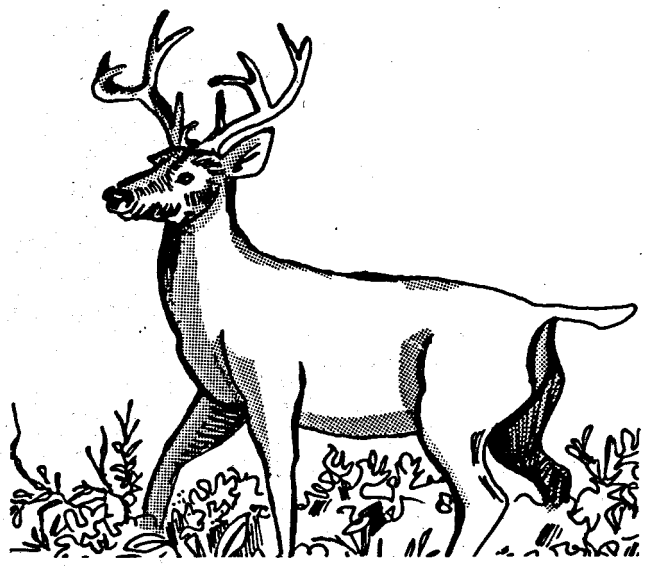
Changes in the numbers and sizes of fires on forest lands,

Changes in the amount of forest being logged,

Changes in livestock grazing on public and private forest rangelands,

Changes in weather patterns,

Changes in long-term carrying capacity for deer on forest rangelands resulting from chronic overstocking by deer themselves.



THE FORESTED RANGELANDS OF CALIFORNIA

DEFINITION

The forested rangelands of California are defined, for the purpose of this Report, as areas which contain at least a 10 percent tree canopy and have grass, forbs and shrubs suitable for livestock and wildlife grazing. Table 7-3 lists some of the more common range forage plants on forest ranges of California. There are approximately nine million acres of forested rangeland in California. Ownership of the forested rangeland is mostly in the hands of the Forest Service and private land owners. Since the BLM does not manage a significant amount of forest land in California (less than one percent), forage outputs were not tabulated for BLM lands.

FIGURE 7-2

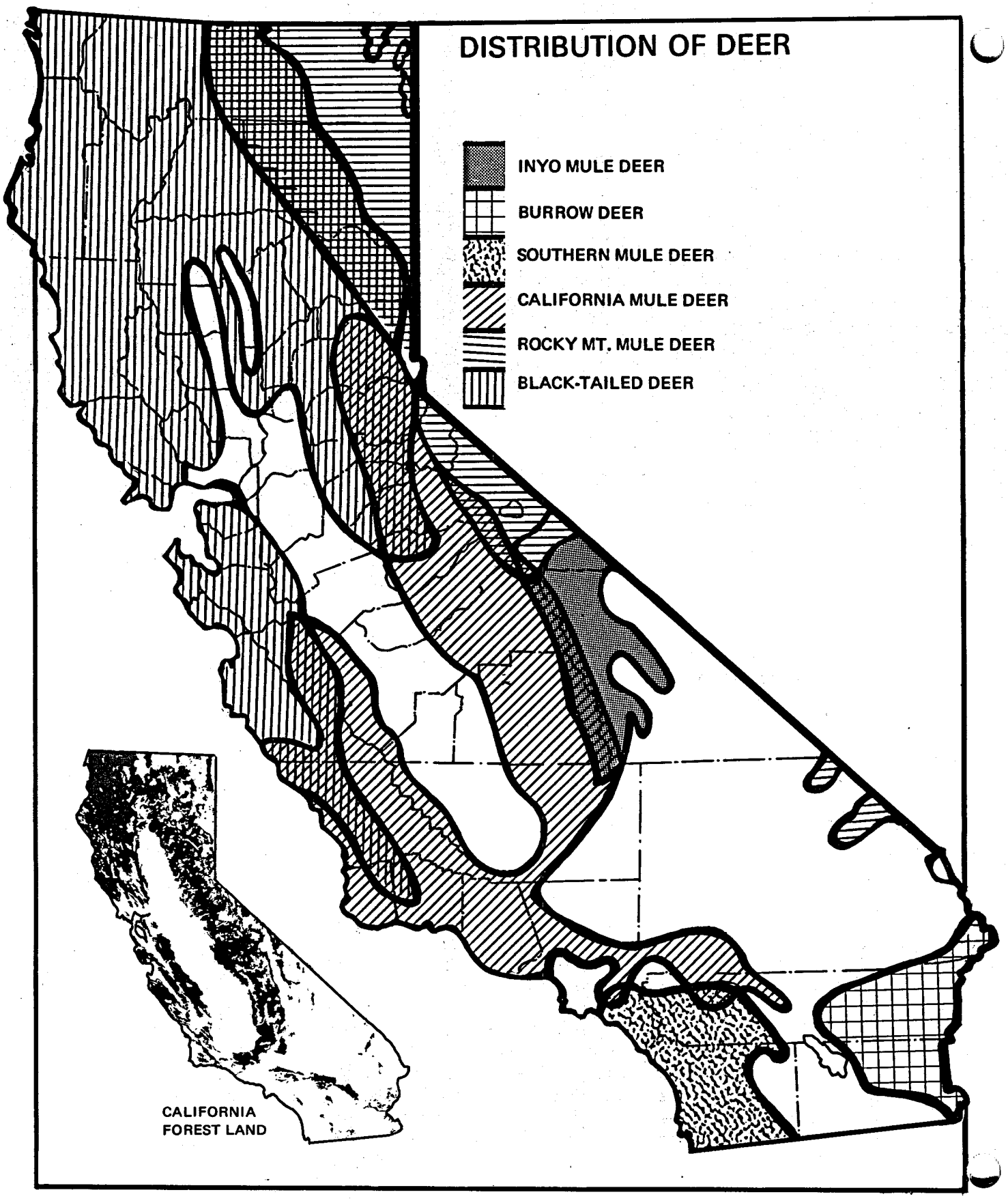

DISTRIBUTION OF DEER
INYO MULE DEER
BURROW DEER
SOUTHERN MULE DEER
CALIFORNIA MULE DEER
ROCKY MT. MULE DEER
BLACK-TAILED DEER
CALIFORNIA
FOREST LAND

TABLE 7-3

COMMON FORAGE PLANTS OF CALIFORNIA FOREST RANGES WITH COMPARATIVE GRAZING VALUES*

GRASSES	FORBS	BROWSE (SHRUBS)
G Perennial bromegrasses	G Bur-clover	G Deer brush
G Perennial fescues	G Filaree	G Bitter brush
G Needlegrasses (Stipa sp.)	G Clovers	G Winterfat
G Oatgrass	G Cow parsnip	G Service berry
G Bluegrasses (Poa sp.)	F-G Mules-ears	G Mountain mahogany
G Soft chess	F Yarrow	G Aspen
G Wild oats	F-P Lupines †	F-G Oaks
G Wild-rye	F-P Vetches	F-G Willow
F Ripgut brome	P Tarweed	F Chamise
F Red brome	P Turkey mullein	F Fireweed
F Foxtail fescue		F-P Sagebrush
F-P Downy chess		P Manzanita
F-P Wild barley		P Rabbitbrush
P Nitgrass		P Cherries (Prunus sp.)

G - Good, F - Fair, P - Poor
† Many species are poisonous
* As compiled by Marvin Dodge in T. F. Arvola's book "California Forestry Handbook" 1978

NATIONAL FOREST RANGELANDS

There are approximately 13.6 million acres of National Forest land within the scope of the Forest Resources Assessment Program. This acreage represents approximately 70 percent of the 20 million acres administered by the Forest Service in California. The remaining 30 percent of the Forest Service's ownership is land that does not fall within the FRAPA definition of 10 percent tree canopy. This includes barren lands, bodies of water, and grassy areas over an acre in size. Of the 20 million acres administered by the Forest Service only 25 percent, or five million acres, is classified as rangeland. At this point in time it is impossible to accurately separate Forest Service nonforested rangeland from forested rangeland. A conservative estimate is that there are 3 to 3.5 million acres of forested rangeland in the National Forests in California. The condition of forested rangelands on Forest Service lands is generally good. The trend is stable or improving slightly. Over-grazing that does occur is usually associated with meadows and riparian habitat.

The grazing use on all National Forest lands within the State in Fiscal Year 1978 was 486,069 AUM's. This represents approximately three percent of the total grazing capacity of the State. It is estimated that 340,000 AUM's were from the forested rangelands within the Na-

tional Forest. The remaining 146,069 AUM's are available on Forest Service lands that are not included in the FRAPA definition of forested lands, such as mountain meadows and sagebrush ecosystems. Eight of the 17 forests provide 338,175 AUM's, or 70 percent of the total 486,069 AUM's on National Forest lands Statewide.

Animal Unit Months In Order of Forage Production on National Forests in California.

Forest	AUM's (FY 1978)
Modoc	99,836
Sequoia	51,734
Los Padres	35,308
Sierra	33,674
Lassen	32,016
Klamath	31,287
Inyo	29,104
Plumas	25,216
Total	338,175

Although the counties of Modoc, Lassen and Plumas produce nearly ten percent (85,400 head) of the State's beef cattle production (966,000 head), the AUM's necessary to produce these cattle are dependent upon the Forest Service lands. Nearly 33 percent of the Statewide Forest Service AUM's are consumed in these national forests:

PRIVATE FOREST RANGELANDS

There are approximately 13.7 million acres of privately owned forested land in California of which about five million acres are forested rangeland. The most productive forest range is the noncommercial oak woodland-grasslands at lower elevations. In general the most productive forage areas are on sites that are not heavily stocked with trees. The foothill regions of the Central Valley and the coastal plains, which are predominately in private ownership, produce a significant amount of the range forage in California. The most noteable problem areas for soil erosion on forested rangeland is along the central and south coast, but the overall trend of private rangelands is stable. Data on the distribution and amount of livestock use on the privately owned rangeland within the forested areas of California is incomplete.

FOREST RANGE OUTPUTS

Outputs from the range environment are numerous and varied. Historically, cattle and sheep have been the two principle marketable outputs of the range ecosystems in California and remain the principal contribution to tax generating incomes. Wildlife has always been an important resource of rangelands, particularly for such recreational activities as hunting and fishing. Rangelands have been important for the conservation of rare and endangered species and the nonconsumptive uses of wildlife such as bird watching, nature study and wildlife photography. See Chapter Six, "Fish and Wildlife Resources," for further discussion of wildlife on forested lands.

Consideration is being given to intensify the use of forested rangelands as alternate sources of energy. In the future, some wood products and new energy sources may come from much of the land now classified as forested rangeland. This is discussed in Chapter Eleven, "Wood Energy."

LIVESTOCK

The livestock industry constitutes the most important sector in the California agricultural economy according to data from the State Department of Food and Agriculture. The industry is composed of cattle, and calf production, milk and dairy products, eggs and poultry, sheep

and lambs, and, pork products. For the purpose of this Report, the term "livestock on forested range lands" refers to cow-calf (breeders) stocker cattle, and sheep. The forested rangelands do not contribute significantly to the dairy, poultry or pork industry. In 1977, cattle and calf production ranked second in value among farm products. This was the first time that cattle production slipped from first place to the number two spot, with milk and dairy products taking the lead. This is the same period that California experienced the worst drought in recorded history.

An evaluation of gross cash receipts over a period of years (except for the drought years of 1976 and 1977) would lead one to conclude that the livestock industry is in a state of economic well being. However, urban encroachment, the rising costs of feed and fuel, interregional competition and depressed market prices in recent years have caused some concern about the industry's ability to compete, at least in some parts of the State, over a sustained time period (Livestock Economics Series). On some of the forested land the current production of red meat is temporarily below potential. Part of the available forage is under- utilized or not utilized at all because the present supply of livestock was reduced during the drought years. In addition livestock grazing, particularly on federal land, has to compete with other multiple use resources such as recreation, wildlife and watershed protection.

There are an estimated 5.4 billion pounds of forage presently being utilized on the forest rangelands of California (see Table 7-4). The potential exists to greatly increase the production and use of forage by better management such as water distribution, fencing, fertilization, and salt distribution. Table 7-4 outlines the present estimated forage used on forest rangelands and potential forage production available to livestock.

Present forage production figures were obtained by using Reed's 1974 data and estimating the information for forested rangelands. The potential forage availability was derived by the CDF/FRAP Range Advisory Group and denotes the total number of pounds of forage present for livestock on forest range lands. Data were derived by:

Acres per geographical region - times
Potential forage production per acre per year - times
Percent allowable use by livestock. (see Table 7-5).

One should remember, however, that the total potential forage availability will be constrained by other land uses such as subdivisions, agriculture, roads, and recreational facilities. In addition there are also limitations in forage production as a result of yearly variations of precipitation, soil capabilities, or areas too steep or geologically unsuited for livestock grazing. The portion of potential forage that falls within these constraints cannot be determined at this time.

Much of the estimated biological potential (expressed in millions of pounds of forage in Table 7-5) is being utilized by other than domestic grazing animals such as deer and rodents. A study made by the CDF in 1972 concluded that livestock production could be realistically and practically increased by 1.5 to 2 times present levels by more careful utilization of the range resource and other using other management techniques such as water distribution, fencing brush control, etc. (Dodge 1979).

On the public unreserved lands (Forest Service), to obtain the potential forage production would require maximizing range management over other land uses such as timber, wildlife, and recreation. It was previously estimated that there were 340,000 AUM's within the Forest Service's forested lands. The 1980 Draft RPA assessment proposes a maximum

TABLE 7-4

ESTIMATED BIOLOGICAL POTENTIAL
(MILLIONS OF POUNDS OF FORAGE FOR LIVESTOCK)

AREA	PUBLIC UNRESERVED		PUBLIC RESERVED		FOREST INDUSTRY		OTHER PRIVATE		OWNERSHIP UNKNOWN***		TOTALS
	CURRENT USE*	** POTENTIAL	CURRENT USE*	** POTENTIAL	CURRENT USE*	** POTENTIAL	CURRENT USE*	** POTENTIAL	CURRENT USE*	** POTENTIAL	CURRENT/ POTENTIAL
North Interior	200.1	888.9	15.0	524.4	23.6	69.1	206.3	651.9	---	---	445.0/ 2,134.3
North Coast	6.0	73.1	---	287.6	13.6	48.9	21.6	65.6	1,114.8	1,145.0	1,156.0/ 1,620.2
Sacramento	143.4	1,135.2	5.0	239.6	27.0	160.7	515.7	1,839.6	---	---	691.1/ 3,375.1
San Joaquin	121.1	684.9	30.0	1,192.6	.4	5.1	974.0	1,357.0	---	---	1,125.5/ 3,237.6
Central Coast	27.5	591.2	---	281.3	---	---	1,161.5	1,193.8	---	---	1,189.0/ 2,066.3
So. California	138.4	403.5	---	452.1	---	---	697.6	---	---	391.2	836.0/ 1,246.8
TOTAL	636.5	3,776.8	50.0	2,977.6	64.6	283.8	3,576.7	5,107.9	1,114.8	1,536.2	5,442.6/ 13,682.3

* Estimated current forage use based upon consumption by livestock within regions using Reed's 1974 work as a basis.

** Maximum forage that could be obtained from all forested lands.

*** Unknown includes land of the North Coast and the land outside national forests in the Southern California region--these would be mostly "other private" but probably also include some public lands.

TABLE 7-5

ESTIMATED POTENTIAL FORAGE PRODUCTION IN POUNDS PER ACRE PER YEAR

TIMBER SITE FT^3/ACRE/ YEAR	NORTH INTERIOR	NORTH COAST	SACRAMENTO	SAN JOAQUIN	CENTRAL COAST	SO. CALIFORNIA
Best 1/3						
> 85	100	500	250	150	400	0
50 - 84	400	1,500	800	600	1,100	0
20 - 49	800	2,500	1,500	1,200	2,000	700
< 20	1,200	3,500	2.500	2,000	3,000	1,200
Poorest 2/3						
> 85	50	200	150	100	175	10
50 - 84	200	400	300	250	350	150
20 - 49	500	1,000	750	600	875	325
< 20	1,200	1,200	1,000	1,000	1,100	500
PERCENT ALLOWABLE USE BY LIVESTOCK						
Best 1/3						
> 85	0	20	0	0	0	0
50 - 84	0	33	50	50	40	0
20 - 49	50	50	50	50	50	50
< 20	50	50	50	50	50	40
Poorest 2/3						
> 85	0	0	0	0	0	0
50 - 84	0	0	0	0	0	0
20 - 49	20	40	40	40	40	15
< 20	25	50	45	40	45	20

of 1.2 million AUM's on Forest Service lands in California. This is only if funding is provided for level I range management (high intensity range management programs). This is an increase of 684,000 AUM's or a 58 percent increase from the 516,000 AUM's presently authorized. Most of this increase would come from land now set aside for recreation, watershed protection, and wildlife habitat. The remainder would come from range improvements and the reallocation of present grazing allotments. Table 7-4 shows an estimated potential of 3.7 billion pounds of forage on the public unreserved lands.

The public reserved lands includes those in wilderness, national parks, and roadless areas. If management policies were changed the potential exists to greatly increase the output of forage on these lands. This is particularly true in the San Joaquin Region where much of the forest land is in the national park system. This would necessitate changes in present policies which prohibit livestock use on much of this land. The possibility to utilize these lands for grazing is highly unlikely because of the recreational value of the land.

A minimal amount of forage for livestock, about 300 million pounds, can be expected from forest industry lands because these lands are predominately occupied by tree species, and because the forest industry does not emphasize forage production.

The amount and distribution of forage on the other private forest rangeland can only be approximated. Very little data are available about this segment of the forest ecosystem. Present forage utilization on private lands is approximately 3.6 billion pounds (see Table 7-4).

According to the data derived in Table 7-5, the other private lands are capable of producing almost twice the amount of forage presently being used, or an estimated potential of 5.1 billion pounds. The best areas on which to concentrate range management practices are along the foothills adjacent to the San Joaquin Valley and along the South Coast where the climate, soil, and vegetation are conducive to good livestock production. One aspect that tends to prohibit the maximum use of forage produced is the lack of flexibility of the farmer to adjust herd sizes for seasonal differences in vegetative growth. In addition, forage variability on a monthly basis prohibits the farmer from stocking his herds to maximum potential. For optimum, sustained livestock production however, herds should be adjusted, not to average conditions or to the months of maximum yield, but to those months and years poorer than average. Increased consumption and higher prices for beef also tend to influence stocking levels.

WILDLIFE

The wildlife outputs from the forest rangelands are varied and diversed. Deer represent the single largest wildlife biomass on forest lands. The populations in the late 1950's were estimated at two million animals. Deer populations have since declined to the present level of approximately 500,000 animals.

The Department of Fish and Game's goal is to intensify deer management programs to increase deer numbers to the 1965 level of approximately 1.5 million animals in order to meet the demand for hunting on forest land. In many respects it will be impossible to achieve increases in areas where subdivision, road construction or water impoundments have permanently disturbed the habitat. However, given adequate funding some kinds of habitat restorations are possible.

Following is a summary of the geographic regions of the State which, accord-

ing to the Department of Fish and Game, have the probability for increased deer outputs:

West Slope of the Sierra. It is probably not very realistic to think that deer herds along the western slope of the Sierra can be improved substantially to increase herd levels. This is mainly due to the loss of habitat through urban development on the winter range, water projects, livestock grazing, and increased recreational use. It will be hard to maintain existing herd populations except in areas where large tracts of winter range remain in private ownership.

Great Basin (Northeastern California). Present populations can be maintained in this area because a good portion of the land is in public ownership. Competition between deer and livestock could result, however, if ranching activities are intensified and ranges are overgrazed. The increased activity in wild horse and burro in this region is having an adverse impact on deer production.

Cascade Range. The Cascade Range in northern California is one of the most productive deer areas in the State. The possibility exists to enhance deer numbers in this area by coordinating deer habitat needs with management practices such as meadow enhancement, increasing browse species and through silvicultural practices such as patch cuts of 60 to 80 acres or less.

Coastal Timber Forest. Because this region is extremely productive for timber, in excess of 120 ft^3 per acre per year, the growing of trees will take precedent over maintaining habitat for deer. Logging will provide short term benefits for deer (7 to 10 years); however, silvicultural practices will encourage rapid tree regeneration and the reduction of competitive brush species.

Coastal Woodlands. This area has the greatest potential for increasing deer outputs. With the proper deer management (the harvest of antlerless animals) and an intensified program of prescribed burning and brush conversion, one can expect to increase deer numbers three to five times. These outputs would be very realistic on public lands; however, assistance through some type of incentive program will be necessary to achieve similar outputs on private lands.

In addition, prior to achieving a substantial increase in deer numbers, criteria must be established by which to control herd numbers. The only practical way to control numbers is through public hunting. If numbers cannot be controlled efforts to improve the habitat will be fruitless and money spent for such purposes will largely be wasted. The control of numbers also implies the harvesting of both sexes (Longhurst 1976).

Various techniques for improving deer range habitat are described in the following section.

DEMAND FOR FOREST RANGE FORAGE

Forage, the product from rangelands, is important to sustain California's livestock industry and wildlife populations. It is anticipated that demands for beef will result in additional use of forested range forage. It is also expected that the demand for more deer will result in the usage of more range forage. Demand data, however, are not available specifically to forested rangelands.

California's consumption of beef has increased substantially from 1961 to 1977. During the 16 year period consumption has increased from 115 pounds to 146 pounds per person. It is anticipated that the number of pounds of beef per person will increase into the 1980's but not at such a high rate as during the previous 16 years. Sheep consumption is expected to remain static or increase slightly within the next 10 years.

Beef and beef products availability may become a more important variable in the future. Thus far the strong California demand has insured a growing and steady flow of beef into the market. If demands continue to grow in other regions, beef availability may become more of a factor. The number and availability of substitutes will also become more important as prices rise. California has the apparent capability of maintaining a strong poultry industry, particularly for broilers. Vegetable protein will also be more important in "lower quality" beef products. "Super Burger," "Protein Plus" and other beef-extended products have been introduced in California recently and merchandised aggressively. Economists have predicted the advent of these products for years and it appears that beef prices are at a point where tastes and preferences can be influenced by such merchandising (Cothern 1973). It is anticipated that increases in beef production will result in additional forage use from forested rangelands. This will be particularly true if the grass rangelands adjacent to urban centers are converted to other uses.

RANGELAND PRACTICES AND IMPROVEMENTS

One of the range manager's goals as a practicing ecologist is to combine the ecology of nature and the economy of man. H. F. Heady, in his book, "Range Management," points out that many rangeland practices are criticized because they have economic goals. Ecological responsibility within an ever-changing social, political, and economic environment requires flexibility in application of range improvement techniques. A balanced use of the range resources means that diversified plant and animal communities are managed on an ecological basis rather than on the basis of obtaining pure stands, monocultures, and replacement of natural communities.

Range improvement on the forested lands of California must be intensified if the goals for increased red meat production, diversified wildlife populations, and better management of our forest resources are to become a reality. This involves flexibility in applications of range improvement techniques including ecological and economic considerations.

The Resources Planning Act addresses 17 range management practices applicable for improving range forage in California. Some of the range practices described by the Forest Service in the 1972 forest-range environmental study are fertilization, irrigation, brush control (mechanical, chemical and fire), seeding, water development, fencing, timber thinning, etc. Range improvement projects in the future will have to continue to address wildlife habitat relationships, endangered and threatened or rare plant and animal species, biomass energy needs, and water quality. Although environmental impacts may appear as roadblocks, coordination and an understanding of other resource needs can produce desirable results for most parties.

An increasing population reduces available acreage for grazing, recreational services, and production of clean water. As Heady comments, because land becomes scarce when demands increase,

range-vegetation management should be practiced with increasing intensity in order to produce high yields of forage and still maintain or enhance other resources.

An example of vegetation management on forest rangeland is the Grindstone Project on Mendocino National Forest. The Forest Service and Department of Fish and Game, in cooperation with private land owners are actively managing the range resource. Numerous techniques to convert brushlands and enhance range, water yields, wildlife habitat, and livestock production have been utilized on the Grindstone Project.

Assembly Bill 1006, the Wildland Fire Protection and Resource Management Act of 1978, is another program that gives CDF the powers necessary to develop two wildland resource management plans for managing vegetation resources. Furthermore, the act grants powers to the Department to provide prescribed-burn standby crews to carry out necessary vegetation management programs. This program is presently unbudgeted however CDF has the capability to use existing fire crews when available for prescribed burning.

The Agriculture Stabilization Conservation Service (ASCS) plays a large role in vegetation management in California. The ASCS administers cost-sharing programs for federal assistance in land management. A key element affecting private efforts in conjunction with agriculture conservation program funds are the priorities placed on these funds. Recently, brushland conversion has been partially eliminated as a priority for ASCS cost-sharing funds. At issue has been whether brushland conversion has a production oriented purpose which is not in conformance with a conservation orientation requirement. Clearly ASCS policies regarding cost-sharing programs can directly affect the ability of private landowners to finance certain vegetation management programs.

The California Department of Forestry has had a program of range resource assessment and range improvement for over thirty years. There have been cooperative field studies conducted in all parts of the State that examined brush control methods, reseeding, grazing management and economics. Annual reports have been issued since 1947 on the range improvement program. As information and program results becomes available, a series of range improvement notes are published to pass the information to ranchers and other land managers.

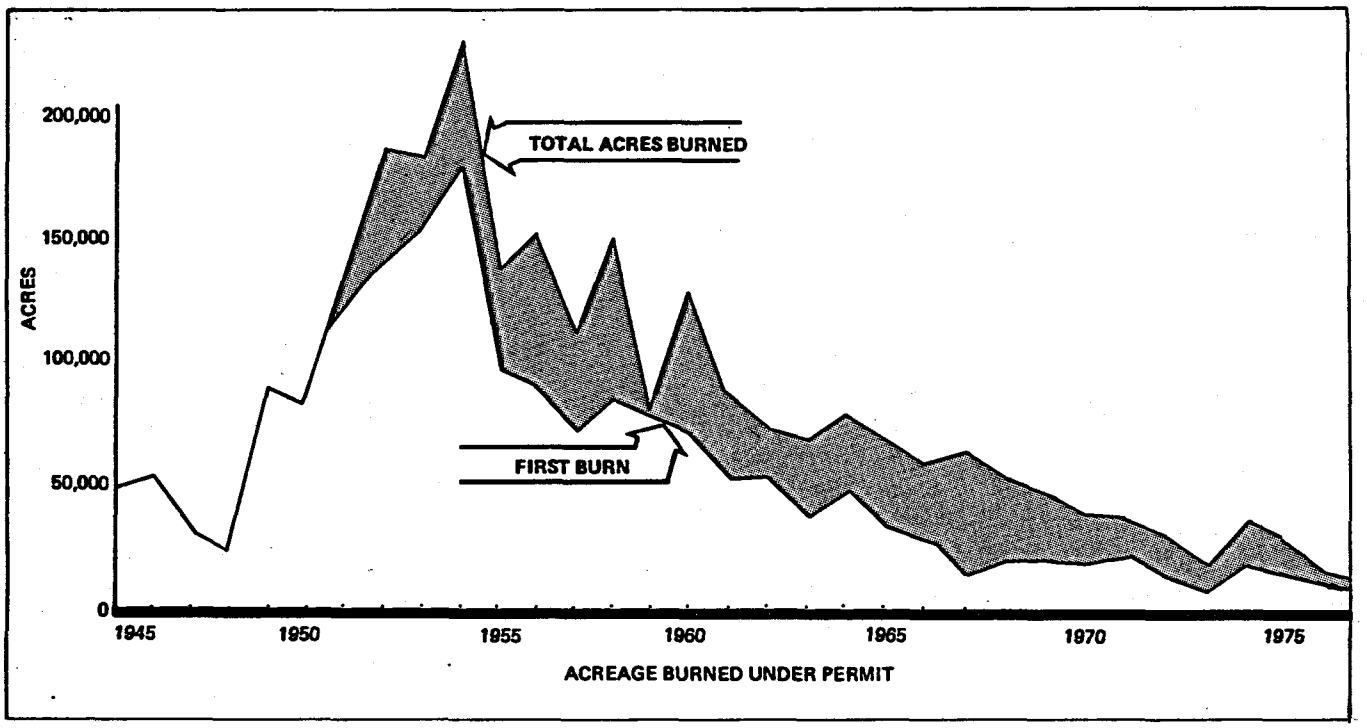
PRESCRIBED BURNING

It has been estimated that about 8.75 million acres of brushland could benefit from brush management for the purposes of range improvement. Where brush is the dominant vegetation about 3.25 million acres could be reconverted to grass for livestock forage, improved wildlife habitat, better fire and erosion control, increased water production, and watershed protection. This could be accomplished by prescribed burning or in connection with other land management practices (Adams 1978).

When a fire occurs on brushland, much of the vegetation above ground level is consumed or killed. Depending on the intensity of the fire and the atmospheric conditions portions of the brush stand are often left unburned. If the fire follows an irregular course, the amount of edge will increase, and the habitat for a number of mammals and birds will improve. This is generally not the case with large, high-intensity wildfires, but prescribed burning on range or forest conversion projects can provide "islands" of habitat for wildlife.

Most brush species are regenerated after a fire either by seedlings or sprouts that grow from surviving subterranean root crowns. The heat of the fire aids in breaking the dormancy of seeds that have accumulated without ger-

FIGURE 7-3



mination in the soil since the last fire. This abundant crop of seedlings and sprouts, together with numerous kinds of grasses and herbaceous plants which grow in burned areas, furnishes a new and significantly more nutritious supply of food for deer, rodents, and birds. The increase in carrying capacity for deer is especially dramatic. On the Hopland Experimental Range census data indicate that deer numbers will increase from about 20 per square mile to 50 or 60 per square mile in brush areas opened up by fire (Longhurst, October 1978). Because of the known positive benefits of fires to increased deer food supplies in most cover types, it seems safe to conclude that decreased acreage of prescribed burns and wildfires in California has contributed to the decline of deer numbers (Longhurst 1976).

The Department of Forestry is responsible for issuing permits for prescribed burns and provides advisory services for reseeding programs for range improvements on private land. During the period from 1950 to 1957, 1.2 million acres were burned under control for range improvement purposes. From 1957 to 1970 the use of prescribed burning gradually declined. From 1970 to 1977 a total of 226,000 acres of brush land was burned or a reduction of 81 percent. Approximately 13,000 acres were burned in 1977 which is the least acreage burned in the history of the program according to CDF's 1978 data (see Figure 7-3).

Department of Forestry range specialists report several reasons for the continued decline in controlled burning, in addition to the impact of the drought years 1975-76 and 1976-77. Air Pollution Control District regulations have a dampening effect in most areas of the State. Frequently the best weather conditions for a good "safe" burn do not coincide with the "burn" days as promulgated by the local districts. Uncertainty about "burn" and "no burn" days makes scheduling of men and equipment for controlled burns difficult. Air pollution regulations also require that applicants planning to burn for wildlife habitat improvement obtain a written statement from Fish and Game. Costs are another factor in the efforts to in-

crease prescribed burning. Winter strip-burning can cost from $10 to $15 per acre while summer burning can cost from $30 to $80 per acre. In addition, prescribed burning involves more serious consideration of such factors as watershed damage, aesthetic impact, and potential liability. Some decreases in burning activity can be attributed to increased land values which could result in greater liability in the event of burns escaping (CDF 1978).

VEGETATION MANIPULATION

Aside from, or in conjunction with, prescribed burning mechanical manipulation of the vegetation can be an important improvement practice. This includes woody and herbaceous vegetation control or manipulation such as brush hogging, mowing, dozing, chaining, plowing, crushing, or shearing. The cost of brush cutting varies depending on the number of tractors being used, the terrain, and the type of vegetation being treated. The use of the ball-and-chain ranges from $15 to $45 per acre. Bulldozer crushing costs range from $30 to $50 per acre. Dozing and piling costs are $50 to $150 per acre. Costs for mechanical brush cutters, because of investment costs, average $40 to $100 per acre and more.

Vegetation manipulation can also be accomplished by chemical or biological means. Chemical control includes the use of herbicides, such as 2,4-D or 2, 4, 5-T. At the time this report went to press, the Environmental Protection Agency (EPA) had suspended the use of 2, 4, 5-T for forest practices. Biological control pertains primarily to the use of insects, fungi, viruses, or similar biological measures in the manipulation of vegetation or control of certain noxious or poisonous plant species, but has very limited application. Manipulation of the vegetation by use of livestock and wildlife can also be used as a tool for controlling vegetation. As an example, goats are presently being studied to control vegetation on some fuel breaks in southern California.

WATER DEVELOPMENTS

One of the more important range improvement programs is the development of stock-watering facilities. Many ranges do not have adequate natural water sources for maintenance of best livestock distribution, except in the high mountain ranges where rivers and springs are abundant. If lands are to receive full use, it is necessary that sources of water be developed or that water be hauled to the animals. The type of development best suited to a range will depend upon local conditions. Improvements may be minor, such as spring or seep development, or they may consist of major projects such as the construction of wells, reservoirs and ponds (Stoddart 1955).

Cattle normally will not travel more than one-half mile for water in rough country and two miles on gentle ground. For sheep, the water should be within one-and-one-half miles on rough topography to three miles on gentle ground.

PROBLEMS AND RESEARCH NEEDS

RESOURCE PROBLEMS

Improved conservation and soil management through vegetation management and grazing control are major needs for some of California's rangelands.

Forage production can be increased on many areas where low infiltration of rainfall and soil degradation has taken place, or is resulting from overgrazing. The encroachment of unpalatable and poisonous plants and species of low forage value to domestic livestock and wildlife is resulting from poor forage management. Woody plants are invading range-

land in some areas because of the decreasing frequency and increasing intensity of wildfires.

Excessive erosion has occurred in the past or is occurring on some California rangelands. Improved range management practices are needed to reduce erosion and maintain water quality in some areas. Water erosion is affecting rangelands to some extent in all areas of the State due to overgrazing, soil compaction, and problems with adjusting herd sizes to the vagaries of California's fluctuating rainfall patterns. The State's predominantly Mediterranean, semi-arid climate creates soil conditions extremely sensitive to overgrazing.

The U.S. Soil Conservation Service is currently developing "best management practices" for California's rangelands to recommend standards and techniques to control non-point pollution from California's rangelands.

Although there were some grazing abuses in the past on federal lands, generally the Bureau of Land Management and the U. S. Forest Service are now practicing good grazing management. Improved management or corrective procedures are also being used on much of the privately owned range, according to a recent canvas made of Resource Conservation Districts by the Department of Conservation.

The problems concerned with evaluating and inventorying the forested rangeland resources of California are twofold:

> Vegetative analysis processes do not fit the FRAPA forest definition and those that are detailed and accurate such as the Soil-Vegetation Survey do not cover the whole State, and
>
> The rangeland resources of the State have not been segregated specifically to forested and nonforested lands. In addition the forested land definition used by FRAP includes much of the land commonly referred to and used as rangeland.

An indirect problem is the assumption by most people that range is a resource for cattle, sheep, and horses; forgetting the use by wildlife.

The forest rangeland resources represent a gray area between the well-defined agricultural land of the valleys and the commercial timber lands. There is uncertainty on what exactly constitutes the rangeland resources in California. One survey, "Forest Statistics of the U.S., 1977," classified 43 million acres as rangeland while another report refers to 36 million acres of rangeland in the State (Reed, June 1974). The review draft for the Forest Service's 1980 "Assessment of the Forest and Range Land Situation" lists 54 million acres as rangelands in California. Much of the difference is due to inclusion of large areas of desert range and chaparral in the higher figures which are primarily useful for wildlife habitat. Because of the vastness and extent of this resource, until just recently very little effort has been directed towards delineating rangelands and describing their productivity. This is particularly true in regards to forested rangeland.

The language in FRAPA further complicates the classification of the range resource. Under the definition of forested lands of California, a majority of the rangeland resources are included; however, this report fails to include the chaparral of the South Coast, the grass steppe surrounding the Central Valley, and the desert range. It is difficult to provide an assessment which adequately determines and conveys the significance of the resource when only a portion of the problem is addressed.

CONCLUSIONS AND RESEARCH NEEDS

In some areas there is much more forage being produced on forested rangeland than is currently being used. The figures for potential forage provided in this chapter are only estimates and should be treated as such. Once the forest range ecosystem is clearly defined and forage productions better quantified, more accurate forage values will be available. Even though the potential estimated forage appears to be high, one must realize that this figure represents what the land is capable of producing no matter what use is presently being made of the land. This implies that land set aside for national and State parks, watershed protection, wildlife habitat, and land split by subdivisions and urbanization may be producing forage even though it is not available to livestock. Some of these land uses however, are beneficial insofar as habitat for wildlife is provided.

Additional forage can also be made available by intensifying range management practices on public and private lands. Prescribed burning, brush manipulation, water developments, fertilization, fencing, etc. can all be used to improve forage production on forested rangelands.

Competition for forage exists between livestock and wildlife. In areas where proper range management techniques are utilized and over grazing does not occur, competition is held to a minimum, or deer and cattle use may actually be complementary. Where competition between livestock and wildlife does occur, it is usually around key areas such as meadows, within riparian areas, and adjacent to ponds and lakes.

The pressure on California's forest rangeland for a broad variety of uses is eliminating or severely restricting livestock grazing in many areas, while the desires for red meat and other livestock products are increasing. Much of the increased consumption has been met through the increased use of feedlots and irrigated pasture but the trend is now back towards grass-fed beef. In addition to increasing production on prime rangelands, research is needed on how to increase range forage for livestock and wildlife on lower-value brushlands, semi-arid lands, and lands which presently are supporting annual plants of relatively low nutritional value. Attention should also be given to methods of reclaiming mountain meadows which have been invaded with brush or trees.

The most striking change in range management is increasing recognition that judicious management of grazing can help meet other problems, such as erosion control, reduction of fire hazard, control of brush species, reduction of competition by trees in young timber stands, and maintenance of an esthetically pleasing landscape. Range management research must continue to place emphasis on values involved in the total, integrated management of ecosystems. Research needs should include but not be limited to the following:

Continue to develop an understanding of the annual-plant ecosystem in California and utilize working models of those ecosystems to account for variations caused by different land-management practices.

Continue to develop range management techniques and policies for properly utilizing and managing high-elevation meadows where past overgrazing and exclusion of fire have permitted tree and brush species to invade the meadows.

Conduct basic research into the nature and control of insects and

diseases which threaten the more important range plants. Develop biological controls for poisonous and noxious plant control.

Determine the preferences of domestic livestock and wildlife for various types of range vegetation, and design management systems to minimize conflicts between the two types of animals.

Delineate optimum deer habitat. Develop through range management practices the necessary amounts and arrangement of cover, forage, and water that will result in increased deer population in balance with food and other habitat needs.

Determine how to maintain high-value herbaceous communities in the face of competition from brush through the use of low-intensity prescribed burning or other techniques.

Determine where brush ranges should be maintained, for supporting livestock and wildlife; determine how to improve the quality of these brushlands.

Develop practical and energy efficient machines for pruning brush; these are particularly needed on winter ranges critical for deer.

Continue to determine the quantity and quality of various range species, by season, so that systems of proper grazing can be developed for the maximum utilization of the forage in consideration of its needs for sustained regeneration and growth.

Determine how the palatability of less desirable range plants might be increased for use by livestock or wildlife; as an alternative, determine how the less desirable plants might be economically harvested and processed for feeding livestock.

Support efforts for a nationally coordinated and standardized system for the identification, classification, inventory, and assessment of rangeland ecosystems.

There is a real need for adequate cost/benefit research on vegetation management practices. Many such management practices in use today cannot be explicitly identified as cost effective based on existing research data. Inadequate data and the variable nature of the vegetation resource place some doubt regarding the wisdom of any given vegetation management practice.

THE WILDERNESS

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INTRODUCTION

The lay perception of wilderness runs the gamut from a hike through a city park to backpacking in the most remote reaches of California's hinterlands where human intrusions are not significant and where one can truly experience solitude. A 1977 Opinion Research Corporation survey concluded that most people are confused over what is or is not wilderness. In fact, one in five people thought they had visited formally established wilderness areas, and yet had not.

California's classified and administratively endorsed wilderness areas vary in location and scenic diversity. They can be found near the Mexican and Oregon borders; in the desert areas, and along the Pacific Ocean; or from near sea level to over 14,000 feet in elevation. They may contain scant vegetation in arid regions or rocky mountain tops, be covered with brush fields, or boast the rain forests of the North Coast.

The 1964 Wilderness Act (federal) established the National Wilderness Preservation System (NWPS) for public lands to be designated within national forests, parks, and wildlife refuges. The Act describes a wilderness area as:

> "Undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least 5000 acres or is of sufficient size as to make practical its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or features of scientific, educational, scenic, or historical value."

The fourth distinction separates wilderness from a purely recreational use context. Wilderness may be more than just an undeveloped area in which to recreate, although the Executive Branch and Congress do not recognize this distinction in allocating money for wilderness management. Forest Service funding to manage wilderness comes from that agency's recreation budget. The California Forest Resources Assessment and Policy Act is specific in separating wilderness from the recreation resource.

Although many supporters of wilderness have no intent or desire to visit these areas still they endorse the existence of areas protected from development or other human modifications. Satisfaction of these needs is largely based upon knowing that large areas are dedicated to maintaining a diversity of ecosystems and size of areas. A delineation of acreages in Tables 8-1 and 8-2 provides an approximate measure of these vicarious wilderness benefits.

Statewide wilderness resource data, other than that giving acreages and certain use-figures are practically nonexistent; and those which are available are not differentiated between forested land and non-forested land. Some data presented in this chapter are of a general nature for all California wilderness, but where possible are specific to the forested portion.

TABLE 8-1

CALIFORNIA CLASSIFIED WILDERNESS AREAS

WILDERNESS AREA	GROSS ACRES (1)	GROSS FORESTED ACRES (2)	1977 VISITOR DAYS USE PER ACRE (3)
NATIONAL PARK SERVICE SYSTEM			
Joshua Tree National Monument	429,690	171,900	
Lava Beds National Monument	56,920	5,700	
Pinnacles National Monument	12,952	12,952	
Lassen Volcanic National Park	78,982	39,500	
Point Reyes National Seashore	25,370	15,200	
Sub-total	603,914	245,252	
NATIONAL FOREST SERVICE SYSTEM			
San Gabriel - Angeles National Forest (NF)	36,137	16,300	1.16
Agua Tibia - Cleveland NF	15,934	0	-- 4)
Desolation - Eldorado NF	63,475	25,400	4.75
Mokelumne-Eldorado NF	50,165	25,000	0.34
Minarets - Inyo NF	102,040	51,000	2.02
Marble Mountain - Klamath NF	214,543	193,100	0.43
Caribou - Lassen NF	19,080	0	--
Thousand Lakes - Lassen NF	16,335	8,200	0.63
San Rafael - Los Padres NF	142,918	28,600	0.31
Ventana - Los Padres NF	159,065	151,100	0.52
Santa Lucia - Los Padres NF	21,250	19,100	--
South Warner - Modoc NF	69,547	62,600	0.16
Cucamonga - San Bernardino NF	9,022	6,800	1.00
San Gorgonio - San Bernardino NF	34,718	29,500	7.12
San Jacinto - San Bernardino NF	21,955	12,100	4.12
Domeland - Sequoia NF	62,695	53,300	0.14
Golden Trout - Sequoia NF	306,000	244,800	-- 4)
Yolla-Bolly-Middle Eel,Mendocino/Trinity NF	113,030	101,700	0.21
John Muir - Sierra NF	483,155	241,600	1.87
Kaiser - Sierra NF	22,500	18,000	0.63
Emigrant - Stanislaus NF	105,345	26,300	2.32
Hoover - Toiyabe NF (in California)	47,937	24,000	2.96
Sub-Total	2,116,846	1,338,500	1.42 weighted average
Fish and Wildlife Service (Farallon Islands)	+ 141	+ 0	
Federal Total	2,720,901	1,583,752	Average for 7 areas = 2.49.
CALIFORNIA WILDERNESS SYSTEM			
Mt. San Jacinto - Riverside County	10,400	8,300	Average for 11 areas = 0.40
Santa Rosa Mountains - San Diego County	87,000	0	
Six separate School Land parcels	1,520	1,400	
Sub-Total	98,920	9,700	
Federal/State Total	2,819,680	1,593,500	

NOTE: "Gross acres" includes public and private areas within wilderness boundaries.

SOURCES: (By Column)

(1) Forest Service, June, 1978, RARE II Maps

(2) Estimate from overlaying CALVEG forest land and RARE II 1:1,000,000 Maps

(3) FRAP

(4) Non-forested or no 1977 Forest Service data available.

TABLE 8-2

POTENTIAL ADDITIONS TO CALIFORNIA'S WILDERNESS

NAME	AGENCY	GROSS ACERAGE	FRAP ESTIMATED FORESTED ACREAGE
ADMINISTRATIVELY ENDORSED WILDERNESS PROPOSALS(1)			
Trinity Alps	Forest Service	291,406	274,000
Monarch	Forest Service	30,689	
Death Valley	Park Service	1,908,000	
Sequoia-Kings Canyon	Park Service	750,690	1,084,300
Yosemite	Park Service	646,700	
Imperial Wildlife Refuge	Fish & Wildlife Service	6,130	0
Havasu	Fish & Wildlife Service	2,510	0
RARE II	Forest Service	899,231	566,500
Anza Borrego Desert	State of California	223,700	0
24 Areas	State of California	96,620	72,500
		4,855,677	1,997,300
AREAS BEING STUDIED FOR POSSIBLE FUTURE WILDERNESS CLASSIFICATIONS			
RARE II - Study	Forest Service	2,648,418	1,668,500
Joshua Trees	Park Service	37,550	15,000
Pinnacles	Park Service	990	900
Point Reyes	Park Service	8,003	4,800
Death Valley	Park Service	6,900	600
Sequoia-Kings Canyon	Park Service	40,080	30,000
Yosemite	Park Service	121	100
California Desert Conservation Area	Bureau of Land Management	5,500,000*	5,000
Northern California	Bureau of Land Management	1,700,000*	1,000,000
6 Areas	State of California	8,428	6,000
		9,950,490	2,730,900
TOTAL ACREAGE OF LANDS BEING STUDIED		14,806,167	4,728,200
OTHER ROADLESS AREAS NOT BEING STUDIED FOR WILDERNESS			
RARE II - recommended against	Forest Service	2,528,989	
California Desert	Bureau of Land Management	7,100,000	
Northern California	Bureau of Land Management	2,000,000	
25 Areas	State of California	66,681	
		11,695,670	
ROADLESS AREAS OF CALIFORNIA		26,501,837	

(1) Source: Forest Service RARE II Map, June, 1978.

*Estimates

FEDERAL WILDERNESS

DESIGNATION

Since passage of the 1964 Wilderness Act, federal wilderness can only be designated by Congress. Prior to the Act the Forest Service, starting in 1924, had designated 9.1 million acres nationwide to wilderness management. This includes establishment by federal legislation as recently as February 1978, of 13 new wilderness areas and expansion of four existing ones. Over 1.3 million acres were included in this expansion of the NWPS. Almost 30 percent of this new wilderness is in California.

The NWPS now includes over 15.7 million acres in 174 areas in the United States. Approximately 90 percent of the wilderness areas are located on national forests. Wilderness proposals now before Congress total over 170 million acres, of which 124 million are in Alaska.

MANAGEMENT

The Wilderness Act allows some administrative discretion in applying resource management decisions. The various wilderness administering agencies, i.e., the Forest Service, Park Service, and Fish and Wildlife Service, have interpreted, through legislative history, their management direction in allowable wilderness improvements, maintenance methods, operation of any mechanized equipment within the wilderness, use of fire in maintaining a desired ecosystem, control of recreation use, grazing and wildlife management techniques, etc. As people-pressures increase and as total wilderness area stabilizes, carrying capacities will have to be defined which respond first to environmental preservation and then to the public use pressures and to the managing agency's capabilities to respond.

Public hunting is prohibited in national parks and in park wilderness areas; however, hunting is permitted under State regulations in national forest wilderness. The same federal limitations apply to grazing, which is allowed in national forest wilderness but not in national park wilderness. Logging is not permitted in wilderness though the Forest Service estimates 23 percent of California national forest wilderness could be classed as commercial forest land. The Act states that wilderness areas which were once public domain will be open to mineral entry and claim filing until 1983. Valid mining may occur in these wilderness areas after 1983, but the purposes for which national parks and monuments were created mandate against the environmental disturbances caused by mining activity.

As mentioned in the introduction, wilderness is classified and managed for a variety of reasons, recreational use being only one. For instance, wilderness areas may be managed to preserve high quality fisheries for trout, salmon and other native fish. A major reason for the creation of the Golden Trout Wilderness was the protection and reestablishment of a viable golden trout population.

Wilderness serves as a refuge for those wildlife species which depend on undisturbed habitat conditions or are vulnerable to human influence. Particularly favored in wilderness areas are species which require old growth forests. In California these species include the pine marten, fisher, wolverine, spotted owl, pileated woodpecker and northern flying squirrel. Other species, although not requiring old growth forests, are associated with wilderness or limited access areas because of a relative intolerance to human activity and disturbance. Such species include the cougar, southern bald eagle, California condor, peregrine falcon and California bighorn sheep.

Historic and cultural values are mentioned in the 1964 Wilderness Act as supplemental characteristics of wilderness. This designation can benefit cultural and archeological resources by being managed to maintain relative inaccessibility which will protect petroglyphs, pictographs, pottery and other artifacts. Cultural artifacts are a non-renewable resource for which options for future study and interpretations are preserved by leaving the properties intact. Wilderness areas in California also contain land sacred to Native American groups.

Relict vegetational types and a diversity of plant communities are found in wilderness areas, and vegetative conditions will be maintained which eventually may be missing or limited on private or other public lands. Diverse forests harbor a storehouse of genetic variability and recessive genes which are necessary for adaptability over time in the face of environmental change. The preservation of genetic variability has been cited as a crucial need for the potential discovery of products beneficial to human health or survial, examples of which are the discovery of medications such as quinine and cortisone.

Wilderness is valuable in scientific research and are managed to provide a baseline for determining the effects of human activities on ecosystems. Wilderness areas provide the best standard available against which the alteration of developed lands can be measured. There also are areas where studies of natural processes and wildlife behavior studies can be undertaken with less concern that human-induced disturbances will alter the results. Wilderness is used in education and pyschological therapy. Environmental educators, college field courses, youth and religious groups utilize wilderness areas as learning resources (Coules 1979).

STATE WILDERNESS

The California Wilderness Preservation System was established by the Legislature in 1974 to preserve suitable State lands in a natural wilderness condition for public use and enjoyment. Several branches of State government are involved in identifying and preserving such wilderness areas. The State Park and Recreation Commission classifies "State wilderness" within the State park system. The State Lands Commission can report to the Legislature its recommendations as to suitability or nonsuitability for preservation as wilderness of State-owned roadless areas under their jurisdiction. The Secretary of the Resources Agency has similar authority for State-owned roadless areas under agency jurisdiction including, but not limited to, lands within the State park system, State forests, and fish and game refuges, reserves, and sanctuaries.

The California Wilderness Act of 1974 (Chapter 1.3 of the Public Resources Code) specified that the Secretary for Resources shall, on or before December 1 of each year, report to the Governor and to the Legislature on the status of the California Wilderness Preservation System, including a list and description of the wilderness areas within the System; guidelines and regulations in effect; and recommendations for additions to the system.

The jurisdiction of lands placed into the State Wilderness System is not changed. The Resources Secretary adopts guidelines for the management of wilderness areas and other State agencies are required to adopt management regulations consistent with these guidelines for lands under their jurisdiction.

The California Wilderness Act's description of area criteria and management principles are quite similar to those in the 1964 national Wilderness Act.

WILDERNESS SUPPLY

EXISTING WILDERNESS SUPPLY

Congressionally classified wilderness in California as of June 1978 includes the 2,720,901 acres shown in Table 8-1.

California State wilderness areas, also shown in Table 8-1, cover 99,000 acres. The six separate parcels of State school lands (1,520 acres) are located in Monterey, Santa Barbara, Siskiyou and Tehama Counties. These school lands are contiguous with national wilderness areas, are managed in a compatible fashion, and because they were not exchanged with the Federal Government to become a part of the federal system prior to January 1, 1977, became a part of the State system pursuant to Section 5093.34(b) of the Public Resources Code.

Figure 5-5 (in Chapter Five, "Forest Lands and the Air Resource") shows classified federal wilderness areas in California and points out the paucity of wilderness near population centers.

POTENTIAL WILDERNESS SUPPLY

In addition to the existing wilderness in California, FRAP has tallied the status of other roadless areas which are or have recently been considered for addition to wilderness systems. The first category includes areas which have already been selected by administrative agencies for inclusion and are in various stages of formal presentation to the California Legislature or to Congress. These areas are shown in Table 8-2 and would almost double the existing wilderness acreage in the State if accepted.

The second category of areas which might be considered potential wilderness are currently under administrative study for determination of their suitability. Nearly ten million acres are included in this category. The forested portion is estimated to be about 2,700,000 acres.

The final category shown in Table 8-2 includes 11.7 million areas which for the most part have been studied for wilderness and not recommended for inclusion in the State or national wilderness systems - or in the case of the indicated RARE II lands such designation has actually been recommended against inclusion in the NWPS.

Potential national park wilderness additions will be dependent on qualifying future land acquisitions; and none are in the immediate offing. A 1972 Department of Interior Guideline provides latitude for designation as wilderness: "When non-qualifying lands are surrounded by or adjacent to an area proposed for wilderness designation and such lands will within a determinable time qualify and be available federal land, a special provision should be included in the legislative proposal giving the Secretary of the Interior the authority to designate such land as wilderness at such time as he determines it qualifies."

Public lands administered by the Bureau of Land Management were not included in the 1964 Wilderness Act. However, in 1976, the Federal Land Policy and Management Act (FLPMA) directed that lands under BLM jurisdiction be inventoried and evaluated for wilderness potential, and that recommendations be made to Congress by 1991 as to the suitability or non-suitability of each wilderness study area so identified for inclusion in the National Wilderness Preservation System.

BLM in California is in the inventory and study stages of wilderness classification. The agency is not in a position to divulge estimates of probable acreage which would be submitted to Congress for

wilderness designation. Most BLM lands are nonforested. The forested areas in Table 8-2 are gross estimates.

The State Resources Agency lists 25 roadless areas, totaling 66,681 acres, within State lands as not recommended for wilderness classification. These areas do not meet wilderness criteria or need intensive management to protect their fragile ecosystems, endangered or rare species or unique features (Resources Agency 1978).

The State Lands Commission is foregoing additional wilderness review until the State land adjustment process has consolidated State holdings into units more suitable for wilderness consideration.

National forest wilderness additions have been the subject of major studies over the past several years. Because the process of allocating land to wilderness is not yet complete, it is useful to briefly discuss the latest Forest Service study. This study includes a means of quantifying wilderness values which FRAP has found useful in programming and no other definitive valuation system has been formulated at this time.

The Roadless Area Review and Evaluation (RARE) process was started in 1972 and was revived in 1977 (RARE II). Included were lands which in the administration's review (USDA) did not show significant marks of human development such as roads, buildings, evidence of tree culture, and so forth, and which were therefore eligible for wilderness classification consideration. The public was asked to review an inventory of these areas in order to suggest additions or deletions and criteria which should be used to evaluate the areas for wilderness or non-wilderness use.

The administration, through the Forest Service, then decided that four major measurable criteria should be used to determine the character and scope of a quality national wilderness system. They were:

Representation of major landforms (such as the Coast Range).

Representation of major ecosystems (such as Bailey's Pacific Forest Province).

Presence of certain wildlife (such as the fisher which lives in large areas of mature forest associated with wilderness).

Distribution of wilderness for better accessibility from population centers.

These four criteria, together with scientific and educational attributes, were used to evaluate the roadless areas, identify gaps in the existing Federal wilderness system, and help describe the "ideal" system. Then a set of criteria relating to costs or impacts of wilderness designation was applied to the inventory. They included effects on the timber, energy, and mineral resources, on motorized or intensive recreation use, and on wildlife management programs.

In order to evaluate the more specific wilderness characteristics of the nearly 2,000 roadless areas nationwide, and to emphasize that wilderness is not just a single commodity, the Forest Service developed the Wilderness Attribute Rating System (WARS) based on criteria specifically mentioned in the Wilderness Act. The system rates on a seven point scale of defined components for the four requisite wilderness attributes described in the Wilderness Act; natural integrity, apparent naturalness, outstanding opportunities for solitude, and primitive recreation.

In addition, WARS provides for rating four supplemental wilderness attributes; outstanding ecological, geological, sce-

nic, and historical features. These are supplementary because their presence is permissible, but not required by the Wilderness Act. The rating system deliberately sought to avoid any reference to value judgments by use of terms such as wilderness quality, suitability, qualifying characteristics or any other phrases with judgment implications. The assumption was that compilation of objective and descriptive data on components of all the wilderness attributes would facilitate consistent wilderness ratings by both resource professionals and the public and thus facilitate decision making (Forest Service, November-December 1977)

The Forest Service analyzed the responses and issued a RARE II final environmental statement in January 1979 recommending that 1,284,830 acres in California be allocated to wilderness, 2,528,989 acres (176 roadless areas) to non-wilderness and 2,648,418 acres (118 roadless areas) allocated to further study and planning. During this remaining planning process the wilderness integrity of these further study acres is not to be violated.

On March 8, 1979 the California Resource Agency made its own recommendations for the future uses of the undeveloped national forest land in California. The Agency recommended designation of 1,450,000 acres to wilderness classification, 1,682,937 acres to non-wilderness classification, and future study of 3,084,067 acres. The State's recommendations were based on a task force, mediation approach representing "broad public involvement."

A third approach to wilderness allocation in California will be offered by Dr. Dennis Teeguarden, University of California at Berkeley, who has utilized Forest Service RARE II data in a linear program and come to different conclusions based on economic considerations.

The Forest Service has assessed the likely physical-biological and economic effects of implementing the various alternatives in the RARE II California supplement to the Draft Environmental Statement. This assessment is necessarily broad due to the number of areas and the acreages involved.

For the FRAP linear programming model the WARS points were used as the best available measure of wilderness. Within each of the six FRAP California regions (shown on Figure 1-3) the attribute points for all RARE II areas were cumulated and expressed on a per acre basis. The model assumes that an "allocation" of forested acreage to wilderness would also include a proportional allocation of the more barren lands in each region.

Because WARS points were assigned to units of widely varying size in the RARE II process, per-acre conversions may drastically affect the desirability ranking of individual RARE II units. This weakness is mitigated by the aggregation of potential and existing wilderness to regions.

A further objection to use of the WARS values is that existing wilderness has not been rated. Presumably these areas would have similar or somewhat higher values. Such values were assumed and results are shown in Table 8-3.

Because the CDF/FRAP linear program (which is based on per-acre values) will tend to allocate to wilderness those areas which produce the most WARS points per acre, and because existing wilderness received the public's highest priority for such classification, it is necessary to attribute sufficient points to existing wilderness if the model is to simulate realistic results. To produce similar per-acre values between existing wilderness and all RARE II areas, it was necessary to raise existing wilderness points per area to 200 (as compared to the high 20's for the most highly rated RARE II potential wil-

TABLE 8-3

WILDERNESS ATTRIBUTE RATING SYSTEM POINTS AND LINEAR PROGRAM COEFFICIENTS BY REGION

REGION(1)	ASSUMED WARS POINTS IN EXISTING WILDERNESS	WARS POINTS FOR ALL RARE II AREAS	ESTIMATED WARS POINTS PER M FORESTED ACRES OF EXISTING WILDERNESS AND RARE II LAND
North Coast	112	176	0.911
Northern Interior	929	1,164	1.559
Sacramento	287	587	1.521
San Joaquin	1,175	802	0.800
Southern California	1,021	825	0.738
Central Coast	570	150	2.727
California	4,094	3,704	1.032 (weighted average)

(1) Refer to Figure 1-3

derness areas). On a forested acreage basis State averages per thousand acres are thus 1.100 WARS points for existing wilderness, 0.966 for all RARE II areas, and 1.032 for both combined. The order of magnitude difference suggests that this scale is not really appropriate for measuring both existing and proposed wilderness.

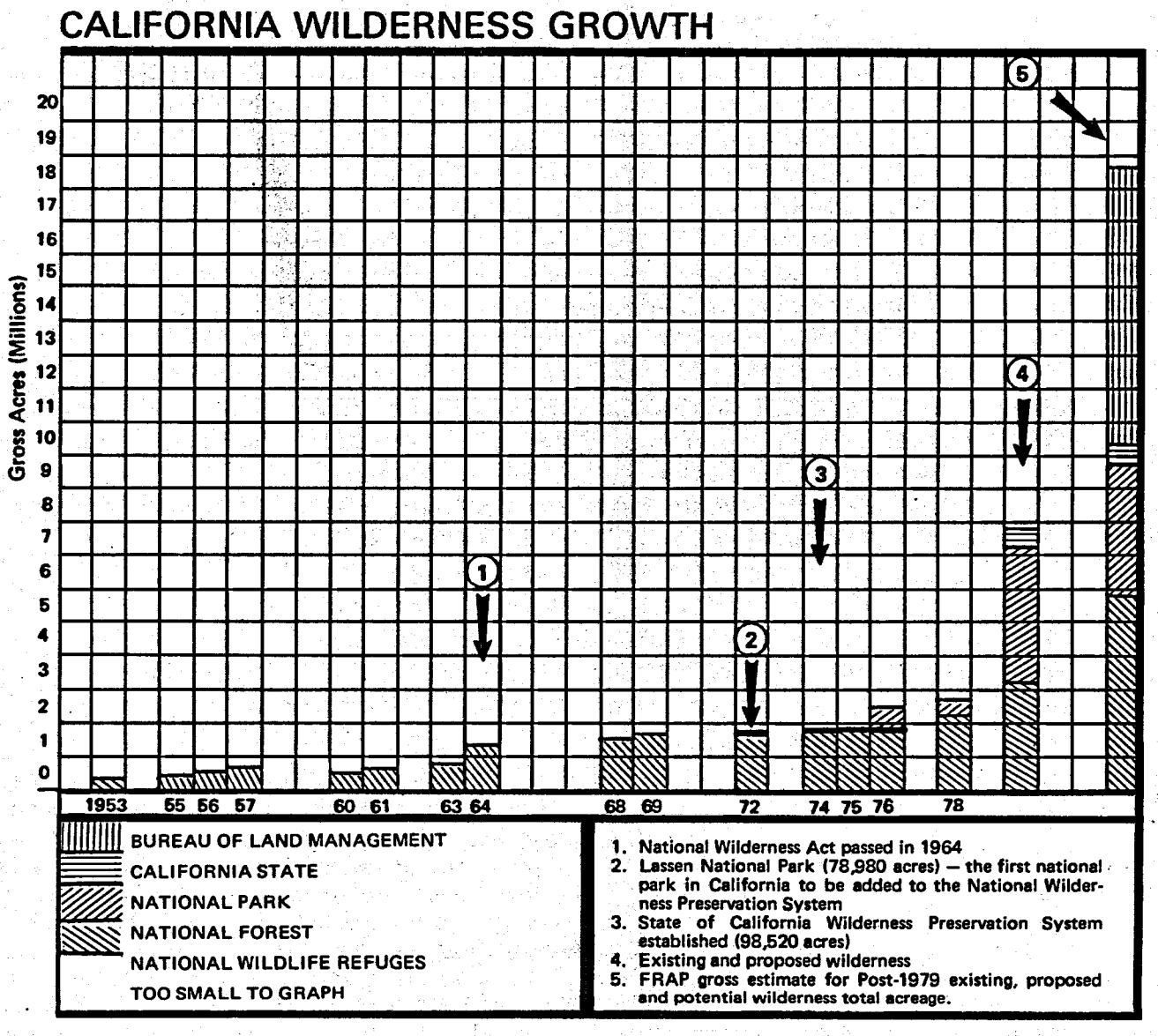
Because WARS points are not determined on a per-acre basis and existing wilderness areas are, on the average, substantially larger, one would expect the sorts of difficulties described above. However, for examining incremental changes in the area allocated to wilderness the measure is reasonable on a regional basis, particularly when the alternatives depending on existing data are considered. For a total evaluation of our wilderness system the measure leaves much to be desired.

Figure 8-1 illustrates the historical growth of California's wilderness. The final bar in the figure includes a gross estimate made by FRAP of area which might eventually be included in wilderness.

WILDERNESS USE

Wilderness use, in this context, refers to people use; recognizing that wilderness is "used" by many living organisms and is a refuge for some from human disturbances.

For many, wilderness is a resource to be enjoyed and used because of the opportunities to experience remoteness, hiking, solitude, etc. Measures of this type of wilderness use ideally should

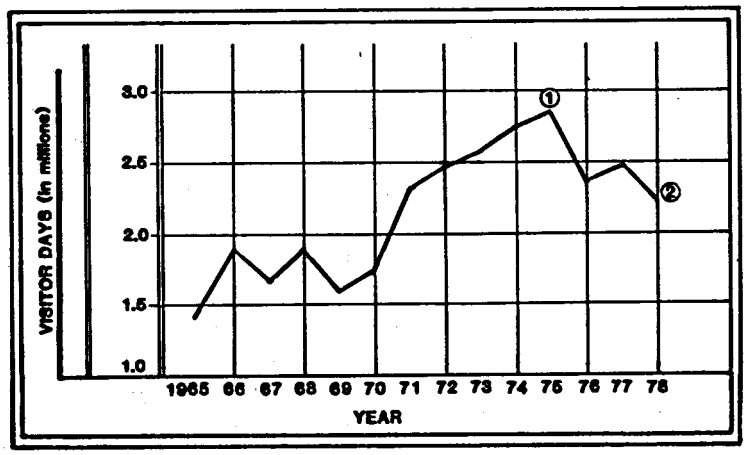


incorporate the use that occurs on somewhat similar roadless areas as well as classified wilderness. It has not been possible to determine accurately the amount of use in the solitude wilderness-type roadless areas. Hence estimates provided by the various agencies represent classified wilderness use, which this Report refers to as "wilderness use". An exception is the Park Service which measures "backcountry" use (including roadless as well as classified wilderness).

The very nature of wilderness precludes accurate measurement of visitor use, even where use permits are required. A recent study showed that nearly 20 percent of all wilderness visitors failed to get the required wilderness permits (Vaux 1977). Trail counters provide some information, but they are not used extensively.

The units for measuring wilderness use utilized by the various agencies are as diverse as the units for measuring gen-

NATIONAL FOREST WILDERNESS USE IN CALIFORNIA



① Wilderness permits required for all national forest wilderness. Provided more accurate information for 1976.

② Late opening of wilderness areas due to deep snow.

eral recreation use. The Forest Service uses visitor-days, the Park Service totals the number of persons and "visitor nights" or overnight stays, and the State uses a count of campers and day hikers.

PAST AND PRESENT USE ON CLASSIFIED WILDERNESS

Use of California national forest wildernesses has increased an average of six percent annually over the past nine years according to Forest Service figures. Use may be leveling off, as is illustrated on Figure 8-2. This Figure shows total national forest wilderness use, including that on forest land. Using a rough estimate that 65 percent of national forest wilderness is forested, and assuming the ratio of use in forested and non-forested wilderness is proportional, visitor-day use shown on Figure 8-2 could be reduced by 35 percent to point out forest land wilderness use.

Some wildernesses are much more intensively used than others over their annual period of accessibility. On California's national forests during 1976 this ratio varied from 7.31 visitor-days per-acre in the San Gorgonio Wilderness to 0.18 in the Domeland Wilderness. Levels of use on certain wilderness areas have reached the point where adverse impacts and land management problems have occurred; a situation which can well be envisioned when 34,700 acres receive 253,800 visitor-days use compared to 62,700 acres receiving only 11,400 visitor-days. Such impacts can be mitigated by restricting wilderness permits and enforcing permit compliance.

To better control adverse impacts, limits have been imposed on the number of permits issued for entry into the San Gorgonio Wilderness area (1975), San Jacinto Wilderness (1976), Desolation Wilderness (1978), and on the John Muir and Minarets Wilderness areas (1979). In addition, special closures have been imposed on some of the southern California wildernesses when warranted by potential high fire conditions.

TABLE 8-4

OVERNIGHT STAYS IN NATIONAL PARK BACKCOUNTRY		
NATIONAL PARKS (NP) MONUMENTS (NM) FORESTS (NF) OR SHORES (NS) WITH WILDERNESS	1977 BACKCOUNTRY RECREATION OVERNIGHT STAYS	REMARKS
Joshua Tree NM	2,468	Day use much heavier but no tally for backcountry.
Point Reyes NS	30,242	No day use figures for backcountry.
Pinnacles NM	--	No backcountry use tally; day use only.
Lassen NP	13,022	Day use: 125,082 visits. Estimate 91 percent of backcountry overnight use is in Wilderness.
PROPOSED WILDERNESS		
Yosemite NF	194,243	
Sequoia NP	94,331	

Source: National Park Service, Region 5, San Francisco

Statistics on use of national park wilderness areas are not available as has been mentioned. However, Table 8-4 presents 1977 back country information for units within the National Park system in California.

Use-statistics on lands under the California Wilderness Preservation System are not generally recorded specifically to wilderness use. In the 1976-77 reporting year, 740 people visited the Santa Rosa Mountain State Wilderness; and at the Mount San Jacinto State Wilderness 30,913 campers registered and 12,250 day hikers were recorded (Resources Agency 1978). During the 1977-78 reporting season, no wilderness tally was available for the Santa Rosa Wilderness; however the tally for the Mount San Jacinto Wilderness was 122,702 campers and day users, which represents an increase of 184 percent in one year.

Weather is a factor which in the past has affected wilderness use. Extreme

fire danger conditions may limit use or cause wilderness to be closed at any time. In addition to fire hazard implications, drought or deep snow affects water related recreational amenities and can therefore adversely affect wilderness use.

FUTURE WILDERNESS USE

The accuracy of recreational use estimates were described in the 1979 Forest Service RPA Review Draft Report to Congress as "generally low" and the suggestion was made that any analysis of "demand" must be conducted with caution.

Table 8-2 shows the potential wilderness acreage in California, and Figure 8-2 indicates a possible trend towards a lessening in the rate of increase of annual wilderness use on California national forests. Within the next few years a much more clear picture of wilderness use should evolve, as the trends on national forests become more evident and roadless area land use classifications within the national parks, BLM lands, and the national forest RARE II areas are resolved.

Many variables affect predictions of future classified wilderness use:

The greatest variable is the question of the eventual size of California wilderness--whether it will stabilize at the present 2.8 million acres or grow to over 13 million acres, with an ultimate potential of around 18 million acres or almost one-fifth of the State's area. Other than Yosemite and Sequoia-Kings Canyon National Parks most of these potential new wilderness areas may not compare in attraction to existing wilderness areas with their cool alpine settings. Despite a certain appeal, the potential arid wilderness areas probably will not attract the visitor-days per-acre of many existing wilderness areas during the heavy use season.

The decreasing availability of, and higher costs for, transportation fuels will have a restrictive impact on travel to distant wilderness. Adverse environmental impacts will therefore probably occur on wilderness areas such as San Gorgonio which are close to population centers unless carrying capacity limits are strictly enforced.

Over a period of time, wilderness managers will be more knowledgeable about visitor impacts as well as visitor wilderness experience preferences. Such information may dictate revisions in wilderness permit issuance policies and lead to needed changes in use patterns.

Another variable that will affect future wilderness use will be management's ability to induce visitors to utilize the less heavily visited wilderness areas (see Table 8-1, which shows visitor-days use per-acre). These generally are the more remote Northern California wildernesses or those of Southern California which are less accessible, have minimum water sources, have large expanses of chaparral, and are consequently more prone to closure due to fire damage.

The results of many wilderness studies perhaps can shed some light on future wilderness use.

Research has shown that wilderness visitors are overwhelmingly urban in points-of-origin; have high levels of education; most are white-collar workers, primarily in the social service and educational occupations, they are somewhat above average in income; and young adults are the most usual visitors. Although this youthful segment of the population has grown enormously in the last 30 years, statistics show that it will grow more slowly in the decades immediately ahead (Forest Service, 1979, "RPA-An Assessment").

In 1975 William McKillop of the University of California made a quantitative analysis of wilderness use in California. Numerous potential factors for influencing wilderness use were investigated including income levels, travel costs, population levels, availability of leisure time, number of lakes, total length of streams, magnitude of trail systems, size and elevation of areas, steepness of terrain, weather conditions, and factors affecting accessibility. Linear programming models were constructed. The model showed that factors appearing to be of major importance in northern and central California regions were the size and elevation of wilderness areas, travel time from metropolitan areas, number of lakes or entry points, and population within 100 miles. For southern California areas the important factors were trails, streams, and population levels in close proximity to an area.

McKillop also reported a strong wilderness-use relationship between college education, today's rapid dissemination of wilderness use know-how, and the growing appreciation of natural phenomena characteristic of the environmental movement. Increased road construction on adjacent national forest land (usually a result of logging) may lead to increased use of wilderness areas because of accessibility and increased numbers of trailheads.

According to the Forest Service 1979 draft RPA Assessment and Report to Congress, various factors affecting wilderness "demand" such as population, income, and education are expected to result in increasing wilderness use, but the rate of growth will decrease. Wilderness use is expected to increase only about two percent a year for the next several decades if the National Wilderness Preservation System is not enlarged. However, studies of wilderness visitors also suggest that a substantial proportion, perhaps one-fourth to one-half of those who now visit wilderness-es, could find the recreation opportunities they are seeking in a nonwilderness, roadless area that is not formally designated as wilderness, as long as the area retains wilderness characteristics.

Future use of wilderness areas can be increased through management options. Most wilderness visitors stay on trails; they do not go cross-country. These trails often originated as stock or primitive access routes not associated with recreational hiking. Consequently, these trails were not located for maximum recreational use or enjoyment. Improved existing trails and new trails into untapped areas would disperse more people more quickly without seriously impacting the environment as long as reasonable carrying capacities are established. Assuming reliable physical carrying capacities can be determined then some wilderness close to urban centers could be managed to allow use to the limit of the physical capacity - which might be unsuitable socially and emotionally for some wilderness users who would value a greater degree of solitude. Eventually, a wilderness permit fee might be charged, the amount varying with popularity of the area, such as is done with entrance fees to some parks.

CONCLUSIONS

This Assessment aims at the inventory of certain human and natural resources on forest lands. Such data currently available for California wilderness areas come mostly from the Forest Service which administers 75 percent of existing designated wilderness. Besides compiling acreage figures (by county), the Forest Service has use data by years and by each classified wilderness area. They further break down wilderness data by recreational activities such as hiking, camping, and hunting. Time did not

permit an in-depth analysis of such data which relates more to recreation experience levels and to management options than to wilderness supply/demand and cost/benefit analyses. Such analysis should be a part of future FRAP activities.

As was noted previously, prior to and since passage of the 1964 Wilderness Act about 2.8 million acres in California has been classified as wilderness. Of this acreage, about 57 percent is forested. An estimated potential of nearly 16 million additional acres on lands within national parks, monuments, forests (RARE II), wildlife refuges, and BLM lands awaits public response and Congressional action.

Other than wilderness visitation data from use permits, such a small amount of multi-resource information is available from classified wilderness areas that it is not inventoried in this Report. Future surveys should attempt to better inventory all wilderness resources. Even visitation figures are statistically impossible to correlate between administering agencies since each records the information in different, and not necessarily compatible, units and time periods. To adequately assess wilderness use it is important for administering agencies to take steps towards creating a common system of counting and recording visitors. Lack of wilderness data seriously hampers any management alternative analysis and therefore makes the decision making job more difficult, to the point that decisions come from a political more than from a professional judgmental position.

The 1987 CDF/FRAP assessment should devote attention to a resource inventory on all restricted forested lands, including wilderness, wilderness study areas, ecological preserves, botanical, wild and scenic rivers and other areas set aside for preservation purposes where most multiple land use options are foregone. A clearer picture of California land zoning would surface and a better understanding of where resource management options could take place would ensue.

FOREST LANDS AS A RECREATION RESOURCE

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INTRODUCTION

Over 22,471,000 people live in California, according to the January 1, 1979 official estimate prepared by the State Department of Finance. This represents an increase of over 12,700,000 during the thirty-year period since World War II when the State's dramatic population climb began. This burgeoning population, coupled with an increase in leisure time and discretionary income, and the many opportunities available here for engaging in recreation, has resulted in annually increasing levels of outdoor recreation participation both in highly urbanized centers and in natural or woodland environments.

These outdoor recreation activities cover a broad spectrum ranging from outdoor sports to driving for pleasure. In forested environments, the activities and requirements are equally diverse. For example, birdwatching requires no support facilities while downhill skiing is highly dependent upon the presence of man-made equipment and facilities.

Four components of the Statewide forest recreation picture are addressed in the remainder of this chapter: data sources and methodology, management of forest recreation, forest recreation use, and facilities that support forest recreation.

FRAP FOREST RECREATION ANALYSIS METHODOLOGY AND DATA SOURCES

An initial objective of the FRAP recreation study was to delineate forest land recreation from outdoor recreation in general. The decision was made to consider only those activities which are most likely to be pursued with some appreciation of the forest environment, and/or those activities which impact most directly upon the forest. The activities selected were: family and organization camping (including auto, trailer and tent camping); picnicking; off-road vehicle use (motorcycle and snowmobile); boating (canoeing, sailing and motorboating); swimming; winter sports (sledding, tobogganing, cross country and downhill skiing, and snow play); fishing (warm and cold water); hunting (big game and upland game); hiking and mountain climbing; horseback riding; gathering forest products; and nature study. These activities are among those identified by the Forest Service, the agency which provides the most opportunities for forest recreation (FS, RIM).

These activities, of course, may occur on nonforest lands and other activities may occur on forested lands. In fact, the Forest Service measures the use of five additional activities which were not included for the reasons described below. A considerable amount of the difficulty in producing FRAP's recreation analysis revolved around the need to overlay a forest land boundary upon patterns of recreational use. This was accomplished by estimating the area of forest land within the jurisdictions of various agencies providing recreation opportunities and by focusing on the particular activities listed above. Errors of estimation were inherent in the required adjustments; however, to a considerable extent, they will be compensating. FRAP believes the resultant picture of recreational use on forest lands is a significant contribution toward understanding this resource. In the interest of maintaining the reader's perspective, it should be noted that forest recreation as defined by FRAP accounts for about 34 percent of total outdoor recreation on public lands of

the major forest recreation agencies in the State (see Table 9-1).

The five categories used by the Forest Service which were deleted from consideration in this report were:

General leisure and sightseeing, and waterskiing and other sports. These are activities which probably occur most commonly on nonforested areas (e.g., lakes larger than one acre in size) and/or are often not particularily dependent on a forest environment.

Resort use and lodging. FRAP considered this activity a support to other recreational activities which were counted and to avoid double counting, it was omitted. To the extent that visitors enjoy the scenic beauty from their lodge, FRAP underestimated recreational use.

Use of private residences on public land. It was found that participation in this activity is limited to a relatively small number of permit holders, and, depending on the amount of use these people made of lands surrounding their cabins, there was also a double-counting problem.

The fifth activity deleted from consideration was "driving for pleasure." Quantification of this activity suffers from methodological problems. Most importantly, the data do not separate business from pleasure drivers. (Prior to 1979, traffic counters monitored traffic on county, state, and federal roads within national forest boundaries and estimates of transport (trucking) were deducted from the total. While some percent of the remainder is definitely tied to an appreciation of forest environments, an equally unknown quantity consists of commuters or those taking long trips on the most accessible highway which

just happens to run through forested areas. A new counting procedure which is scheduled to be initiated in 1979 will identify only the traffic on Forest Service developed roads: a much more reliable estimate of that quantity of driving which is related directly to an appreciation of the forest environment should result).

In summary, the deletion of use estimates for these activities, to the extent that they actually occur on forest land, constituted an underestimate in the FRAP results. On the other hand, much "hiking and mountain climbing," an activity included in the FRAP results, occurs above timber line and hence not within the State's forest area. An overestimate thus results. In the absence of sampling surveys of recreation users within the forest land boundaries, these sorts of estimates were the best possible with the available data.

Two rather elaborate outdoor recreation measurement systems utilized by the State Department of Parks and Recreation and by the Forest Service produced most of the data upon which the FRAP results were based. A brief description of each of these systems is found in the following paragraphs. Additional information was obtained by FRAP from a questionnaire requesting information about recreation at the local level which was sent to all county planning departments (see Appendix Item V). A final source of data involved, in some cases rather

TABLE 9-1

1977 FOREST AND TOTAL OUTDOOR RECREATION ON PUBLIC LANDS
(THOUSANDS OF 12-HOUR VISITOR DAYS)

RESOURCE AREA	NAT'L FORESTS	NAT'L PARKS	STATE PARKS	BLM	STATE FORESTS	TOTAL
North Coast	393	511	3,254		25	4,183
Sacramento	6,034	133	1,241		2	7,410
N. Interior	2,521	1,864	228		1	4,614
San Joaquin	10,200	4,670	525		32	15,427
So. California	6,976	748	1,427		—	9,151
Central Coast	460	1,170	2,126		—	3,756
ORV Use*	606					
Total Forest Recreation	27,190	9,096	8,801	95	60	45,242
Other Recreation	20,346	10,230	51,358	4,721	20	86,675
Total Outdoor Recreation	47,536	19,326	60,159	4,816	80	131,917

* Data on national forest off-road vehicle use available only to the regional level.

Source: Contact with regional headquarters for federal agencies, and contact with State agencies.

frequent, contact with various of the major recreation agencies. As the following discussion should make clear, many approximations and assumptions were required to bring these diverse data (such as differences in units of measure and accounting periods between the various agencies) together into an integrated recreation picture (see Table 9-2). FRAP assumes responsibility for any discrepancies resulting from the methodology used.

PARKS AND RECREATION INFORMATION SYSTEM (PARIS)

The Parks and Recreation Information System (PARIS) was developed in 1966 by the Department of Parks and Recreation to provide planners and administrators with information on the adequacy of the quantity of outdoor recreation opportunities available to California's residents and visitors. It is a computor-facilitated information system which estimates and projects participation in outdoor recreation and compares this use with an inventory of existing and proposed recreation areas and facilities.

The basic geographic unit used in PARIS is the "geopiece," of which there are 465 in California. Each geopiece is wholly within a county and contains land under a single federal jurisdiction or nonfederal jurisdictions (State or local government, or private lands, or a combination of these). For the purposes of this assessment, inventory data were accessed at the geopiece level and aggregated to counties and to the resource areas illustrated on Figure 1-3.

Public agencies which have been inventoried in PARIS include: BLM, Park Service, Forest Service, Fish and Wildlife Service, BIA, Bureau of Reclamation, and Corps of Engineers; the California Departments of Fish and Game, Forestry, Parks and Recreation, and Transportation; and a total of 532 cities, counties and special districts. Inventory data were collected from these public agencies in 1974-1976. Private recreational facilities (based on a 1973 National Association of Conservation Districts study) were added to PARIS subsequent to the computer runs used in this report.

Because some of the PARIS data obtained from this multiplicity of agencies were incompatible and other significant data were missing, certain adjustments had to be made by FRAP. These included the addition of information on all facilities for Yosemite National Park and on some facilities for the national forests. In addition, the use-estimates in PARIS were very fragmentary. FRAP, therefore, compiled use-figures independently of PARIS.

PARIS evaluated the suitability of each geopiece for 22 outdoor recreation activities. The factors considered in determining the geopiece ratings include physical attributes of the area. Other parameters, important to the determination of an area's recreation potential, such as its location with respect to population centers, are handled elsewhere in the PARIS model. Using these geopiece ratings for 13 of PARIS' activities, FRAP devised regional coefficients for use in the FRAP linear programming model.

RECREATION INFORMATION MANAGEMENT SYSTEM (RIM)

The Recreation Information Management System (RIM) of the Forest Service was the second major source of information. As with PARIS, RIM is a computerized system that allows for the continued updating of recreation information necessary for resource management. RIM applies to national forest land only. Data on the number and types of facilities and use information by facility or activity type are available, and all data are delineated to the ranger district, county, forest, state and regional levels.

TABLE 9-2

DIFFERENCES IN RECREATION USE DATA

	VISITOR-DAY	VISITOR-DAY	VISITOR-DAY	CAMPER-DAY	VISIT
	12-hour period of a given recreational activity	1 person visiting for any part of a day other than overnight	1 person visiting for 24 hours or less, including overnight stay	1 person remaining in an area occupying overnight facilities for 1 night	The entry of 1 person into a recreation area or site to carry out 1 or more recreation activities
California Dept. of Forestry		X		X	
California Dept. of Parks & Recreation			X		
U.S. Bureau of Land Management	X				
U.S. Forest Service	X				
U.S. Park Service					X
	ANNUAL ACCOUNTING TIME			TO COUNTY?	TO ACTIVITY TYPE?
	Fiscal Year July 1 to June 30	Fiscal Year October 1 to September 30	Calendar Year		
California Dept. of Forestry			X	Yes (Each State forest is located within a county)	Yes - To County
California Dept. of Parks & Recreation	X			Yes	No
U.S. Bureau of Land Management			X	No	Yes (Statewide only)
U.S. Forest Service		X Beginning w/ 1977-1978	X through 1977	Yes	Yes - To County
U.S. Park Service			X	No	No

Only the major public agencies which are directly concerned with the provision of forest land recreation, and those local public agencies which responded to the FRAP recreation questionnaire were considered in any detail for this Report. Other local public jurisdictions, several public utilities (including power companies) and the private sector control forested acreage, some of which is available for recreational use. This resource base is undoubtedly of considerable significance in some localities and potentially important to the entire state. Currently, however, it is, in the aggregate, a minor component and efforts to comprehend the significance of the major agencies therefore receive the emphasis in this Assessment.

MANAGEMENT OF FOREST RECREATION

Providing recreational opportunities is a major objective of several public agencies; such use is authorized on other public forest lands to the extent that it does not conflict with the major purposes for which the lands are managed. Recreational use is allowed on public forest lands, subject to certain types of restrictions (see Table 9-3). Use of designated primitive and backcountry areas, assigned to these classifications respectively by the Forest Service and the Park Service, and all classified wilderness areas (State and federal) requires a permit. These permits are restricted in number for areas that have received heavy use. Entry fees are required at certain State and national park system units.

Forested areas may be closed to entry on a permanent or temporary basis by their administering agencies. In the aggregate, research natural areas, watershed preservation areas, administrative areas, etc., where public entry is prohibited, remove an insignificant fraction of forest land from the total amount available for recreation. Legal access is unavailable on some BLM land and on about 80 percent of forested lands administered by the State Lands Commission due to the adjacent land being held in private ownership. Temporary closures may result from fire hazards and timber harvest operations.

REGULATED ACTIVITIES

Once entry has been effected, pursuit of recreational activities is restricted according to the management philosophy of each agency. Only those recreational restrictions that apply generally to all forest lands under the jurisdiction of an agency are mentioned here. These include hunting, fishing and off-road vehicle use (see Table 9-3).

On all lands, including federal, where hunting is permitted, the seasons are established by the State Fish and Game Commission. By law, hunting is prohibited in all units within the National Park System and all units containing forested land within the State Park System except Lake Oroville State Recreation Area. The right to hunt on BIA lands is reserved for Indians.

Licensed fishing is permitted on all public land under consideration in accordance with seasons and policies established by the Fish and Game Commission. On some BIA land, a permit is required in addition to a State license.

The off-road use of vehicles is an activity that is coming under increasing regulation and prohibition. Such use is prohibited on all BIA, Park Service and Department of Forestry land, and on classified wilderness areas administered by the Forest Service. In addition, regulations specific to each national forest limit or ban off-road vehicle use in some nonwilderness areas.

Snowmobiling is the only off-road vehicle use sanctioned on State Park System lands. There are some restric-

TABLE 9-3

MANAGEMENT OF RECREATION ON PUBLIC FOREST LANDS

AGENCIES HAVING MAJOR FOREST RECREATION USAGE	ENTRY REQUIREMENTS * GENERAL	ENTRY REQUIREMENTS PRIMITIVE, WILDERNESS, BACKCOUNTRY	** FISHING ALLOWED?	** HUNTING ALLOWED?	OFF-ROAD VEHICLE USE ALLOWED?
Bureau of Indian Affairs	Permit for non-Indians	N/A	Permit for non-Indians	Restricted to Indians	No
Bureau of Land Management	None	N/A	Yes	Yes	Yes
Forest Service	None	Permit	Yes	Yes	None in classified wilderness; some in other areas
Park Service	Some fees	Permit	Yes	No	No
California Department of Forestry	None	N/A	Yes	Yes	No
California Department of Parks and Recreation	Some fees	Permit	Yes	Only at Lake Oroville	Some snowmobile use
OTHER AGENCIES			DATA NOT OBTAINED		
Bureau of Reclamation	None	N/A			
Corps of Engineers	None	N/A			
Fish and Wildlife Service	None	N/A			
California Department of Fish and Game	None	N/A			
California Department of Transportation	None	N/A			
State Lands Commission	None	N/A			
Local Public	Various	Various			

Source: Contact with agencies and FRAP recreation questionnaire

* Does not include fees charged for use of developed sites such as campsites.
** State hunting or fishing license required, except for Indians' use of BIA land.

tions on off-road vehicle use in the desert areas under the jurisdiction of the BLM. Off-road vehicle use has not presented any problems on BLM forest land and is therefore not regulated on such land at present, according to information given FRAP by the BLM (Westover 1978).

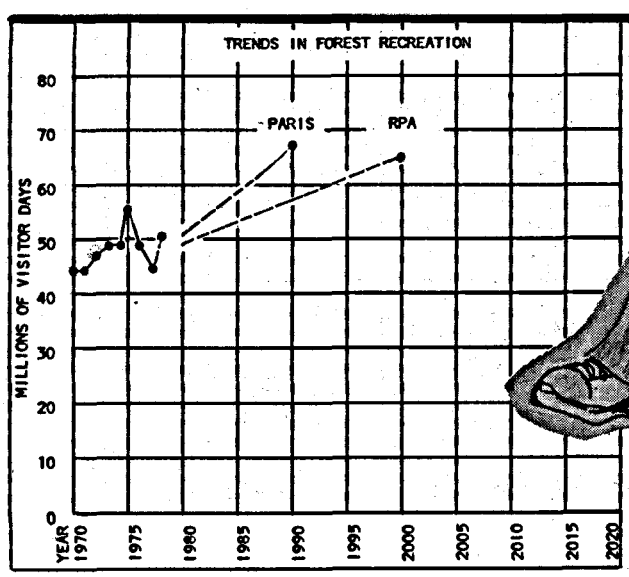
FOREST RECREATION USE

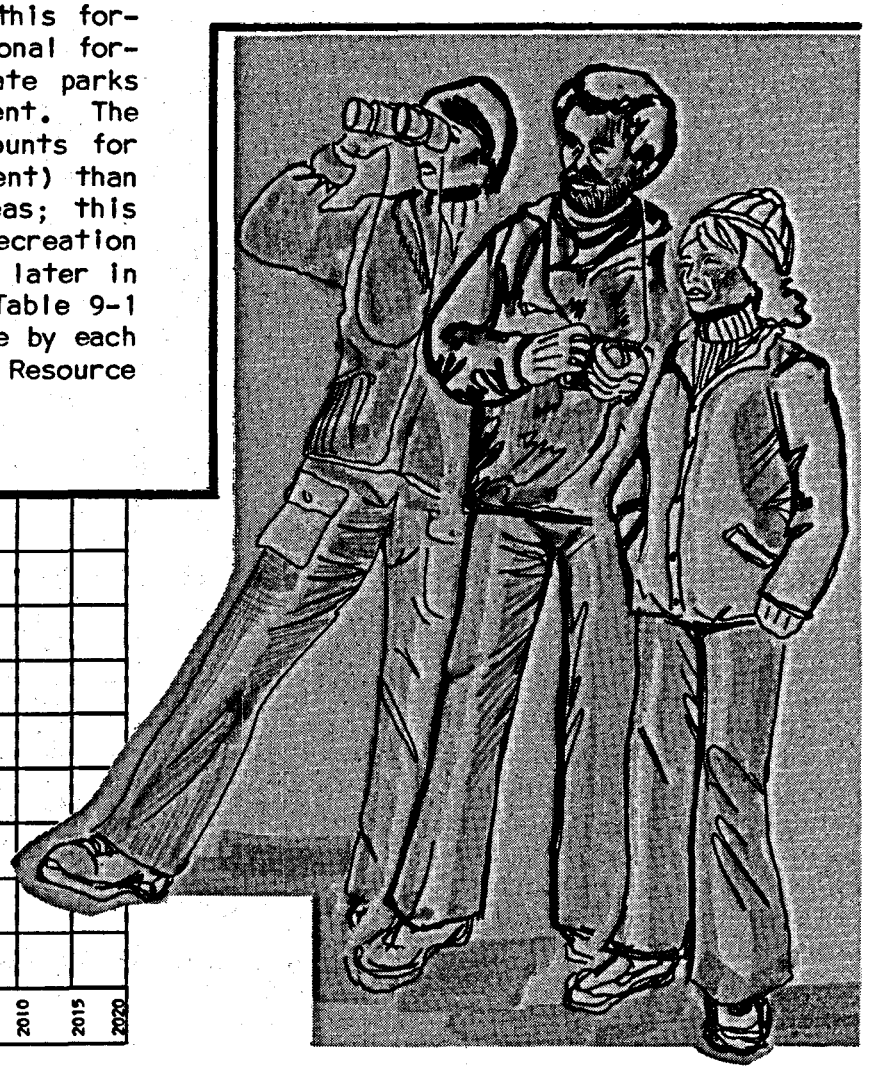
Forest recreation accounted for a total of 45 million visitor-days (a 12-hour period of a given recreational activity) of use in 1977, the latest year for which data sources were complete on lands administered by the BLM, Forest Service, Park Service, and the State Departments of Forestry, and Parks and Recreation. Sixty percent of this forest recreation occurred on national forest land; the national and State parks each contributed about 20 percent. The San Joaquin Resource Area accounts for more recreational use (23 percent) than any of the other resource areas; this region also contains the most recreation facilities as will be described later in this chapter. The figures in Table 9-1 illustrate the contribution made by each of the agencies within the six Resource Areas.

HISTORICAL AND PROJECTED USE-TRENDS

The significance of 45 million visitor days of forest recreation can be more fully appreciated once an historical perspective has been provided. FRAP estimated that from 1970 through 1975, recreation on forest land increased at an annual rate of about 3.3 percent. During the drought years of 1976-1977, forest recreation declined significantly. Estimated 1978 figures indicate growth has resumed (see Figure 9-1).

In 1971, the Department of Parks and Recreation, using PARIS, projected outdoor recreation participation statewide to the year 1990 in 10-year intervals beginning with 1970. These figures were based on annual per capita participation





rates determined from a survey of 11 western states conducted in 1960-1961, and population projections from the Department of Finance. Because these projections cover total outdoor recreation, adjustments were made by FRAP to consider only forest recreation activities.

Table 9-4 contains the 1977, 1980, and 1990 PARIS projections and the 1977 actual forest recreation figures. Except for discrepancies in the San Joaquin and Central Coast Resource Area figures, the 1977 projections are very similar to the 1977 use-estimates. On a Statewide basis these PARIS projections suggest about a 2.8 percent annual increase in forest recreation to 1990. Figure 9-1 illustrates the projections for forest land recreation.

The Forest Service, in its review draft of the 1980 RPA Assessment, addresses the future of outdoor recreation participation nationally and regionally. According to these projections, outdoor recreation is expected to increase 1.5 percent annually to the year 2000 for the Pacific Southwest Region (see Figure 9-1). It should be noted that these projections not only consider a geographic area beyond California, but also include certain outdoor recreation activities in addition tc those identified by FRAP.

A number of factors may contribute to the projected increases in forest recreation use. Growth in population is a major factor. Increases in per capita income and leisure time are also expected to affect forest recreation partici-

TABLE 9-4

PROJECTED AND ACTUAL FOREST RECREATION USE
(MILLIONS OF 12-HOUR VISITOR DAYS*)

RESOURCE AREA	1977 ACTUAL USE	PARIS PROJECTIONS		
		1977	1980	1990
North Coast	4.18	4.54	4.89	6.52
Northern Interior	4.61	5.17	5.56	7.48
Sacramento	7.41	7.46	8.02	10.66
San Joaquin	15.43	11.27	12.10	16.07
Southern California	9.15	7.74	8.32	11.08
Central Coast	3.76	8.87	9.55	12.58
TOTAL	44.54	45.05	48.44	64.39

* PARIS participation-day converted to visitor-day with assumption that a participation-day equals two hours, or one-sixth of a visitor-day.

Source: Table 9-1 for actual use figures and PARIS for projections of use.

pation. Participation by women in such activities as cross country skiing, fishing, and hunting, has more than doubled since 1970 and this fact is expected to account for increases in forest recreation use (FS, RPA Review Draft 1979).

Several factors, however, are likely to dampen the projected increases. As use increases, the quality of certain recreation experiences will decline due to crowding. Another negative influence on forest recreation participation is the rising cost of energy, including possible travel restrictions caused by the unavailability of gasoline. Other costs, such as entrance and user fees, are likely to be instituted or increased. This trend will be especially apparent if more private forest lands near urban centers are developed for recreational use. The general aging of the population (medium age in 1977 was 29.4; by 2030 it is projected to reach 39.9) is a phenomenon that is expected to dampen national participation in outdoor recreation, especially for such activities as backpacking and primitive camping (FS, RPA Review Draft 1979).

RELATIVE IMPORTANCE OF FOREST RECREATION ACTIVITIES

The relative importance of each activity constituting forest recreation was determined by FRAP from Fiscal Year 1978 Forest Service attendance figures for the State (RIM). Because 60 percent of forest recreation use in 1977 occurred in national forests, the Forest Service ranking was considered to be a reason-

TABLE 9-5

RELATIVE IMPORTANCE OF FOREST RECREATION ACTIVITIES IN CALIFORNIA
(STATEWIDE DATA EXCEPT FOR ORV USE WHICH IS TO REGION)

ACTIVITY	PERCENT OF TOTAL FOREST RECREATION			
	1970	RANK	1978	RANK
Family and organization camping	58.4	1	51.6	1
Fishing	11.3	2	9.6	2
Winter sports	5.6	4	9.3	3
Hiking and mountain climbing	4.9	5	7.0	4
Swimming	4.2	7	4.8	5
Hunting	6.1	3	4.5	6
Picnicking	4.7	6	4.4	7
Boating	1.8	8	2.7	8
Off-road vehicle use	No Record		2.0	9
Gathering forest products	.6	11	1.6	10
Horseback riding	1.4	9	1.4	11
Nature study	1.0	10	1.1	12

Source: RIM

ably valid indicator of the entire forest recreation use picture. Table 9-5 points out the participation rates and the relative importance of each forest recreation activity in the State.

A comparison of this ranking with the one for 1970 indicates how recreation use patterns are shifting. Camping and fishing, while retaining their top ranks, have contributed relatively less to the total recreation picture since 1970. Participation in all of the remaining activities has increased except for hunting and picnicking. Hunting reveals the most significant drop, from 6.1 percent in 1970 to 4.5 percent in 1978. Off-road vehicle use (scooters, motorcycles, snowmobiles, autos and other four-wheel vehicles in dispersed areas and on trails) has become a much more significant use. In 1970 it was not even identified as a use category.

FOREST RECREATION FACILITIES

Many activities which constitute forest recreation are related to the use of man-made facilities. The facility may be as simple as a picnic table, or as complex as a downhill ski site. FRAP selected from among the facilities identified from PARIS, with some additions from RIM, those most likely to relate to forest recreation. They are indicated in the left two columns of Table 9-6.

METHODOLOGY USED FOR FRAP STUDY

A "site" was chosen as the common denominator for simplifying and combining PARIS and RIM data. Two types of sites are identified in this Assessment: land (various camping, resort, and picnic sites) and water (swimming and boat sites).

A land site refers to a facility or some fraction of a facility with a five-person or single family capacity at one time. This definition is based upon a picnic site and campsite capacity used by the Forest Service (FS Manual). In this Report, FRAP has extended the meaning to include all land sites. The length of stay at this family unit for the various types of sites varies from less than an hour (at some picnic sites) to many hours (at some campsites and ski sites).

In aggregating the water site data, it was not possible to simplify the data to a common capacity basis. Thus the reported water sites range in capacity from several hundred to several thousand persons at one time. Because of the discrepancy between the variable capacity for water sites, and the five-person capacity for land sites, the total number of land and water sites are initially reported separately.

Trails, including bicycling, hiking, interpretive, equestrian, hiking/riding, off-road vehicle, and snowmobile are reported in miles. Table 9-6 describes the original format of the PARIS and RIM data and indicates the modifications made by FRAP to better meet the needs of this report.

This FRAP analysis estimates the number of facilities on public forest land only. To distinguish forest from non-forest-based land sites, a factor representing the percent of each geopiece that is forested was applied to the total number of facilities reported in PARIS for that geopiece. It was assumed that the types of facilities under consideration are distributed homogeneously with regard to vegetative cover, and thus the application of a geopiece forest factor would give a reasonable estimate of the number of facilities on forest land. Water site data from PARIS were delineated to forest area through the use of computer produced maps of boating and swimming sites in conjunction with a 1:1,000,000 CALVEG map of forest land. No conversions were ap-

TABLE 9-6

AGGREGATION OF PARIS AND RIM FACILITY DATA

RIM FACILITY	PARIS FACILITY	REPORTED UNIT	CONVERSION	FRAP FORMAT
				Unit
	Family picnic area	Table	table = site	Land site
	Group picnic area	Guest	÷ guests by 5	" "
	Day camp area	Guest	" "	" "
	Lodge/resort	Guest	" "	" "
	Group campsite	Guest	" "	" "
	Organization campsite	Guest	" "	" "
	Boat access campsite	Site	None	" "
	Hike-in campsite	Site	" "	" "
	En route campsite	Site	" "	" "
	Vacation/family campsite	Site	" "	" "
Ski site		People at one time (PAOT)	÷ PAOT by 5	" "
	Launch ramp Slip/buoy	Each "ramp" facility and "slip/buoy" facility plotted on a computer map	Each plotted facility = site	Water Site " "
Boat site		Boat site		" "
	Swimming beach Swimming pond	Each "swimming beach" facility and "swimming pond" facility plotted on a computer map	Each plotted facility = site	" "
Swimming site		Swimming site		" "
	Trail	Mile		Trail Mile
Trail		Mile		" "

Table 9-7

TOTAL PUBLIC OUTDOOR RECREATION FACILITIES
ON PUBLIC LAND*
(1974-1978)

RESOURCE AREA	NUMBER OF LAND SITES	NUMBER OF WATER SITES	MILES OF TRAIL	TOTAL "SITE EQUIVALENTS"**
North Coast	5,028	22	1,518	11,122
Northern Interior	4,555	55	3,712	19,458
Sacramento	14,898	102	2,404	24,616
San Joaquin	27,490	57	5,064	47,803
So. California	12,349	22	2,926	24,075
Central Coast	7,565	12	1,250	12,577
State Total on Forested Land	71,885	270	16,874	139,651
State Total on Other Land	114,335		5,361	135,779
Total	186,490		21,235	275,430

* NOTE: Includes water sites located on private as well as public land, and some ski sites located partly on private land.

** According to the 1974 California Outdoor Recreation Resources Plan (Department of Parks and Recreation), the use standard for a hiking trail is 20 persons per mile of trail. This is the equivalent of four five-person sites as defined in the Report. Trail miles were multiplied by four for purpose of aggregating them with the other site data.

Source: PARIS and 1978 RIM Data

plied to any of the RIM data: instead it was assumed that the great majority of national forest facilities are on forest land.

Table 9-7 shows the estimates of land and water sites and trail miles located within each of the six resource areas. The relative importance of each area with respect to the quantity of land and water sites and trail miles is indicated, respectively, in the first, second, and third columns. In the fourth column, trail miles have been aggregated, according to a procedure explained in Table 9-7, with the combined land and water site data to indicate an over-all figure for recreational "site equivalents" per resource area. It must be remembered that there is no

uniform occupancy capacity for the site equivalents.

The San Joaquin Resource Area ranks first in total number of sites and in trail mileage. The total site equivalents for the San Joaquin area number almost twice the figure shown for the second ranking area. This seems reasonable given that Yosemite and Sequoia-Kings Canyon National Parks, as well as extensive national forest land, are located within this resource area. It will be recalled that the San Joaquin Resource Area received the greatest amount of forest recreation use.

The Forest Service annually computes the visitor capacity at any one time of its facilities and sites by county (RIM). A review of people-at-one-time (PAOT) figures reveals the trends as established by the Forest service toward increasing or decreasing the supply of recreation sites. Only those facilities and sites judged to be directly supportive of forest recreation activities were considered in the FRAP analysis. These facilities include: boating and swimming sites, family and group campgrounds, family and group picnic grounds, hotels, lodges and resorts (public and private), organization camps, and winter sports sites.

A decline is shown on Table 9-8 in PAOT capacity between 1975 and 1977 for several of the resource areas. Beginning in 1974, the Forest Service evaluated all campsites and picnic sites where occupancy rates were less than five percent to determine the advisability of retaining such sites; as a consequence, several of the sites were removed. Overall, the total PAOT capacity will have increased by about two percent since 1970 if the plans for proposed additions for 1979 are implemented.

Table 9-8

PEOPLE-AT-ONE-TIME CAPACITY
CALIFORNIA NATIONAL FOREST LAND

RESOURCE AREA	1970	1975	1977	1978	PROPOSED 1979
North Coast	2,225	2,225	2,160	2,160	no change
North. Interior	35,244	35,808	34,643	34,848	Increase by 400
Sacramento	74,926	79,011	80,422	79,929	Increase by 625
San Joaquin	91,996	92,976	93,470	95,318	Increase by 400
Southern Calif.	76,409	76,528	75,874	73,556	Increase by 550
Central Coast	2,840	2,810	2,735	2,735	no change
State Total	283,640	289,358	289,304	288,546	290,521

Source: 1978 RIM

According to the Forest Service's 1975 Resource Planning Act Program, the financing of recreational development on all national forest land will follow the current trend. For California, this amounts to $1 to $3 million annually. Thus, for the immediate future, the quantity of recreational facilities on California national forest land will increase slightly each year, if the RPA's recreation program is funded.

CONCLUSIONS

Since 1970, the average growth rate in forest recreation has exceeded the growth in the number of recreational facilities. According to two major projections, forest recreation use will continue to increase from 1.5 percent (Draft RPA 1979) to 2.8 percent (PARIS) annually. If this trend continues, the following consequences in some combination are likely to occur: (1) there will be more intensive use and/or crowding of facilities and probably a decline in the quality of the recreational experience for many people, and (2) the desires of many to participate in forest recreation will be unrealized, because people will be turned away from filled campgrounds, etc., or people will not even attempt to participate.

Efforts to mitigate these consequences fall into two categories: increases in the capacity of facilities, and changes in use. With regard to capacity, existing facilities could be more efficiently used by greater efforts to inform the public of vacant sites, and of the range of recreational opportunities available to them. In addition, existing facilities could be expanded or new facilities constructed.

Traditional patterns in forest recreation use indicate the public's preference for certain activities, locations, times, and costs. To the extent that any of these preferences are broadened, opportunities for forest recreation are increased. A more even distribution of the public's leisure time through shifts in the work week would facilitate a more efficient use of the existing facilities. A shift from developed to dispersed forest recreation activities (those that require no facilities) could be promoted through information programs. The institution of higher recreation fees might reduce participation and thus crowding, etc. Rising transportation costs might reduce participation also and will likely be even more prohibitive than increased fees in forest recreation.

Many of these shifts in use are already occurring. For example, in 1978, dispersed recreation accounted for 59.4 percent of all recreation on national forests in California (FS, RIM). Dispersed recreation is increasing faster than developed recreation on national forest lands (FS, RIM). It is likely that some combination of all the above circumstances will occur, and consequently the potential lack of recreational facilities will perhaps not be realized.

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INTRODUCTION

In spite of the rising demand for wood products, California's timber production is expected to decline six percent in the next 20 years and not regain current levels until 2030 (Appendix Item VII). This reduction in harvests is due to a number of reasons. On private lands most of the accessible old-growth timber has been cut and a large portion of adequately stocked young stands will not be of harvestable size for 10 to 40 years. Conversion of productive commercial forest land is decreasing the State's wood growing potential. In 1972, over 200 thousand acres of young-growth timberland in private ownership were developed for residential uses such as first and second homes, grazing, and other non-timber purposes.

Old-growth timber on public lands, mostly in national forests, has been made available in smaller quantities. Litigation, and shortage of funds have caused delays in national forest timber sale preparation. Public lands under multi-purpose management yield less timber than would be available if timber production were the only objective and the Forest Services's non-declining even flow policy does not permit significant increases in timber harvesting. Additional reservations for uses that preclude timber management have been made. Also, approximately one-quarter of the commercial forest area in national forests is on harsh sites that have never been successfully managed for continuous timber crops.

Finally, and of greatest significance, current timber growth on all ownerships is only half of the land's "potential" as measured by a comparison with fully stocked natural stands because of the poor timber-producing condition of many stands. For example, even though reforestation on all lands has generally kept pace with logging in recent years, extensive areas that were logged and/or burned in the past are now inadequately stocked with commercial coniferous trees. Investments in forest practices to improve stand conditions thus can lead to substantially increased yields. This chapter reviews these causes of decreasing supplies and explores options to increase production.

The following section describes the timber resource data collected by the Forest Service and the land classification system used in its inventory. The information collected concentrates on the area classified as commercial forest land. Presently, the Forest Service inventory is the only existing Statewide timber inventory.

TIMBER RESOURCE DATA

Timber resource data for lands outside national forests were collected by the Forest Survey (PNW). Photo and field plots were used to develop area and volume estimates by double sampling for stratification estimators as described by Cochran (1963). For lands outside national forests in southern California, the basic data collected for Forest Survey Release 25, 1954; and the State of California Fish and Wildlife Plan, 1966; were used along with records of timberland and brushland conversions to approximate forest areas and timber volumes in 1975.

The basic timber resource data for national forests were collected by Regions 4, 5, and 6 of the Forest Service. A combination of type mapping

and aerial photo and ground sampling procedures were used to inventory national forests. Further details on this methodology are contained in the Appendix "Forest Service Inventory Procedures and Data Reliability".

The Forest Survey and the national forests classify all of the land area within the State into "Productive Forest", "Unproductive Forest" and "Nonforest" categories. This classification system is described as follows:

Productive forest land is that which is capable of producing 20 cubic feet per acre per year of industrial wood and is manageable for continuous timber crops.

Commercial forest land is productive forest land not withdrawn for nontimber purposes.

Productive-reserved forest land is that which is withdrawn from timber utilization through statute, ordinance, or administrative order but otherwise qualifies as comercial forest land.

Noncommercial forest land includes both productive-reserved and unproductive forest land.

Unproductive forest land is land considered incapable of yielding crops of industrial wood products because of adverse site conditions such as sterile soil, poor drainage, high elevation, steepness, and rockiness.

Nonforest land has never supported forests or was formerly forested and is currently developed for nonforest uses. Included are areas used for agricultural crops, improved pasture, residential areas, city parks, improved roads of any width and their right-of-way clearings, powerline clearings of any width, and 1-to-40 acre areas of water classified by the Bureau of the Census as land.

Traditionally the chaparral vegetation type has been included in the "Unproductive Forest" category by the Forest Service. This type is characterized by heavily branched dwarfed trees or shrubs, primarily Quercus, Cercocarpus, Garrya, Ceanothus, Arctostaphylos and Adenostoma. There are over five million acres of chaparral in the Southern California Resource Area alone. Areas in which the predominant cover is Artemisia, Purshia, Gutierrezia, and Opuntia (sometimes called "soft chaparral"), or semidesert species, are not included in this definition (Forest Service 1972). Thus areas of sage scrub or brushfields that develop after forest land has been disturbed are not considered chaparral by the Forest Service. The 7.5 million acres of chaparral inventoried by the Forest Service were not considered part of the forest land base by FRAP and therefore were not included in this Assessment.

The Forest Survey combines its data with the data from the national forests into regional reports. However, these inventory systems are designed for different purposes (i.e. the Forest Survey for the RPA assessment and the national forests for timber planning). Thus substantial data dissimilarities exist between information from the national forests and the Forest Survey. These variations were caused by the use of different forest type definitions and the inconsistant use of these definitions by the individual national forests. Also, the national forests south of Lake Tahoe have not collected inventory data by county, and no national forests will collect data by county in the future under the present system adopted in the late 1960's. This makes the combining of Forest Survey and national forest data for a geographic area very difficult.

Unfortunately, large amounts of data collected by individual management units of the national forests (Ranger Districts) have not been compiled to useful regional levels (e.g., county). Of primary concern is the lack of compiled data on national forest lands concerning forest stand condition and opportunities to increase forest growth. This includes specific information on timber mortality, growth and the age class distribution needed to project potential yields.

The most recent Forest Survey and national forests inventories concentrated on "commercial forest" land due to legislative and budget constraints. This means that data on volume and growth on reserved and unproductive forest land are not available and estimates of the character and condition of wilderness areas and woodlands are rough. The latest Forest Survey field data were collected between 1964 and 1972 and the national forest data were collected between 1958 and 1977. Office updating has been done to adjust the estimates of volume growth and ownership classes to 1975 for the North Coast Region and of ownership classes for the remainder of the State except Southern California.

This chapter utilizes data as compiled by the Forest Survey (Bolsinger, draft, 1979). The description of the timber resource and opportunities to increase timber growth are restricted to the areas classified by the Forest Service as commercial forest land, the source of almost all of California's timber production.

THE ECONOMIC IMPORTANCE OF TIMBER

The forest industries in California employed approximately 106 thousand persons in 1978. While this is only about one percent of total employment and six percent of the manufacturing employment in the entire State, forest industries often provide the bulk of the economic base of local regions (see Appendix Item VIII).

Forest industrial employment is composed of two major components, lumber and paper. Approximately two-thirds of the lumber and wood products employment is in resource oriented primary manufacturing (logging, sawmilling and production of plywood and veneer) while paper and allied products employment is mostly in secondary manufacturing activities (paperboard container and converted products), that are generally market oriented and located in population centers (Oswald 1970).

Table 10-1 shows a breakdown of employment by resource area and industry sector in 1975, the most recent date for which information has been compiled. Employment in 1975 was well below that reported for 1978. The difference largely reflects changes in employment associated with fluctuations in the residential construction cycle. Most of the forest industrial employment in the Southern California, Central Coast, and parts of the Sacramento regions is secondary wood processing activity and does not depend directly on California-grown timber. However, approximately 50,000 to 55,000 persons do depend on California's timber for jobs (Bolsinger, draft, 1979). These people and the rural areas in which most of them live are especially affected by the level of timber harvests in California.

Lumber and wood products employment and the relative importance of timber vary amoung counties. Humboldt County ranks first in lumber and wood products employment followed by Mendocino, Shasta, Siskiyou, and Tehama Counties.

The proportion of wood products employment to total employment in each

TABLE 10-1

EMPLOYMENT IN FOREST INDUSTRIES IN CALIFORNIA BY RESOURCE AREA AND INDUSTRY SECTOR, 1975

	LUMBER AND WOOD PRODUCTS SECTOR (Number of Employees)					
Resource Area	Logging	Sawmills and Planing Mills	Veneer and Plywood Plants	Other Wood Products Plants	PAPER AND ALLIED PRODUCTS SECTOR (Number of Employees)	TOTAL
North Coast	1,350	7,875	1,316	2,193	773	13,507
Central Coast	47	277	0	2,329	9,632	12,285
Northern Interior	940	3,562	682	428	462	6,074
Sacramento	859	3,591	16	4,518	1,135	10,119
San Joaquin	318	2,682	0	3,790	2,438	9,228
Southern California	46	386	499	15,159	20,137	36,227
Total	**3,560**	**18,373**	**2,513**	**28,417**	**34,577**	**87,440**

NOTE: PAPER AND ALLIED PRODUCTS SECTOR INCLUDES: paper and paperboard mills, converted products, and paperboard containers.

See Figure 1-3 for Resource Area location.

DATA SOURCE: California Employment Development Department, compiled by Forest Survey.

county measures the relative importance of timber to the economies of individual counties. Counties with more than 30 percent of their work force employed in the lumber and wood products sector include: Sierra, Trinity, Del Norte, Plumas, Tehama, Humboldt, and Siskiyou.

Manufacturing forms an important component of the economic base of many counties. Wood processing provided over 90 percent of the manufacturing employment in Del Norte, Lassen, Plumas, Sierra, Siskiyou and Trinity Counties in 1973, indicating that there was almost no other manufacturing in these counties.

The 38 percent increase in forest industry employment from 1950 to 1976 masks opposite trends within the major components of the industry. Employment in lumber and wood products reached a peak of 62.4 thousand persons in 1955, declined to a low of 47 thousand in 1967, and then increased to the 1976 level of 54.2 thousand. These changes were due to fluctuations in timber production (generally declining) and increases in labor productivity in all stages of manufacture in the forest products industries. Employment in paper and allied products, on the other hand, has shown a more or less steady increase from 13.5 thousand in 1950 to

36.7 thousand in 1976 as production has increased to meet rising consumption (Ruderman 1976).

Employment trends have varied regionally. From 1960 to 1975 employment in lumber and wood products declined the most in the North Coast Resource Area. Employment in this sector declined very little in all interior areas of the State combined. A number of counties dropped slightly (Northern Interior counties, for example) while other counties increased (Tulare and Yuba, for instance).

In a number of counties, manufacturing employment other than lumber and wood products employment declined more rapidly so that the importance of wood products to the local economy actually increased. This situation is especially evident in rural counties such as Lassen, Modoc, Plumas, Siskiyou and Trinity.

Projections of recent trends in forest industrial employment coupled with the expected supply and demand for timber (discussed in the following section) indicate that California will experience employment growth in this sector of the economy. But to a major degree that growth will not be dependent on the State's own timber resources. Rather, the increased employment will occur in the secondary, market-oriented stages of manufacture and will be located predominantly in the large population centers. Forest industrial employment in the timber resource areas will decline because of decreasing availability of raw material and increasing labor productivity. The North Coast will be most affected by the projected declines in employment (Oswald 1970). However these declines can be avoided by increasing California-grown timber supplies. Opportunities for higher timber production are discussed in a later section.

In 1976 there were 200 primary forest product mills in California, including 142 lumber mills, 21 veneer and plywood plants, 17 pulp and board plants and 20 "other industry" plants, (e.g. shake and shingle, post, pole, piling, and export facilities). Since 1962, about 85 percent of the industrial wood processed in California has been processed into lumber, and 10 to 13 percent has gone into plywood. Mill residues (chips) make up 99 percent of the raw material used by the pulp and particle and fiber board industry.

Though relative log consumption by the various sectors of the forest products industry has remained fairly constant for many years, the number of sawmills declined from 297 to 142 between 1962 and 1976, while the number of veneer and plywood mills declined from 39 to 21. The trend in the forest industries in California, as is true throughout the nation, has been toward fewer but larger firms with greater plant capacity and larger land holdings.

THE SUPPLY AND DEMAND FOR TIMBER

Anticipated sustained growth in California's population makes it evident that the State's consumption of pulp and paper products will increase steadily throughout the 1976-2030 projection period. It is estimated that by the year 2030 levels of consumption of all types of paper and paperboard combined will have increased approximately threefold (see Appendix Item VII).

The growth in consumption of other wood products will also be strong but in a number of cases consumption will level off towards the end of the projection period. Softwood lumber and plywood consumption, for example, will increase markedly from its 1976 level of 1.23 billion cubic feet; is expected to peak

at nearly 1.72 billion in 2010; and remain at about that level until 2030.

This pattern is due to expected "real price" increases (over and above inflation) in wood products (discussed later) and to changes in the level and type of construction within the State as the composition of the population and the rate of family formation change. It is anticipated, for example, that production of all forms of new residential units will rise from a 1976 level of 244 thousand units to a peak of 330 thousand in 1990, and then decline gradually to a level of 280 thousand in 2030 (McKillop, 1979). In some situations, such as residential construction, increasing use of wood per unit produced will tend to offset lower levels of industrial activity. In other cases, such as manufacturing, declining use of wood per billion (constant) dollars of shipments will not be offset by increasing levels of manufacturing activity, so that the total use will remain stable or decline slightly. These trends in forest products consumption could be modified by wood and paper conservation and recycling efforts.

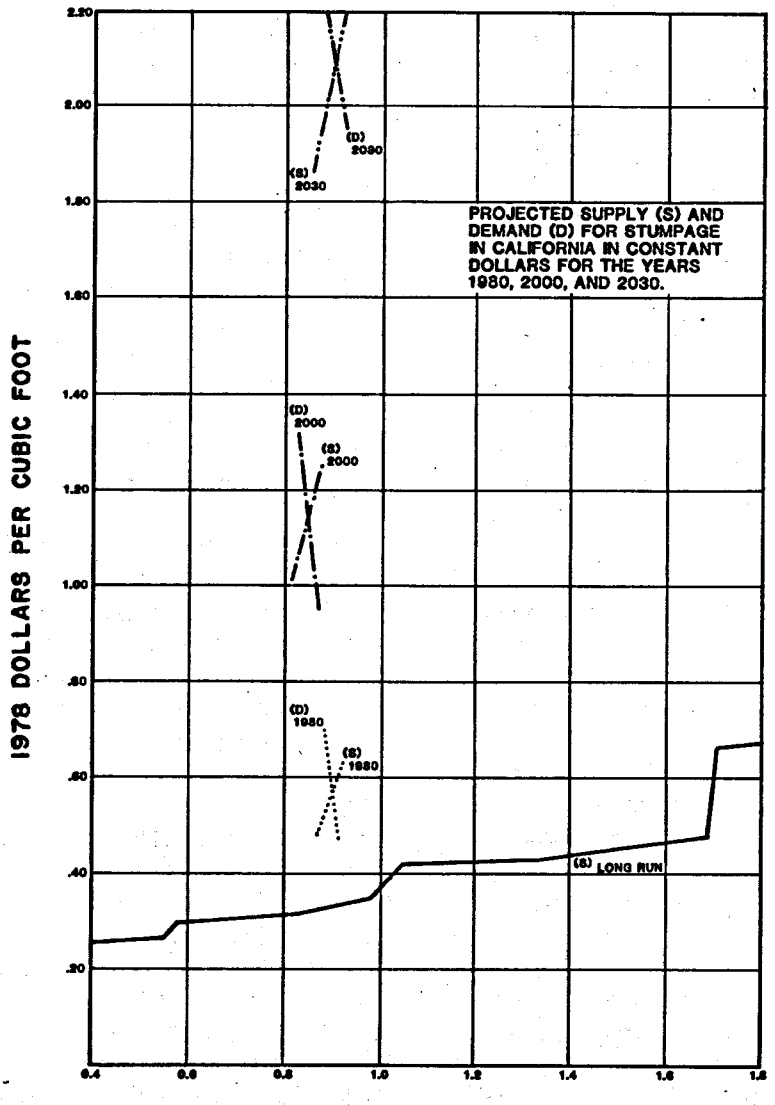
The increasing consumption of wood and paper products by Californians raises the question of where the State stands in meeting future consumption. Figure 10-1 presents supply and demand analyses (see the Glossary) for California stumpage (standing timber) for the years 1980, 2000 and 2030 as obtained from the Haynes and Adams econometric model (1978). (This mathematical model is described in detail in Adams and Haynes 1979, a supplementary document to the 1980 RPA Assessment.)

This model represents a major advance in techniques for projecting stumpage consumption and prices over long periods. It has been tested on historical data and includes a great many variables which interact to produce the estimates. It can be critized for the omisson of certain factors, however, it will undoubtedly be improved with time. Inherent assumptions which seem reasonable today may not be realized over the next 50 years and the projections may not be realized. Nevertheless, it is a considerable asset for the purposes at hand and substantially improves the quality of the analysis of projected supply and demand that can be presented.

Briefly, the model considers the interaction of imports and domestic timber production of the various forest regions of the United States. These supply regions further interact with consumption regions in a simulated market. Private timber producers, the model assumes, determine their harvets rates on the basis of available inventory and prices. Public cutting rates are set by users of the model.

The model is a long-run model in the sense that it incorporates the kinds of variables which affect the trends of prices and output levels. The 1980 estimates shown are included to tie the trends to current time. When actual 1980 data become available they will likely vary from the model estimates due to the influence of short-run factors such as the business cycle, fluctuations of fuel availabilities, weather, strikes, and similar factors. It is important to concentrate on the trend, rather than the values for a specific year when viewing long-run model results. While actual supply and demand figures are not expected to correspond exactly to model estimates, over all trends should be similar, and it is these trends that are most significant.

The "X's" in Figure 10-1 represent the intersection of segments of supply and demand curves for the years shown. If these estimates are realized the price of stumpage will increase from about 60 cents to $2 per cubic foot (in addition to any increase due to inflation) from 1980 to 2030. The quantity of timber cut annually in California will not change appreciably over this time interval.



SOURCE: Haynes-Adams Econometric Model 1978 and Vaux 1973

These changes in price result from shifts in both supply and demand. The supply curves depicted in Figure 10-1 indicate that supplies will decrease over time. This means that less timber will be obtained at any given price. California is still cutting old-growth timber and consequently both reducing its existing inventory and incurring higher costs of management. The remaining timber is found in less accessible locations and hence costs more to bring to market. These factors all imply decreasing supply.

The demand curves over a period of time are shifting to the right; in other words, demand is increasing. Increase in the standard of living and a burgeoning population are two significant factors causing the increase in demand. Note that it does not follow that increasing demand leads to increased consumption. In fact, in this case, if the model's results are correct, consumption of California grown timber will drop somewhat to the year 2000 because of the decreasing supply and dramatic price increases.

The remaining line on Figure 10-1 is a long-run supply curve taken from information presented by Henry J. Vaux in his article, "How Much Land Do We Need for Timber Growing?" (Journal of Forestry, July 1973). (The long-run is a sufficient time period to develop a fully regulated forest.) This curve assumes that greater annual timber outputs result from allocating more and more land to timber production beginning with those which produce at the lowest cost per unit of wood (i.e. the most productive land). The implication of this long-run curve is that substantially lower timber prices could be realized in the long run were society to begin developing an appropriate timber age-class structure and ensuring appropriate levels of management on the more productive forest lands of the State. (Analysis would be required to determine which age-class distribution is appropriate.)

As California timber production decreases and consumption increases, competition in most wood products markets is likely to be increasingly severe. This will result in the State's dependency on outside sources increasing greatly in the next 10 to 25 years. Lumber and plywood imports from Oregon and Washington will rise significantly (CDF 1978). In-State production of lumber and plywood, now about 74 percent of consumption, may comprise only 57 percent in 2000. At this time paper and allied products imports may be approximately double the 1976 level (Appendix Item VII).

The projections in Figure 10-1 for 1980, 2000, and 2030 assume that the timber harvest on public lands would decline from an average annual level of 346 million cubic feet during the decade of the 1980's to about 300 million in the 1990's and then gradually increase to about 330. This cutting pattern is consistent with Forest Service expectations and policies - most particularly the non-declining yield policy. (This policy, intended to assure that the cutting rate is not higher than could be maintained in perpetuity, is a topic of considerable debate and is considered later in this chapter and in the Assessment Chapter.)

At the request of FRAP, two alternative public-lands cutting schedules were also examined using the model. The purpose of these alternate computer runs is to quantify the likely price impacts of different public-lands cutting policies. (Consistent changes were made for the Pacific Northwest public-lands cut for these analyses.) Results of the three runs are shown in Table 10-2.

The "Current Expectations" column shown in the results are those already described and shown in Figure 10-1. The "Low Public Cut" column figures represent a total drop of nine percent over the fifty year period from the cutting rates described as "Current Expectations". The 1980's level in this schedule approximately represents the "Programmed Harvest" category of the "Standard Component" of Forest Service lands. Subsequent decreases to 270 million cubic feet annually are not now anticipated by the Forest Service but could occur as the result of significant changes in land use pressures. Should the cut thus decline, for whatever reasons, the model suggests that the effects would be felt in both price and quantity. As compared to the "Current Expectations" results, stumpage prices in 2030 would be about 11 percent higher following this public low-cut scenario.

The "High Public Cut" figures represent a total increase of 64 percent over the fifty year period as compared with the levels shown in the first alternative. The harvest, under this "High Public Cut" alternative would quickly increase in the 1980's and be double its otherwise expected rate in the 1990's after which it would fall. Such a rate would significantly decrease the Forest Service inventory of old-growth timber and also reduce its even flow capability

TABLE 10-2

PROJECTED STUMPAGE CONSUMPTION AND EQUILIBRIUM PRICES IN CALIFORNIA AS A FUNCTION OF CUTTING RATES ON PUBLIC LANDS

CUTTING SCHEDULE (Average Annual Cut in millions of cubic feet)			EQUILIBRIUM STUMPAGE		
			PRICE (1978 dollars per cubic foot)	TOTAL QUANTITY FOR ALL CALIFORNIA LANDS (in million of cubic feet per year)	IN YEAR
Current Expectations:	Public	Private			
1980's	329	559	0.58	899	1980
1990's	305	558			
2000's	314	549	1.16	849	2000
2010's	325	554			
2020's	335	556	2.10	898	2030
Low Public Cut					
1980's	328	564	0.58	899	1980
1990's	295	570			
2000's	285	560	1.23	846	2000
2010's	275	568			
2020's	270	570	2.33	833	2030
High Public Cut					
1980's	512	448	0.42	916	1980
1990's	600	485			
2000's	550	527	0.70	1,085	2000
2010's	500	569			
2020's	475	584	1.70	1.048	2030

NOTE: Prices shown are uncorrected for changes in the ratio of board feet to cubic feet. Such corrections would lead to somewhat higher prices in later years as the age and thus diameter of stumpage decreases.

SOURCE: Adams-Haynes Econometric Model, 1979.

over the next several decades. Subsequent increased management intensity could, over time, compensate for these reductions. The cut on private lands would decline 13 percent during the remaining two decades of this century as a result. The decreased pressure for harvesting timber nearing cutting age on private lands would provide an opportunity for building growing stocks and enhancing subsequent productivity. Stumpage prices would be about 40 percent lower in 2000 and almost 20 percent lower in 2030 than current expectations indicate.

Assuming Fowler's (1977) estimates of the effect of doubling the public cut for 20 years in Humboldt County are at least somewhat comparable to this alternative, one would expect the age-class distribution of all California's forest lands to be significantly smoothed as a result of implementing such a cutting schedule. As a consequence the even flow capacity for the State as a whole would likely be reduced no more than ten percentage points. (Fowler estimated a four percent reduction for Humboldt County. Increased management could compensate for some or all of the drop that would otherwise occur.) This Humboldt County analysis is only suggestive of the consequence of such a schedule; no analysis has been made by FRAP and Statewide data are not now sufficient to do so.

Changes in the price of stumpage, of course, are subsequently reflected in the prices of wood products. Because there are many inputs besides logs into the production of, for example, lumber, the proportionate magnitude of product price changes is less. The model suggests that lumber prices would be reduced by about two percent in 2030 as a result of the accelerated-cut alternative and increased by about one percent were the low-cut levels realized (as compared with the current expectations). FRAP, does not advocate any of the public cutting schedules presented. Forest Service cutting rates are an important policy variable. The results indicate to some extent how and why they deserve attention.

TIMBER VOLUME, PRODUCTIVITY, AND GROWTH

TIMBER VOLUME

California's commercial forests contain an estimated 49.7 billion cubic feet of wood in sound growing stock trees. The State ranks third in the nation in standing softwood inventory behind Oregon and Washington. Over 60 percent of the softwood volume is on national forest lands (see Table 10-3).

Growing stock in California has decreased as old-growth stands have been harvested and as timberlands have been cleared for nonforest use. Fire, insects, disease and weather have also contributed to the reduction in volume. A comparison of 1975 volume estimates with those published for 1953 (Forest Service 1954) shows 25 percent less cubic foot volume in 1975. Less than ten percent of the volume decline is as a result of a change in the land status from unreserved (commercial) to public reserved. Redwood and Douglas-fir volume declined the greatest amount; 41 percent and 38 percent respectively. Pines and true firs declined an average of 24 percent while hardwood volume increased by 35 percent. It should be noted, however, that a decline in timber volume is not necessarily an indication of a reduction in timber availability. Decreasing timber volume is an expected and necessary part of the conversion from old-growth to young-growth. Of more importance is the increased growth that results from this conversion.

As expected, the volume decline has been concentrated in large trees. In

TABLE 10-3

NET VOLUME OF GROWING STOCK ON COMMERCIAL FOREST LAND BY OWNERSHIP AND SOFTWOODS AND HARDWOODS, CALIFORNIA, 1975

OWNERSHIP	GROWING STOCK (BILLION CUBIC FEET)		
	SOFTWOODS	HARDWOODS	TOTAL
Public Unreserved	29,180	1,417	30,597
Forest Industry	10,525	800	11,325
Other Private	6,269	1,476	7,745
All Ownerships	45,974	3,693	49,667

Source: Forest Survey, 1979

1953, 89 percent of the softwood sawtimber volume was in trees 21.0 inches in diameter at breast height (DBH) and larger compared with 78 percent in 1975. Percent of hardwood volume in trees 21 inches DBH and larger also declined, though total hardwood volume increased. Two factors caused this: When associated softwoods were logged, many of the large hardwoods standing in 1953 were killed or they were damaged and became cull trees, and small hardwood trees have restocked several hundred thousand acres of logged and burned-over land.

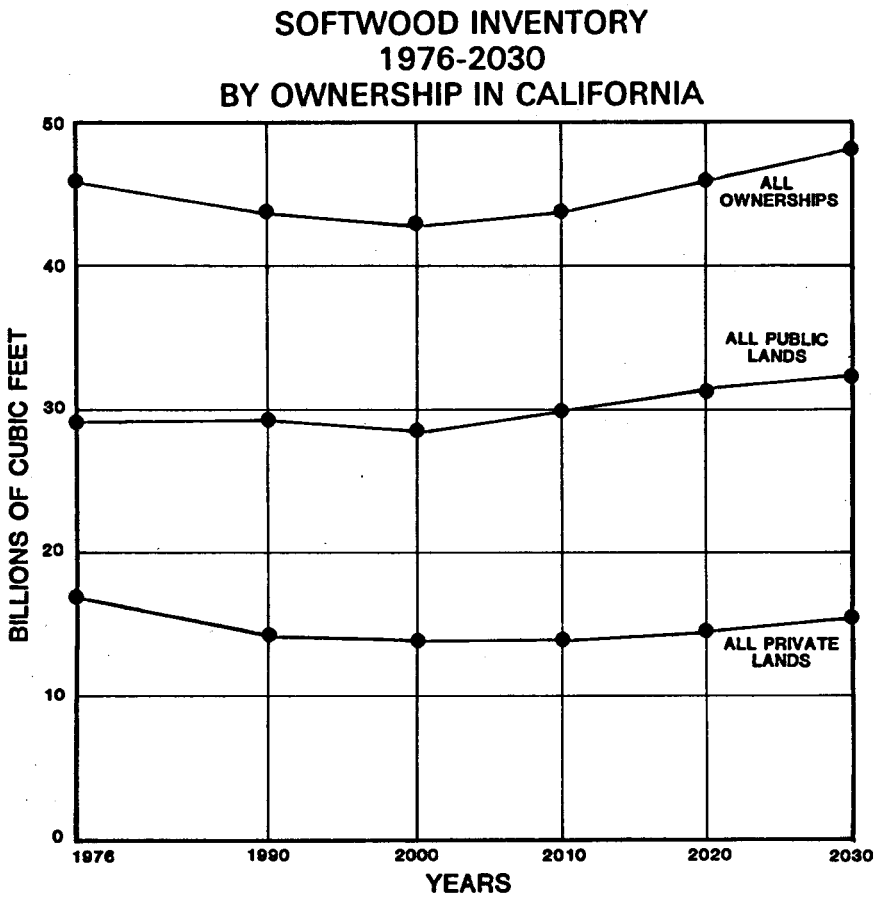
In addition to California's 49.7 billion cubic feet of sound growing stock trees, there were an estimated 2.3 billion cubic feet of wood in cull and dead trees in 1975. (This volume has undoubtedly increased substantially as a result of the 1975-78 drought and insect losses.) Cull and dead trees contained about four percent of the total sound wood volume in the national forests and six percent of the total wood volume outside the national forests. They represent an underutilized resource because they are widely scattered with low per-acre volumes. Utilization of this sort of material has improved considerably in the past two decades.

As old-growth stands are replaced by fast growing young stands forest growth rates and inventories are expected to increase. The Haynes and Adams econometric model projects softwood inventories until 2030 (see Figure 10-2). On all ownerships the cubic-foot inventory will decline 7 precent by 2000 and then increase 12 percent by 2030. The public lands cubic-foot inventory will decline until 2000 and then increase as young stands develop on reforested cutover lands. The cubic-foot inventory on Other Private lands is expected to increase after 2000 while the Forest Industry inventory is expected to decrease.

PRODUCTIVITY

The amount of wood that a forest can produce depends on climate, soil, tree species, and stocking condition. The productive capacity of commercial forest lands in California varies greatly. Some alluvial soils in the mild and rainy North Coast area are capable of

FIGURE 10-2



SOURCE: Haynes-Adams Econometric Model 1978

growing 400 or more cubic feet per acre per year if well stocked with healthy redwood trees. These same soils can grow 200 or 250 cubic feet of Douglas-fir, or as much as 150 cubic feet of hardwoods. At the other extreme are serpentine and periodotite soils in the Coast Ranges and western slopes of the Sierra Nevada, and granitic and volcanic soils in the arid interior which will barely grow 20 cubic feet of wood per year when well stocked with Jeffrey or ponderosa pine. Approximately half of the State's commercial forest land is capable of growing at least 85 cubic feet of wood per acre per year when well stocked with productive coniferous species such as redwood, ponderosa pine, sugar pine, Douglas-fir, and white fir (see Table 10-4). This area has approximately 80 percent of California's timber growing potential.

California contains three percent of the nation's commercial forest land, but has about nine percent of the area capable of growing 120 or more cubic feet per acre annually, which includes 13 percent of the area capable of growing 165 or more cubic feet per year. The estimated biological potential for all of California's commercial forest land averages 97 cubic feet per acre compared with 75 for the entire United States (Forest Service 1973). These estimates are based on yield-tables developed for fully stocked even-aged stands of single species. The estimates of biological potential do not necessarily indicate the yield-potential of stands currently occupying the land and are less than the potential of intensively managed stands. They are useful in ranking the potential of lands for allocating funds for forest intensification and in setting priori-

TABLE 10-4

AREA OF COMMERCIAL FOREST LAND IN THOUSANDS OF ACRES BY SITE CLASS AND OWNERSHIP CLASS, 1975

SITE CLASS	PUBLIC UNRESERVED	FOREST INDUSTRY	OTHER PRIVATE	ALL OWNERSHIPS
≥ 120 cubic feet	1473	1570	1222	4265
85 to 119 cubic feet	2017	757	792	3566
50 to 84 cubic feet	3775	978	1033	5786
20 to 49 cubic feet	1402	731	504	2637
All Classes	8667	4036	3551	16,254

Note: The "Other Private" column excludes six thousand acres in Central Coast and 39 thousand acres in southern California for which information is not available.

Source: Forest Survey

ties. California thus has high site lands and good timber production opportunities.

GROWTH

On all ownerships combined, the net annual growth on commercial forest land in 1975 was 802 million cubic feet or 46 percent of the land's estimated potential (see Table 10-5). Losses due to mortality were 131 million cubic feet of softwood and 5 million cubic feet of hardwood. These estimates represent levels of Statewide growth in "normal" years. However, during the 1975-1977 drought, growth on all ownerships was exceptionally low and mortality extremely high, resulting in negative net growth. Causes of mortality are discussed in the following section.

At the time of the inventory national forests had the highest growth rate relative to the land's potential. This is because there are extensive young stands of timber on national forest lands in the north-central Sierra Nevada that are approaching maximum growth. Also in 1972, large areas of forest industry land, especially on the North Coast, contained trees too small to have measureable growth. However, forest industry lands have the highest absolute growth rate (see Table 10-6).

TABLE 10-5

NET ANNUAL GROWTH OF GROWING STOCK ON COMMERCIAL FOREST LAND IN 1975

Ownership	Million Cubic Feet
Public Unreserved	402
Forest Industry	219
Other Private	181
All Ownerships	802

Source: Forest Survey, 1979

TABLE 10-6

TIMBER SITE[1], GROWTH, AND MORTALITY OF SOFTWOOD ON COMMERCIAL FOREST LAND, BY OWNERSHIP, CALIFORNIA, 1975

OWNERSHIP	TIMBER SITE	GROSS GROWTH	MORTALITY	NET GROWTH	NET GROWTH AS PERCENT OF POTENTIAL	GROSS GROWTH AS PERCENT OF POTENTIAL
	- - - - CUBIC FEET PER ACRE PER YEAR - - - -				- - - - - PERCENT - - - - - -	
Public Unreserved	86	53	9	44	51	62
Forest Industry	104	56	8	48	47	54
Other Private	101	47	6	41	41	47
All Ownerships	97	52	8	44	46	54

Source: Forest Survey, 1979

[1]See Glossary for Definition

National forest average growth ranges from a high of 87 cubic feet per acre per year on the Stanislaus, a Sierra-Nevada forest with extensive areas of healthy stands on productive land; to a low of six cubic feet on the Angeles, one of five national forests in Southern California with limited timber resources and poor sites.

The Central Coast Resource Area (see Figure 1-3) has the fastest growing timber stands in private ownership, with average annual growth ranging from 96 to 129 cubic feet per acre. This area is generally well stocked with redwood and Douglas-fir stands approaching the age of maximum growth. Private lands in the Northern Interior Resource Area have the lowest growth in the State, ranging from 28 to 36 cubic feet per acre. This area has extensive areas of low site land, and some heavily cutover stands in poor growing condition. Lands in the North Coast categorized as "Forest Industry" and "Other Private" have low growth relative to their potential. Much of the cut-over area is stocked with trees too small to have measurable volume and growth; and a substantial area is occupied with brush and hardwoods.

Annual growth rates have been increasing as a consequence of the conversion of old-growth stands to young-growth stands and intensive management. This trend is expected to continue and some suggest that it may accelerate, having noted that the Forest Service has consistantly under estimated future wood growth (Clawson 1979).

INJURIOUS AGENTS AFFECTING FOREST LAND

Growth of California's forests is affected by many significant damaging

agents. If future timber yields are to be increased, efforts in forest protection and damage control must be intensified. The relative importance of injurious agents as indicated by percent of mortality in a "normal" year is summarized below:

Cause	Percent
Insects	23
Weather	16
Diseases	11
Animals	Trace
Logging	4
Fire	3
Suppression	4
Unknown and Unclassified	39

FIRE

Fire protection is probably the most important single management activity in the State's highly flammable forests. California's wildland fire fighting and fire prevention organizations are effective. Since 1964, the average acreage burned per year has changed little although the number of fires has more than tripled. Still, the occasional catastrophic year is a powerful reminder of fire's devastating potential. In 1977, one of California's worst wildfire years due to the drought, about 175,000 acres of commercial forest were burned. Fire statistics indicate that all of the increase in the number of fires is man-caused. Therefore, as forest use increases, so will the incidence of fire, unless fire prevention can be made more effective.

Fire in old-growth timber stands usually leaves salvable timber whereas fire in young trees usually results in a total loss. Thus, as large, old-growth trees are removed and more of the forest is occupied by small trees, the relative effect of a fire on yields will be more severe, and less of the fire-killed volume will be salvageable. It is important to distinquish between the effects of uncontrolled and controlled fire. Where uncontrolled fire can be extremely damaging, controlled or prescribed fire can be used to increase forest regeneration and productivity by slash removal. Also, prescribed fire can reduce the harmful effects of uncontrolled fire by decreasing fuel loads and fire intensity.

INSECTS

Many species of insects attack California's forests. Western pine beetles, flathead borers, tip moths, and budworms are major problem causing insects.

In addition to killing trees, insects, especially those which are defoliators, weaken millions of trees thus reducing their growth. Extensive insect damage occurs in plantations and natural stands of young trees. From 1971-1975, the total acreage infested by defoliators and insects which attack young trees has ranged from 100,000 acres a year to 450,000 acres (California Forest Pest Control Action Council 1964-78).

DISEASES

Less spectacular than fire or insects, forest diseases are nonetheless a serious forest management problem. Two root diseases that lower trees' resistance to insects, weather, or other diseases and sometimes kill even large trees outright are Fomes annosus and Armillaria mellea. Other important diseases include rusts, damping-off fungi, cytospora canker, needle diseases, heart-rotting fungi and dwarf mistletoe.

Dwarf mistletoe is considered the most serious disease agent infesting the forests of Western North America. It reduces growth, invites insect attack and kills trees outright. Several coniferous species on about 21 percent of California's commercial forest land are infested with dwarf mistletoe. About 15 percent of the trees on national forest

lands and 25 percent of trees on other lands are infested. Dwarf mistletoe infections are common in the interior of the State, but are found less frequently in coastal areas. Forest managers will have to control this disease, or accept greatly reduced yields.

Stocking control measures (such as precommercial and commercial thinning) can reduce insect and disease mortality by maintaining stands in a vigorous condition. However, more research is needed to develop silvilcultural prescriptions that limit pest conditions from reaching damaging proportions.

WEATHER DAMAGE

Wind throw or windbreak are periodically widespread phenomana and are often associated with root disease or heart rot. Other types of weather damage include: late spring frosts; foliage burn on sunny, windy days when the ground is frozen; hail; heavy snow; ice storms and drought. Normally weather is a relatively insignificant cause of injury; however, the 1975-77 drought in California was particularly severe and injurious. CDF estimates that since 1976 45 million trees have have been killed by drought, by bark beetles, and/or diseases. These trees contained an estimated four billion cubic feet of timber. Tree mortality is declining as the forest continues its recovery from the stress of the drought.

ANIMAL DAMAGE

Many of the wild animals that delight forest recreationists, attract hunters and add to the general richness of life also damage and kill forest trees. Deer browsing on young conifers is a serious animal damage problem in parts of California. Extensive damage has been caused by pocket gophers in the North Coast region. Other animals whose activities are damaging include rabbits, porcupines, mice, elk and bear.

PEOPLE-CAUSED FOREST DAMAGE

Many of the activities of people either directly or indirectly damage trees. In addition to the man-caused fires mentioned earlier, two primary causes of such damage are logging and air pollution.

Trees injured during logging operations often become infected by wood rotting agents. A sizeable portion of the volume lost due to decay and weather damage can be traced back to logging damage, especially in the true firs and hardwoods.

A serious and growing forestry problem in California is oxidant damage. First noted in the 1950's, oxidant damage and accompanying insect attack have resulted in the death of thousands of trees throughout Southern California. More recently, pines on the western slopes of the Sierra Nevada have been affected as far north as Fresno County (see Chapter Five, "Forest Lands and the Air Resource" for further information).

CURRENT LEVELS OF FOREST MANAGEMENT AND TIMBER REMOVALS

The level of forest management in all ownerships has increased significantly in the last ten years. The Z'berg-Nejedly Forest Practice Act of 1973 and related Public Resources Code regulations which include minimum stocking requirements have increased forest planting. Also, the rising price of forest products has served as an economic incentive to private land owners to reforest nonstocked areas and implement silvicultural techniques to increase timber production. Silvicultural treatments not involving timber harvesting total over 200,000 acres annually (see Table 10-7).

TABLE 10-7

RECENT ANNUAL AREA OF COMMERCIAL FOREST MANAGEMENT ACTIVITIES IN CALIFORNIA BY SILVICULTURAL TREATMENT AND OWNERSHIP (1)

SILVICULTRUAL TREATMENT	PUBLIC	PRIVATE	TOTAL OF AVAILABLE DATA
		Acres	
TREATMENTS NOT INVOLVING TIMBER HARVEST			
Planting and seeding	35,921	47,139	83,060
Site preparation for planting	25,581	NA	25,581
Site preparation for natural regeneration	14,049	20,466	34,515
Timber stand improvement	33,216	21,908	55,124
Pruning	315	NA	315
Fertilizing	409	NA	409
Prescribed burn to control understory	1,914	NA	1,914
Total of Treatments Not Involving Timber Harvest	111,405	89,513	200,918
TIMBER HARVEST TREATMENTS			
Clearcutting	19,600	15,700(2)	35,300
Selection cutting	22,800	286,100	308,900
Shelterwood and seed tree cutting	73,200	46,900	120,100
Intermediate cutting (includes commercial thinning)	52,100	42,400	94,500
Sanitation-salvage cutting	164,600	92,300	256,900
Other	—	84,800	84,800
Total Timber Harvest Treatments	332,300	568,200	900,500
Total All Treatments	443,705	657,713	1,101,418

(1) These data are presented to indicate the approximate area being treated annually in California's forests. The sources are: U.S. Forest Service, State Summary, Reforestation and Stand Improvement, Report 24.245, compiled at Fort Collins,Colorado, January 1979; U.S. Forest Service, 1977 Report; Forest Planting, Seeding, and Silvical Treatments in the United States, Washington, D.C., 1978; State of California Forest Practice Report, 1977, Sacramento, California, 1978; U.S. Forest Service Region 5 office files, 1978.

(2) Timber harvest plans as filed for 1977, presented as the best indicator of acres actually treated.

Reforestation of private lands increased from 9,000 acres in 1969 to 47,000 acres in 1977 while reforestation of public lands increased from 25,000 acres in 1969 to 36,000 acres in 1977. These increases were made possible by increases in nursery production and improvements in the economics of forest investment.

Production from private nurseries reached 39.8 million seedlings in 1977 compared to 900,000 in 1965. Production of seedlings in public nurseries increased from 21.2 to 23.7 million from 1965 to 1977. Yet even with this great increase in planting on all ownerships, the acreage reforested annually is just keeping up with the area deforested by wildfire and timber harvesting. Thus, to decrease the planting backlog that has accumulated in past years, even greater reforestation must occur.

Timber harvesting occurs on over 900,000 acres annually. Selection cutting occurs on over half of the area of private land harvested. On public land, sanitation-salvage cutting is the major treatment in terms of acres, occurring on over half of the treated area.

Timber removals from California forest land peaked in 1955 when over one billion cubic feet were harvested. Since then annual timber removals have declined to about 750 million cubic feet (see Figure 10-3). This data series indicates past cutting trends. (The series used in the Adams-Haynes model is somewhat different. No significant increase in cut is projected for 1978-80 as a comparison would suggest.)

Timber removals on the North Coast, the major timber producing area in the State, have fluctuated considerably in keeping with an over-all decrease since the 1950's. In the remainder of the State, the cut has remained fairly stable, especially in the Sacramento and San Joaquin Resource Areas (see Figure 1-3). Relatively little timber has been harvested in the Central Coast Resource Area since the 1930's.

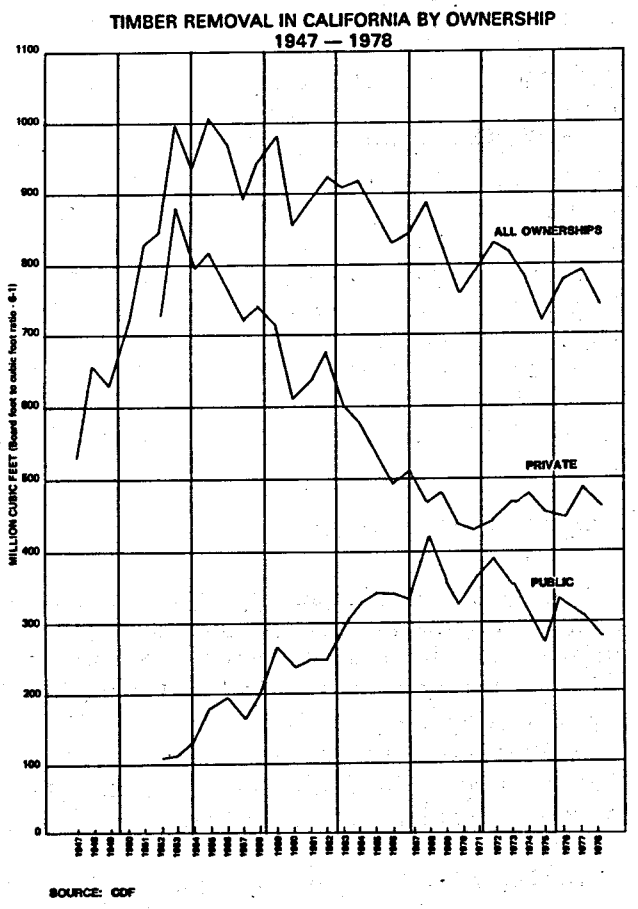
In the early years cutting was done predominantly on private lands. In the early 1960's, as the cut declined on private lands, cutting on national forest lands increased, making up some of the decrease. National forest cut has declined some in most recent years.

In 1978 timber removals from commercial forest lands in California were approximately 744 million cubic feet; 69 percent private and 31 percent public (State Board of Equalization 1979). Payments to 39 counties from Forest Service revenues (primarily from harvested timber) were approximately $50 million. Yield tax revenues from California timber harvests in 1978 were $45 million.

Timber harvested from all ownerships in the North Coast Resource Area in 1978 amounted to 32 percent of the State's total. The remaining 68 percent was harvested in the interior, as shown below:

RESOURCE AREA	MILLION CUBIC FEET	PERCENT
North Coast	260	35
Northern Interior	223	30
Sacramento	164	22
San Joaquin	89	12
Central Coast and Southern Calif.	4	1
	744	100

California's forest industries have, until recent years, relied almost exclusively on old-growth timber to meet their needs. As the available old growth has been logged, a gradual transition to the utilization of young-growth timber has taken place. Still, almost 70 percent of the present log consumption is from trees at least 100 years old.



The increase in use of young-growth timber is most evident in the North Coast and Central Coast Resource Areas where many of the old-growth stands on private lands have been logged and relatively little public timber exists. In these resource areas, 38 percent and 91 percent repectively of the lumber production is from young-growth timber (less than 100 years old) (Howard and Hiserote 1978). In the interior of the State (Northern Interior, Sacramento and San Joaquin Resource Areas) where extensive old-growth stands exist within the national forests, 25 percent of the lumber production is from young-growth timber. The utilization of young-growth timber is expected to increase significantly in the next 10 years.

California's timber production. Currently, California's industrial wood consumption is composed of 23 percent Douglas-fir; 19 percent redwood; 31 percent ponderosa pine and sugar pine; and 23 percent true fir. The remaining portion is made up of other softwoods such as incense cedar and some hardwoods, with tanoak and oak predominating.

The relative importance of a particular species to the total annual harvest-volume has changed over the years due to changes in the market and species availability. Douglas-fir, redwood, and ponderosa pine each, at one time or another, constituted at least half of

AVAILABILITY OF COMMERCIAL FOREST LAND (CFL) FOR TIMBER PRODUCTION

Approximately half of the State's forest land is either too low in productivity for the production of commerical timber or is withdrawn from timber harvesting in national and State parks, wilderness areas, and other legally established forms of reservations. The remainder, according to the Forest Service definition of "commerical forest land" is 16.3 million acres. While the term "commercial forest land" may unfortunately suggest forest land held for commercial timber production purposes, in fact ownership objectives are highly variable.

NATIONAL FOREST LANDS

The Forest Service manages 8.2 million acres of commercial forest land. Because national forests are to be managed for the continuous high level production of various commodity goods and amenities including outdoor recreation opportunities, water, fish and wildlife, timber and forage, timber management on this commerical acreage is planned within a framework of all recognized resource values.

The commerical forest area (40 percent of the total land area in national forests) has been classified into four com-

ponents which bear on timber management intensity (Forest Service 1972). The standard component, managed intensively for timber production, yields 90 percent of the timber harvested from national forest land and includes 62 percent of this commerical forest land.

The other components yield significantly less timber because of other resource needs, low expected economic returns and inaccessibility. The special component may include lands adjacent to streams, highways, and recreational sites, and habitats of endangered wildlife species. The marginal component is composed of land which is deemed marginal for timber production, because of poor productivity, low product value or the need for access roads. Commercial forest lands that will not be managed for sustained timber production such as experimental forests and administrative and recreational sites are within the unregulated component.

The area involved in these components is shown as (in thousands of acres):

NATIONAL FOREST COMMERCIAL FORESTLAND, 1978

FOREST COMPONENT	THOUSAND ACRES	PERCENT
Standard	5,064	62
Special	898	11
Marginal	1,960	24
Unregulated	245	3
TOTAL	8,168	100

Recently 1.66 million acres of national forest commercial forest land were considered for wilderness status under the Forest Service's second Roadless Area Review and Evaluation Program (RARE II). (Interspersed with the public roadless areas are an additional few thousand acres of private productive timber land.) Conversion to "Public Reserved" (wilderness) status of the 240,000 acres of commercial forestland included in the federal recommendation to Congress could result in a two percent decrease in timber harvest from national forests. The California Resources Agency Wilderness Proposal could reduce annual yield by approximately four percent. However, the majority of this RARE II commercial forest land is outside the standard component. For further information on lands considered in RARE II refer to the Wilderness Chapter.

OTHER PUBLIC AGENCIES

Lands administered by the Bureau of Land Management (BLM) are managed for sustained yield under multiple use principles defined in the Federal Land Policy and Management Act of 1976 (Public Law 94-579). The commercial forest land totals about 240,000 acres in scattered parcels throughout the State.

Indian lands are managed under the guidance of the Bureau of Indian Affairs to provide income for the Indian owners. Strictly speaking, these lands are privately owned, though historically they have been classified as part of the public lands. Indian lands total about 100,000 acres in the larger reservations such as the Hoopa Valley in the North Coast, and the Tule River in the San Joaquin resource areas. Timber is managed on a sustained-yield basis with a long-term allowable harvest equal to the land's capacity under the planned management intensity.

State-owned commercial forest lands include seven State forests and scattered parcels of other State lands. The total classified as commercial forest by the Forest Survey is 79,000 acres. The four State forests which are managed primarily for timber production, research and demonstration in modern forest management practices contain about 68,000 acres (CDF, 1975).

PRIVATE LANDS

The Forest Service classifies 7.6 million acres of privately-owned land in California as commercial forest land. Very little detailed information on size and location of private parcels and ownership objectives exists. Although much of this land has been logged in the past, only part of it is available for growing and harvesting timber today.

Forest Industry

Most dependable for timber production are the 2,688,000 acres of commercial forest land owned by companies that operate forest products mills, and the 1,348,000 acres owned by other companies that grow timber for sale to the companies that operate mills. These firms have forestry staffs and manage timber on a continuous yield basis. The total acreage in these ownerships has increased and the number and size of these holdings has been changing generally toward fewer and larger companies. Though intensity of timber management varies from company to company, investment in mills and high quality timberland is some assurance that the companies will continue to produce timber.

Other Private

With the exception of a few large corporate owners, the "other private" timberland is composed of a very large number of individually held small forest properties, which are subject to fairly rapid turn-over in ownership and increasing fragmentation. A recent study indicates approximately 50 percent of these landowners live in the county in which the property is located, or in an adjacent county (Laacke 1979).

Commercial forests owned by farmers and ranchers total 1,646,000 acres. Miscellaneous private owners including nonfarmer individuals, banks, churches, real estate development companies and other organizations hold 1,950,000 acres of commercial forest. Most of this timberland is not managed for timber production, although many tracts are logged rather sporadically and some areas are being managed by consulting foresters.

The total area of farmer-owned and miscellaneous private-ownership forest has decreased due to grazing, clearing, residential development and other conversions.

LAND CONVERSION AND TPZ

The Forest Survey estimates that 221,000 acres of commercial timberland were developed for nontimber purposes in the interior and central coastal forests from 1970-72. The current Statewide area of forest being developed each year, thought to be significant by some, is unknown.

Continued conversion of the commercial forest land base to non-forest use is decreasing the States' ability to grow timber. The timberland preserve zoning provision of the Z'berg-Warren-Keene-Collier Forest Taxation Reform Act of 1976 is a partial solution to this problem. Land designated Timberland Preserve Zones (TPZ) by counties may be used only for production of forest products and other compatible uses. In turn, the taxes levied against TPZ lands are to be based on the capability of the land to produce forest products. These changes in the tax system were made to eliminate disincentives to investments in timberland resulting from higher annual timber and property taxes. As of April 1978, 5.68 million acres (75 percent of the private commercial forest land) were in TPZ's. (See Appendix Item IX for a listing of the area in TPZ by county.) While these lands are not used solely for timber production, and the level of timber management varies from "high yield forestry" to minimum legal requuirements, they will remain forested. The nearly two million acres of productive timberland not in TPZ's (com-

posed primarily of non-industrial holdings too small to meet minimum area requirements set by counties) are probably where most timberland conversion will occur.

With 3 million acres of national forest commercial timberland in nonstandard components, 3.6 million acres in farmer and miscellaneous private ownership, and 52 percent of the State's timberland low in wood growing potential, the majority of future timber production can be expected to come from one-half to two-thirds of the existing commercial forest land base. However, more timber could be grown by small private landowners if they were provided with economic incentives and technical assistance. Furthermore, investments in all ownerships will be necessary to maintain or increase timber supplies.

OPPORTUNITIES FOR INCREASING TIMBER SUPPLIES

There are many opportunities to increase timber supplies in California. Growing more timber is one way of slowing price increases, averting declines in both employment and revenue, and meeting paper and other wood product needs. However, biological opportunities for improving forest productivity may be limited by environmental, economic, and institutional constraints. Also, increased yields from forest investments will not prevent projected timber supply reductions from private land in the next 20 years because the additional timber produced will not mature until the middle of the next century. Consequently, intensive management, by itself, is not enough. Revised Forest Service harvesting policies and improved utilization of harvested timber could be used to avoid the decline. These opportunities are discussed in detail in this section.

BIOLOGICAL OPPORTUNITIES FOR INCREASING TIMBER GROWTH

Forest management activities which improve forest productivity can be grouped into two general categories: (1) stand regeneration; and (2) timber stand improvement. These treatments are designed to increase commercial softwood growth. Commercial softwood species offer the best opportunity because they grow much faster than hardwood species in California and are suitable for the kind of products needed. (Although fertilization and planting genetically superior seedlings are expected to make significant contributions to improved forest productivity in future years, these opportunities were not considered due to lack of sufficient data on yield responses.)

Opportunities for improving productivity depend on the physical condition of forest stands which vary by land ownership. The 8.7 million acres of public commercial forest land still contain extensive areas of old-growth sawtimber. Approximately 78 percent is sawtimber, the remaining 12 percent being poletimber, 6 percent sapling and seedling and 4 percent nonstocked. The predominant treatment opportunity in sawtimber stands is stand regeneration. The California Forest Productivity Committee has estimated treatment opportunities for the national forest component of public forest land where limited data were available.

Most of the 7.6 million acres of private commercial forest land have been harvested at least once. Some uncut old-growth stands can still be found, mainly in remote mountain regions, and considerable residual volume has been left in many logged stands. Volume in some young-growth stands on land cut decades ago is as great as the volume in many uncut old-growth stands. Much of the more recently logged area is now forested with seedling, sapling or poletimber stands. On the other hand, older

logging and mining operations, fires, insect and disease epidemics, storms and unsuccessful attempts to convert forest to pasture, have left extensive areas of productive land stocked with low value hardwoods, rotten and damaged conifers and brush. Because of the longer history of disturbance on private land than on public lands and the various objectives pursued by the many owners, opportunities for silvicultural treatment on these lands are more extensive and varied.

Treatment opportunities exist on three-quarters, or nearly 12 million acres, of California's commercial forest land. The remaining area is considered to be growing timber at an adequate rate. Stand regeneration opportunities occur on 7.9 million acres, which is almost equally divided between public and private lands. Timber stand improvement treatment areas total four million acres, and are primarily found on private land (see Table 10-8).

Stand Regeneration Opportunities

Stand regeneration treatments are undertaken to remove brush, hardwoods and/or slowgrowing softwoods and replace them with more productive softwood seedlings.

Brush Clearing-and-Planting

After forest lands are cleared, many sites convert to brush or hardwoods if not immediately restocked with conifers. Although nonstocked areas do reforest naturally, succession to conifers once other species are established is very slow. Large fires such as those which occurred in 1977 increase the planting backlog.

At the present time, over 1.6 million acres of commercial timberland in California are nonstocked or poorly stocked with sapling or seedling conifer trees. Most of this area will require some kind of site preparation such as the removal of shrubby vegetation and/or logging residues using prescribed burning before planting can take place. The current softwood growth on these lands is about one million cubic feet per year. The average annual yield could be 80 million cubic feet (over a 70 year period) if this area were at least 60 percent stocked with conifers. Statewide growth could increase 10 percent (Bolsinger, draft, 1979). Over 40 percent of this nonstocked timberland is medium and high site, (capable of growing at least 85 cubic feet of wood per acre per year). These areas could be viewed as first priority planting sites.

There has been a general trend toward the development and use of genetically improved planting stock. These efforts should be encouraged as they can substantially improve growth. Much of the present seed source used in seedling production is collected without regard to genetic quality.

Hardwood Conversion

Hardwood stands are important in that they provide wildlife habitat and add diversity to forest scenery. Unfortunately, in terms of meeting California timber products needs, only two or three of the more than 20 hardwood species which grow in California's forests have been utilized to any degree. Hardwoods amount to less than two-tenths of one percent of the State's roundwood consumption by forest product mills (Howard and Hiserote 1978). This is because California hardwood trees are typically crooked, forked and sprawling; they are difficult and costly to log and process; and there exists little market for these species. Research could be undertaken to develop utilization techniques and markets for hardwoods.

In many areas hardwoods have become the predominant species after logging or fire. Black oak and tanoak now occupy hundreds of thousands of acres that once grew more productive softwoods. Remov-

TABLE 10-8

TREATMENT OPPORTUNITIES				
AREA (M Acres)				
TREATMENT	PUBLIC UNRESERVED	FOREST INDUSTRY	OTHER PRIVATE	TOTAL
STAND REGENERATION				
Brush Clearing-and-Planting	389	480	779	1648
Hardwood Conversion	505	230	557	1292
Harvest-and-Plant	2888 (1)	1307	772	4917
TOTAL	3782	2017	2058	7857
TIMBER STAND IMPROVEMENT				
Precommercial Thinning	314	820	654	1788
Commercial Thinning	465 (1)	1020	722	2207
TOTAL	779	1840	1376	3995
TOTAL	4561	3857	3434	11852

(1) National forest portion from Forest Industries Council estimate

Source: Based on Forest Survey data, 1979

ing hardwoods and establishing conifers on these commercial forest lands could substantially increase the amount of usable wood produced in California.

Hardwood stands occupy 1.3 million acres of commercial forest land which are capable of growing softwoods. Of this acreage, 61 percent is in private ownership, 39 percent is in public custodianship. If reforested with conifers, annual softwood growth could increase from about 11 to 89 million cubic feet per year (over a 70 year period) and Statewide growth could increase 10 percent (Bolsinger, draft, 1979). Sixty percent of this private forest is medium or high site land compared to 36 percent on public land. Hardwood conversion (and brush conversion) could also increase the populations of certain wildlife species. The complementarity of producting more wood and game is discussed in the Assessment and Fish and Wildlife Chapters.

Harvest-and-Plant

A factor also contributing to poor growth in relation to potential is the extensive area of sawtimber stands which are in poor condition. On private lands, the sequential removal of the more valuable dominant trees has reduced some stands to a collection of damaged and diseased trees and undesirable species. Net growth in these stands is low and sometimes negative because of mortality. These low-growth stands are producing 60 million cubic feet per year, yet they could be producing 273 million. The loss in productivity of these private forest lands is greater than the total loss in hardwood stands and nonstocked areas on all ownerships.

Growth rates are not expected to improve until the present cover is removed and young conifer stands established. Unfortunately, not much of this is being done; the common practice seems to be for continued selective logging and for leaving a residual low-value, low-growth stand to occupy the land. Present stocking provisions of the Forest Practice Rules may be satisfied by such logging practices. However, these rules might be amended by including higher seed tree standards for example, to prevent such losses to future growth. Private lands in this condition total about 1.8 million acres. An additional 300,000 acres are slow-growing old growth. The total area representing harvest-and-plant opportunities is 67 percent forest industry, 33 percent other private.

Low growth residual stands also exist on public land, but of greater significance are the extensive areas of uncut old-growth timber, especially in the national forests. These large areas of old-growth timber reflect the Forest Service's non-declining even flow policy whereby timber yields are maintained in perpetuity at a near constant level. This policy extends the conversion period of old-growth to young-growth timber and thus delays the potential increased growth. Any significant acceleration in the national forest harvest level would require a change in policy. This issue is described in more detail near the end of this section and in the Assessment Chapter.

As on the private land mentioned above, net growth in many of these stands is low or even negative because of mortality. Site preparation and planting opportunities will exist as the 2.9 million acress of mature public timber are harvested (Forest Industries Council, draft, 1979). Regeneration of these stands could yield the greatest potential increase in Statewide growth of all treatments, an estimated 43 percent.

Timber Stand Improvements

Timber stand improvement treatments are made in areas where adequate numbers of young softwood trees occupy a site but their growth is impeded by brush, hardwoods, and/or the presence of too many low quality softwood trees. This overcrowding and the resulting slowed tree growth lengthens the time required for trees to reach a merchantable size. Improvements are also made to stands in the poletimber-young sawtimber stage of development by removing commercially valuable wood and releasing the residual stand for additional growth.

Precommercial Thinning

Precommercial thinning treatments can be grouped into two categories according to the stage of conifer development: (1) seedling-sapling, and (2) poletimber-young sawtimber. At the present time, research is needed to find methods of release for seedling-sapling conifers that are both more economically and environmentally acceptable. A recent brush control project in southern Oregon found that because of the high number of stems the cost of cutting brush with chain saws was very expensive ($556-

$1269 per acre) and about one-third of the desirable conifers were damaged or killed by the workers (Bernstein 1977).

Spraying brush and hardwoods with herbicides has proven effective in most cases, but environmental concerns have caused the use of 2,4,5-T and Silvex on forest lands to be suspended by the Environmental Protection Agency until a full review of their impacts on human health and their benefits is completed. For additional information on the effects of herbicides and other pesticides, refer to the Air and Watershed Chapters.

The use of animals that prefer to browse on brush and hardwoods has been tried with mixed results. Biological control methods would be desirable. Defoliating insects which attack unwanted vegetation have been used with some success in weed control and offer possibilities in forestry. The use of the Klamath weed beetle (Chrysolina) on St. Johnswort, and the cinnabar moth on tansy ragwort are good examples. However, until more acceptable methods that are applicable to forestry are found, release treatments of young conifers will be limited.

Once conifers reach the sapling-young poletimber size, precommercial thinning usually involves the removal of diseased and deformed trees and undesirable species. Though precommercial thinning usually produces no immediate revenue, it can greatly increase yields. Further study is needed before the growth response on a Statewide basis can be quantified. Dense poletimber stands of the four main species groups (Douglas-fir, ponderosa and Jeffrey pines, redwood, and true firs) on sites capable of growing 85 or more cubic feet per acre probably could be improved by thinning. Overly dense poletimber stands on low sites probably present poor thinning opportunities because of the advanced age of the trees.

With fewer stems to cut per acre the cost of using chain saws is one-fifth to one-sixth of the cost of brush removal using hand labor ($100-$200 per acre). An improvement in the small log or chip markets could result in some of these young stands becoming opportunities for commercial thinning opportunities.

Commercial Thinning

Over two million acres of adequately stocked young sawtimber conifer stands can be commercially thinned (i.e., will yield a return when thinned). Although studies in the Pacific Northwest indicate that in general commercial thinning does not increase total fiber yields, it does yield wood and income at an earlier date and it may reduce mortality from insects (Lang et al. 1978). Also by concentrating fiber growth on larger stems it can increase yields of wood for certain products. Whether or not a given stand in this category should be thinned depends more on the owner's objectives than on the condition of the stand.

Nonstocked and poorly stocked land, "converted" hardwood stands and old-growth stands are the major underproducing forest conditions in California. Reforestation and replacing hardwoods with conifers would increase current Statewide growth by 20 percent. If only the planting and stand conversion opportunities on high and medium sites (those capable of growing at least 85 cubic feet per acre), were treated, the prospective harvest in 70 years would still be 80 percent of the potential yield even though less than half of the area was treated (distributed by ownership as follows: 26 percent on public forest land, 15 percent on forest industry land and 59 percent on other private lands).

The low-growth sawtimber stands represent by far the greatest potential increase in forest growth. If the cutover stands in poor condition on lands outside national forests were harvested

TABLE 10-9

TOTAL CURRENT NET ANNUAL GROWTH, POTENTIAL ADDITIONAL ANNUAL GROWTH AND GROWTH THAT COULD RESULT FROM MEETING THE OPPORTUNITIES CAPABLE OF RETURNING 10 PERCENT ON THE INVESTMENT AFTER TAX IN CALIFORNIA BY OWNERSHIP.

OWNERSHIP	CURRENT NET(1) ANNUAL GROWTH	ADDITIONAL(2) POTENTIAL	ADDITIONAL POTENTIAL(2) AT 10 PERCENT RETURN
	(MILLION CUBIC FEET)		
Public	402	368.7	288.6
Forest Industry (3)	162	273.6	257.5
Other Private	238	337.0	282.0
All Owners	802	979.3	828.1

Source: (1) Forest Survey, 1979
(2) Forest Industries Council, draft, 1979
(3) Includes only companies or individuals operating wood-using plants

and regenerated, in time the average annual timber growth in California could increase by 27 percent. Regenerating uncut old-growth stands on national forests could increase Statewide growth by 43 percent.

The California Forest Productivity Committee (CFPC) has also estimated potential growth response to the treatment opportunities on all ownerships. The Committee determined that treatment opportunities could increase the State's total annual forest growth by 122 percent, or 979 million cubic feet (see Table 10-9). Achieving this growth would, of course, take several decades for the effects of investments to be realized.

ECONOMIC OPPORTUNITIES FOR INCREASED TIMBER GROWTH

Biological opportunities for increasing timber supplies must be viewed in relationship to a consideration of costs and returns. Only part of the biological opportunities can be expected to yield an acceptable rate of return on the investments required to put the opportunities into practice.

There are several disincentives to the investment of capital needed to utilize the timberland fully. The growing of timber crops is an enterprise characterized by long production periods (typically ranging from 40-80 years or more); substantial physical risks of loss to fire, insects, and disease; the major uncertainties associated with producing for market so remote in time; and a modest rate of return (Zivnuska and Vaux 1975). However, as timber prices continue to rise sharply relative to prices generally, rates of return are increasing.

Forest investments could be encouraged by government incentive programs such as

the California Forest Improvement Program (CFIP), the Forestry Incentives Program (FIP), and the Agricultural Conservation Program (ACP), which offer grants and technical assistance. Without such programs investments by small nonindustrial private forest land owners are less likely to be made.

Although more information on the long-run cost of timber growing by site quality, forest types and ownership is needed, progress has been made in determining Statewide economic treatment opportunities. An analysis of the costs and benefits of intensive management has been developed by the California Forest Improvement Committee as part of an ongoing study by the Forest Industries Council and the Forest Service. In this study university, industry and government foresters estimated initial costs of and growth responses to treatments and values of the harvested timber. The potential treatment opportunities were evaluated on the basis of the net present value of the incremental investment. In the analysis both a continuation of the general economic inflation and a real increase in the value of timber were assumed. The assumed long-term annual inflation rate was four percent.

Results from the study show economic opportunities for treatment which yield a positive net present value at a cost of capital of 8, 10 and 12 percent. As expected, the acreage showing a positive net present value declines as the cost of investment capital rises. At eight percent, 9.8 million acres have a positive return but this acreage declines to 6.2 and 2.6 million acres at 10 and 12 percent respectively. Table 10-10 shows the acreage by ownership and treatment for the 10 percent cost-of-capital option.

Stand regeneration treatments (which generally have high growth responses), make up 77 percent of these investments. Harvest-and-plant with revenues from the timber harvest (especially on high volume national forest stands) is the predominant opportunity of these treatments. The study found that 46 percent of all the investments are on public forests, 32 percent on other private lands and 22 percent on forest industry owned lands (Forest Industries Council, draft, 1979).

The total initial cost of treatment required to fulfill all the economically feasible investments on 6.2 million acres of all ownerships, at an assumed cost of capital of 10 percent, is estimated to be $676 million (see Table 10-11).

These treatments could increase annual growth by 828 million cubic feet, or 103 percent over the current growth (see Table 10-9). The largest percentage of increase in growth could occur on forest industry lands and the least percentage of increase on public lands. However, in absolute terms, public forests hold the greatest potential for increase (289 million cubic feet) (Forest Industries Council, draft, 1979).

ENVIRONMENTAL FACTORS AFFECTING THE FEASIBILITY OF TREATMENT OPPORTUNITIES

In addition to the economic considerations just discussed, environmental factors will affect the availability of forest land for timber management and the kinds of treatments used.

In California's interior, the steepness of the land and problems related to shallow, rocky soils restrict forest manageability. Steep slopes of over 45 percent are usually difficult to manage regardless of soil characteristics; lands with rock outcroppings and poor soils are difficult to manage regardless of slope. Roughly 30 percent of all the commercial forest land in California's interior have steep slopes or soil problems.

Where slopes are steep and soils highly erodible, extra precautions are nec-

TABLE 10-10

AREA OF COMMERICAL FOREST LAND WITH POTENTIAL FOR GROWING ADDITIONAL WOOD AT A COST OF CAPITAL OF 10 PERCENT AFTER TAX BY TREATMENT AND OWNERSHIP

	AREA (M ACRES)			
TREATMENT	PUBLIC UNRESERVED	FOREST (1) INDUSTRY	OTHER PRIVATE	TOTAL
STAND REGENERATION				
Brush Clearing and Planting and Hardwood Conversion	644	373	834	1851
Harvest-and-Plant	1632	633	626	2891
TIMBER STAND IMPROVEMENT				
Precommercial Thinning	234	231	262	727
Commercial Thinning	385	93	234	712
TOTAL	2895	1330	1956	6181

Source: Forest Industries Council, draft, 1979

(1) Includes only companies or individuals operating wood-using plants

essary in order to minimize environmental impacts. In the North Coast Resource Area a study prepared for the California State Water Resources Control Board by Jones and Stokes Associates, Inc. in 1973, classified 83 percent of the commercial forest area as having a high or very high erosion hazard. Any forestry activity in the North Coast area will have to take into account the erosion hazards which are prevalent there if forest productivity and other resource values such as fisheries and water quality are to be maintained. For a detailed discussion of the impacts of timber harvesting on soil and water resources, refer to the Watershed Chapter. Provisions to maintain or enhance fish and wildlife habitats are described in the Fish and Wildlife Resources Chapter.

California presently has one of the most comprehensive systems of public regulation of private timber harvesting practices in the United States. The system attempts to balance the public's need for wood with the need for high environmental quality. It does so through a system of timber harvest planning and review under which timber output and environmental quality tradeoffs are carefully weighed. The Watershed Chapter provides further information on this system and evaluates its ability to control nonpoint pollution. Although significant progress has been made in the development of this system, problems arise from fragmentation of the regulatory authority between agencies and because not all silvicultural activities (such as road construction outside of

TABLE 10-11

COST OF MEETING THE TREATMENT OPPORTUNITIES TO GROW ADDITIONAL WOOD WITH A POSITIVE NET PRESENT VALUE AFTER TAX AT A 10 PERCENT COST OF CAPITAL BY TREATMENT AND OWNERSHIP

	COST (MILLION DOLLARS)			
TREATMENT	PUBLIC UNRESERVED	FOREST (1) INDUSTRY	OTHER PRIVATE	TOTAL
STAND REGENERATION				
Brush Clearing and Planting and Hardwood Conversion	108.5	63.3	138.6	310.4
Harvest-and-Plant	195.2	73.3	73.2	341.7
TIMBER STAND IMPROVEMENT				
Precommercial Thinning	5.1	10.7	7.6	23.4
Commercial Thinning	—	—	—	—
TOTAL	308.8	147.3	219.4	675.5

Source: Forest Industries Council, draft, 1979

(1) Includes only companies or individuals operating wood-using plants

timber harvesting plan areas) are regulated. In an effort to control pollution sources "Best Management Practices" for all land use activities are being developed by State and federal agencies as required by Section 208 of the 1972 Federal Water Pollution Control Act.

In order to better evaluate the impacts of land uses more complete data are needed on the reactions of soil types and other resources such as wildlife to various development practices. Certainly, a Statewide intensification of timber management will involve some resource tradeoffs, but undesirable effects of silvicultural practices can be reduced through careful planning and management. Also, concentrating treatments on the medium and high sites will yield the greatest growth and economic return while disturbing a reduced land area.

FOREST SERVICE HARVESTING POLICY

The Forest Service in accordance with its interpretation of the National Forest Management Act of 1976 restricts the harvest rate on each national forest to a quantity which can be removed from each forest annually in perpetuity on a sustained-yield basis. This policy is often termed the "non-declining flow" or "non-declining even flow" policy. The policy is criticized by many because it results in long retension periods for old growth timber. Because old growth has very low growth rates and because associated mortality is large in volume

and widely scattered in area (so that it is generally uneconomic to salvage most of it) the policy is seen by some as wasteful especially when timber demand is high and increasing. The purpose of the policy is to ensure that future generations are provided with a sufficient timber resource. Under the policy they will be able to cut at least as much timber as the present generation.

The policy is basically a planning tool. The Forest Service considers a variety of factors and uses a linear programming model to develop these plans. For purposes of explanation the most basic considerations might be described as follows: The timber resource is inventoried and the maximum possible cutting rate that can be maintained in perpetuity is determined. The determined level is called a "potential yield" or "allowable cut" and is utilized for a ten year planning period. After a new inventory is obtained the entire process can be repeated and a revised allowable cut will be determined. The new cut may differ because the actual cut or growth may not have been that assumed in the plan, some stands may have been destroyed by insects or fire, utilization standards may have changed, etc.

Attempts to develop alternatives to this policy which overcome some of its shortcomings while at the same time providing protection to future generations are worthwhile. One example of another approach is provided here. It recognizes the interrelationships of various forest ownerships as they affect timber supply. Because private land in TPZ's has a declared public purpose of timber production it is reasonable to consider this land in the base for allowable cut determinations. The approach examined simply assumes that the even flow calculation should be based on these lands as well as the national forests.

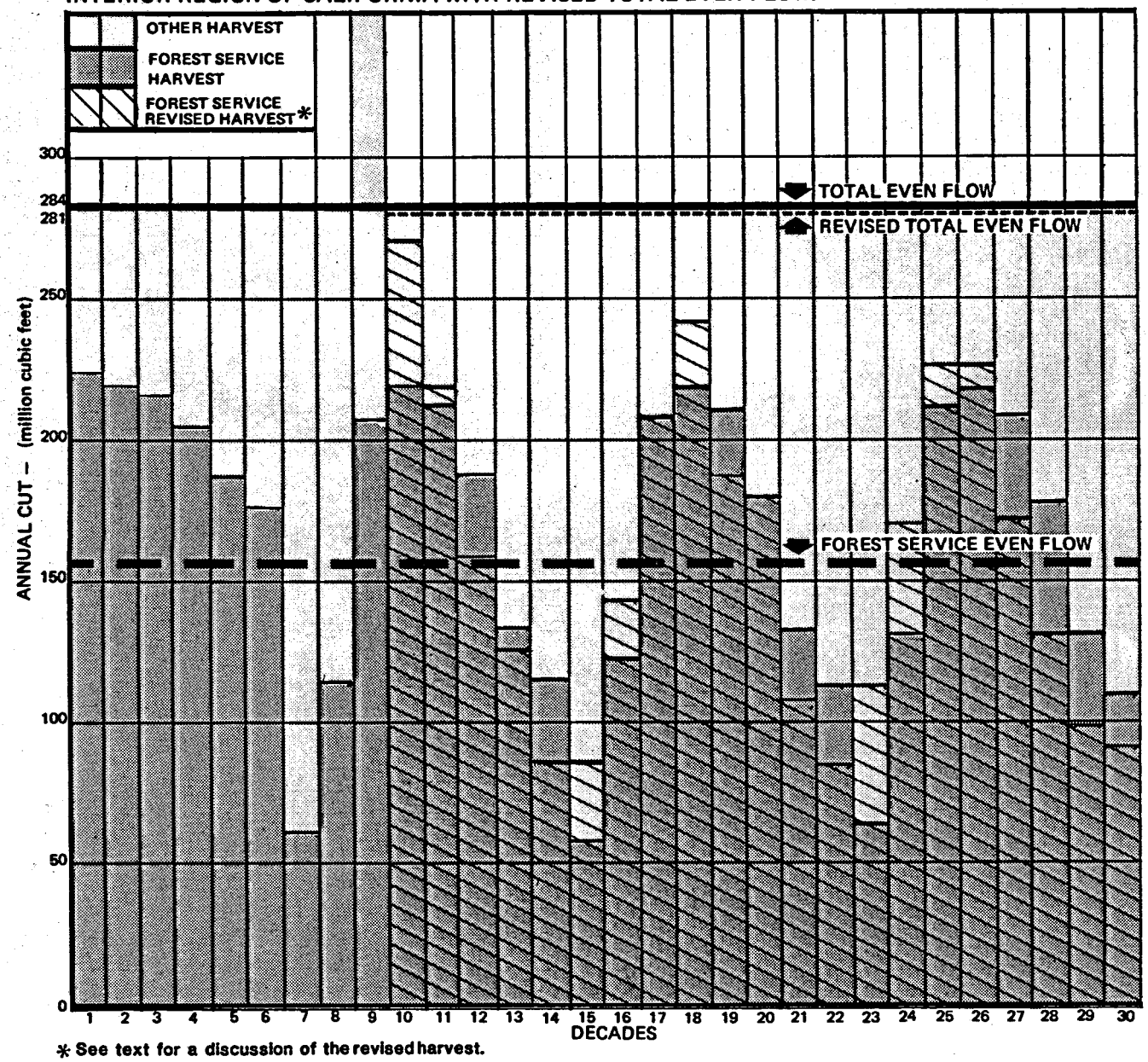
The example used to illustrate the effect of such a policy change is the Northern Interior Region. Data for the analysis were taken from Bolsinger (1976). It was assumed that existing stands not cut during the next 70 years and those planted in the future will grow according to a yield function having a maximum annual growth rate of 64 cubic feet/acre/year at age 80. This rate is approximately 20 percent below what would be appropriate for fully stocked natural stands in this region but is 56 percent above current growth rates. Stands cut during the next 70 years are assumed to follow a yield function which approximates current volumes per acre (as a smoothed function of age). National forest land available for timber production in this region was approximated as 75 percent of the commercial stocked national forest land. 85 percent of the total of other public, forest industry, and other private lands were used to represent the non Forest Service timber base - primarily land in TPZ's.

The maximum non-declining flow for the national forest alone under these assumptions would be 156 million cubic feet/year. (Combined potential yield figures from each of the national forests in proportion to their area in these northern interior counties would produce the same estimated yield.) The present harvest for the entire region under the current Forest Service policy is shown in Figure A-1 of the Assessment Chapter at about 240 million cubic feet per year. It will probably decline over the next three or four decades to about 220 million, the sustainable yield estimated by the Forest Survey (Bolsinger 1976). However, if all lands were included in the allowable cut determination process the flow would be 284 million. This figure is 31 percent above the level projected by the Forest Survey. Thus coordination of public and private harvest scheduling could produce a significantly greater allowable cut for the region.

The planned total harvest would be constant at 284 million cubic feet per

FIGURE 10-4

PROJECTED FOREST SERVICE AND OTHER HARVEST FOR THE NORTHERN INTERIOR REGION OF CALIFORNIA WITH REVISED TOTAL EVEN FLOW.

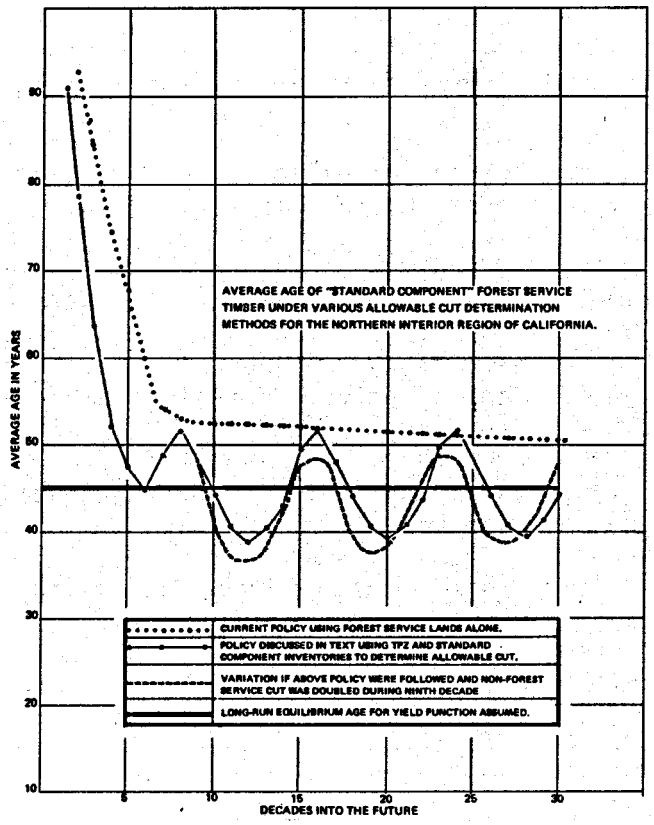


* See text for a discussion of the revised harvest.

SOURCE: CDF

year under the alternative policy described here. Figure 10-4 shows the fluctuations in Forest Service and other harvests which would occur because the appropriate stands in which to make cuts would shift year by year between ownerships. Under the existing policy the planned national forest cut would be constant at 156 million and any fluctuation would occur only in the private harvest rate. Because of the present age class distribution of private forests a total cut of 284 could not be maintained without more heavily utilizing public old growth initially.

A useful measure of forest stock is average age (Allison 1978). Figure 10-5 illustrates how the average age of this timber on the national forests would be-



SOURCE: CDF

have under such constant cutting rates. The dotted line represents the current policy, the solid line the alternative policy. The bold horizontal line shows the long run age to which both are trending. (This age depends on the particular yield function assumed.)

One question raised by a consideration of such a policy alternative is whether it is necessary to control private harvest rates to successfully implement the approach. In other words, what would happen if the private cut did not match the expectations inherent in a joint non declining flow determination?

The cross-hatching in Figure 10-4 indicates a revision that would result if during the ninth decade the non-Forest Service cut were doubled. The resulting recalculation of the total allowable cut would show a one percent reduction from 284 to 281 million from the tenth decade onward. The total forest under the revision would still tend toward the same long run average age.

The relative magnitude of the change in private cut (100 percent) and the resultant change in total cut (one percent), coupled with the fact that increases as well as decreases in the public and private cuts can occur; clearly suggest that the public interest in future timber supply could be adequately protected by such a policy. Control of private lands would not be necessary because of the large area in public ownership.

Thus consideration of private inventories in the national forest harvest determination process appears to be not only a reasonable option, but also an opportunity for realizing increased harvest and growth. Furthermore, this change in policy could avert the projected decline in timber production and the associated decline in jobs and increases in lumber imports.

IMPROVED UTILIZATION

Additional increases in timber supplies can be made through improved timber utilization. This includes more efficient timber harvesting, increased recovery from lumber and wood product processing and programs which provide technical assistance to landowners. CDF in cooperation with the Forest Service conducts felling and bucking and sawmill improvement studies throughout the State in an effort to extend timber supplies by advising loggers and mill owners and operators how to improve practices.

Past studies have shown that 2 to 16 percent of the potential wood volume is lost through improper felling and bucking practices. Statewide, the potential for improvement averages 7 percent. Losses result from excessive stump height, logs bucked too short or too long and merchantable volume left either

as bucked out stem sections or in the tops.

Practically every mill can increase its capability of converting logs to lumber by improving manufacturing conditions in the sawing system. Greater lumber recovery can be realized by using narrow saw kerfs, salvaging shorter and narrower lumber, utilizing available equipment and programs that help operators make better sawing decisions and running well-managed mills (Forest Service 1975). Statewide the average potential increase in recovery is 9 percent. Lumber drying which uses 70-75 percent of the energy consumed in lumber production, has opportunities for improved utilization (3 percent), and energy conservation. In addition to these improvements, new pulp and paper technology can substantially extend timber supplies.

CDF encourages landowners to develop land management plans and to salvage accessible timber killed by insects, diseases and fires. Technical assistance and information on where to obtain timber sale analysis and administration is also provided by CDF to improve utilization of the timber resource.

RESEARCH NEEDS

Research needs have been discussed throughout this chapter. Significant areas in which research is needed are summarized below:

Develop information on the long-run costs and growth response to intensive forest management practices by site quality and forest type.

Appraise environmental impacts of timber harvesting (including reactions of individual resources to specific harvesting methods and cumulative impacts of several harvests on a watershed over time) and develop effective techniques to reduce adverse consequences.

Develop alternative brush control measures for use in reforestation and operational pest suppression techniques.

Assess current Statewide timber volume, growth rates and age class distributions by ownership and county, and determine size, location (and ownership objectives) of private forest land holdings.

Develop utilization techniques and markets for hardwoods.

Continue research into alternative federal harvesting policies and their effects on the environment, cost tradeoffs and multiple uses of public lands.

CONCLUSIONS

In concluding, the following generalizations that might be drawn from this chapter are summarized:

The demand for lumber and wood products will increase, but Statewide harvests will decline for the next 20 years as the remaining private old-growth inventories are harvested. This will result in tripling of timber prices by 2030, serious impacts on local economies and increased imports.

2030 levels of consumption and imports of paper and allied products may be approximately four times the 1976 level due to increases in population and per capita consumption. However, trends in forest products consumption could be modified by wood and paper conservation and recycling efforts.

Planting understocked areas, replacing hardwoods with conifers on sites that

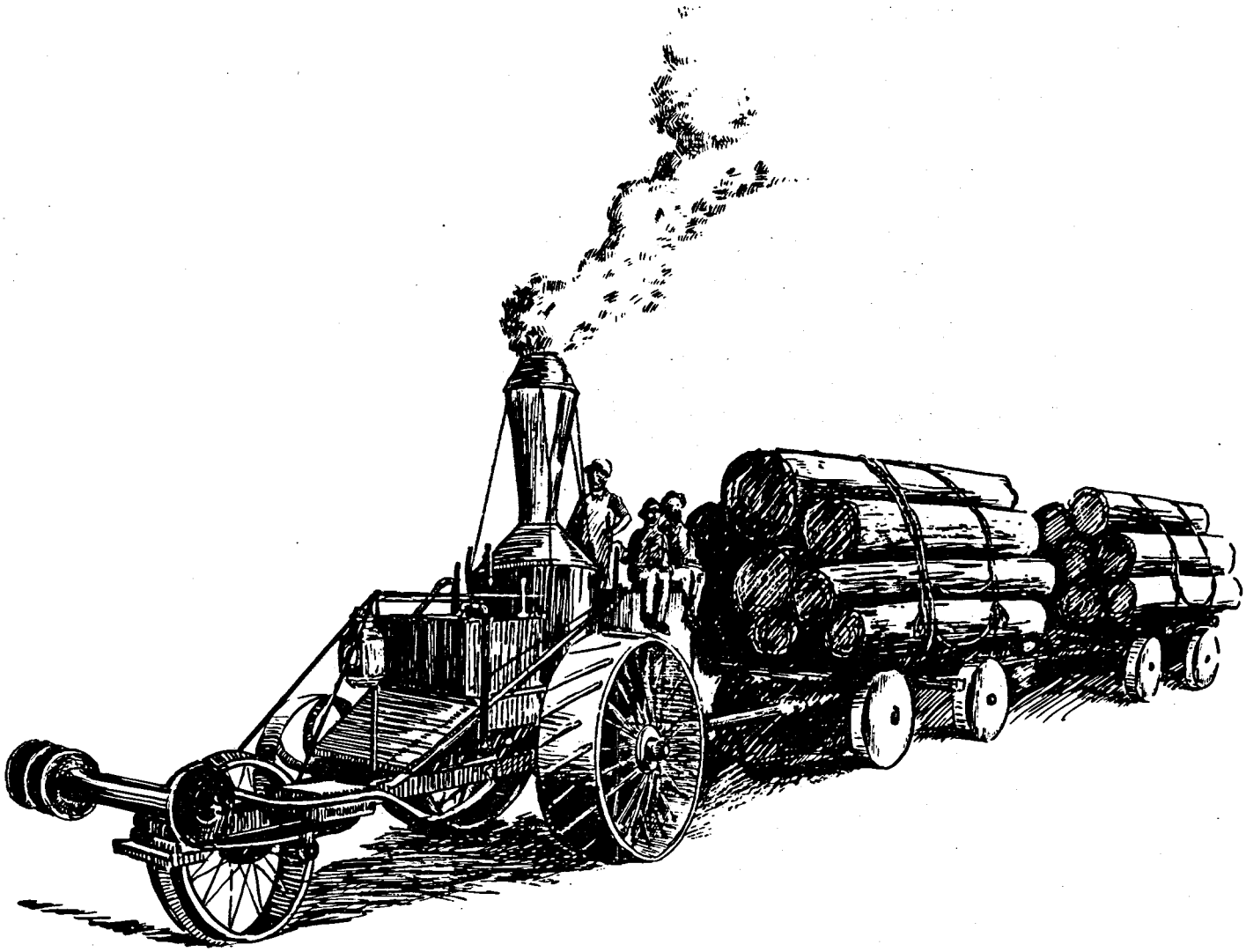
once grew conifers and converting low-growth sawtimber stands to young-growth could double timber growth in California. Concentrating efforts on medium and high sites would yield most of this increased growth, show the greatest economic return and reduce environmental impacts by disturbing less area.

Use of genetically improved seedlings could substantially improve growth on areas planted.

Yields from increased investment will do little to mitigate the supply decline between now and 2000; such yields will have a substantial beneficial impact on timber supplies during the second quarter of the next century. Revised Forest Service harvesting schedules could avert harvest reductions projected for the next 20 years. However, significant increases in harvests would require fundamental changes in the present non-declining even flow policy.

Additional increases in timber supplies can result from improved utilization. This includes more efficient timber harvesting, increased recovery from wood processing, and programs which provide technical assistance to landowners.

The average potential productivity of California's commercial forest land (16.3 million acres) is nearly 30 percent higher than the national average. One-half to two-thirds of the timberland is of sufficient quality and in ownerships such that it can realistically be considered as the base for moderately intensive forest management.



CHAPTER ELEVEN

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INTRODUCTION

Wood has always been used for fuel. Americans satisfied 90 percent of their energy requirements in 1850 by burning wood for heating and cooking. Even now, less technologically developed countries still rely on firewood for heating and cooking. This results in roughly half of the world's wood production being burned for fuel.

If California were considered as if it were a nation, it would rank ninth in its total energy consumption (Distributed Energy Systems 1978). Thus, California depends upon abundant energy, 90 percent of which is provided by crude oil and natural gas. These fossil fuels are used for transportation, they furnish raw materials for agriculture and business, and service most of the State's need for electricity and space and water heating. Hydroelectric, geothermal, and nuclear power at present make a relatively smaller contribution to annual supplies.

California's demand for oil is expected to increase, while at the same time the State's oil production has dropped 50 percent since 1960 and is expected to decline further (California Energy Commission Biennial Report 1979). As these trends continue, California will be forced to compete with oil-poor regions for whatever oil may be available on the unstable world market.

Restrictions due to concern over the use of more traditional alternatives to petroleum such as nuclear and hydroelectric power, coal, geothermal energy, and liquified natural gas compound the alarming projections for oil production. Coal and geothermal power plants pose air pollution problems and droughts threaten hydroelectric power production. Controversy regarding the siting of liquified natural gas (LNG) facilities has already delayed development of that energy option for California. A host of issues surrounding nuclear energy has thrown this alternative into question.

California must explore all feasible alternatives for securing energy resources that are free from some of the complex problems facing the use of traditional alternative energy sources. This chapter describes the technical and economic feasibility of producing energy from wood in California.

WOOD ENERGY TECHNOLOGIES IN CALIFORNIA

Techniques that combust wood directly and also those that convert wood to other solid, liquid, and gaseous fuels use basic thermal and biological processes. These technologies range from simple methods such as wood stoves and other combustion techniques to more complicated processes such as digestion and fermentation, many of which are still in various stages of development. All techniques produce usable heat or fuel by accelerating the natural deterioration processes that occur in any organic material over time.

DIRECT COMBUSTION TECHNOLOGY

The simplest and most efficient application of wood fuel is to burn it directly in readily available furnaces and boilers to produce steam. A power plant using wood fuel with a 50 percent moisture content will have a boiler efficiency from 60 to 70 percent. Power plants that use conventional fossil fuels such as oil, coal or gas have

boiler efficiencies between 80 and 90 percent.

The steam, in turn, can be used directly for heat or motion, or indirectly to generate electricity through steam turbine-generators. The overall direct combustion efficiency of wood used to produce electricity is from 20 to 30 percent, depending upon moisture content and the particular design of the energy facility. Since fossil-fueled power generating facilities are typically larger and have greater boiler efficiencies, they can produce electricity at an overall efficiency of from 35 to 40 percent.

Wood and bark fuels have negligible sulfur content but a small ash/sand/dirt content. Directly combusting them produces mostly particulate air emissions, but also produces minimal amounts of CO, NO_x and hydrocarbons. Thus direct combustion boiler stacks are usually equipped with some sort of "scrubbing" device to control particulate emissions.

In a conventional power plant producing steam or electricity, much of the heat energy generated by the direct combustion equipment is necessarily wasted to the environment. A more efficient power generating system that utilizes this waste heat is known as cogeneration, or the production of electricity in conjunction with process steam or heat. Because a cogeneration system uses the normally wasted heat, it is inherently more fuel efficient than generating electricity and steam/heat separately. Cogeneration has usually been applied in industries that require both process steam and electrical power. The forest products industry has demonstrated the technical feasibility of wood combustion and cogeneration for many years. With the increasing cost of electricity, industrial and commercial users who utilize only process steam have reached the point where it is economical for them to consider investing in their own power generation. Thus these higher costs have spurred a renewed interest in cogeneration.

WOOD ENERGY FACILITIES IN CALIFORNIA

In California, 58 forest products firms in 24 counties are using wood waste-fired boilers to produce steam and to cogenerate electricity.

Table 11-1 shows that a total of 123.5 megawatts (MW) of installed electrical generating capacity currently exists within the forest products industry in California.

Table 11-2 shows additional wood energy facilities currently planned or proposed by the forest products industry, electric utilities and State government. If their current plans are realized in the future, 370 megawatts of capacity could be added by 2000. This would result in a cumulative total of 490 MW of installed capacity by 2000.

POSSIBLE FUTURE WOOD ENERGY TECHNOLOGIES

Pyrolysis: The chemical decomposition of wood brought about by the action of heat in the absence of oxygen to produce chars and oil, as well as synthesis gas which in turn can be converted into methanol, ammonia, hydrogen and synthetic gasoline.

Gasification: A type of pyrolysis involving the conversion of wood to synthetic gas in an oxygen, or air-fed, atmosphere.

Fermentation: The biochemical conversion of wood into alcohol in the absence of oxygen. Some alcohols, mainly ethanol and methanol, can be blended with gasoline which can be used directly in existing internal combustion engines.

Hybrid Geothermal: A system designed to use low temperature geothermal fluids to dry logged wood material and preheat boiler water. This boiler water is then

TABLE 11-1

EXISTING WOOD FUELED BOILERS IN CALIFORNIA IN 1978 (1)

RESOURCE AREA	STEAM GENERATING CAPACITY (10^3 TONS/YR.)	WOOD WASTE USED (10^3 TONS/YR.)	ELEC. GENERATING CAPACITY (MW)
Northern Interior	1151.2	868.2	22
North Coast	3857.3	837.3	98.5
Sacramento	1592.0	716.3	3
San Joaquin	384.0	184.9	Ø
	6984.5	2606.7	123.5

(1) Compiled by the Solid Waste Management Board, Energy Commission and the Department of Forestry.

superheated in a wood-burning boiler to produce electricity.

Pelletization: A densifying process to produce wood pellets ranging from the size of animal feed to the size of Presto Logs. These pellets can be used in any of the processes described above and do not necessarily constitute a new technology since the process has been used since the 1920's. Also, pelletization can reduce shipping costs and decrease handling since the pellets are approximately twice as dense as wood chips.

AVAILABILITY AND ENERGY POTENTIAL OF WOOD RESIDUES

Wood "residues" are basically the leftovers from the primary processing of logs by forest products mills as well as from logging or forest management operations. Wood residues are also generated from urban areas and agricultural lands. Furthermore, noncommercial forest lands as well as chaparral and other brush covered lands can be viewed as potential sources of wood fiber for energy production.

This section defines and quantifies five wood residue categories:

(1) mill residues;
(2) forest residues;
(3) noncommercial softwoods and hardwoods;
(4) chaparral
(5) "Other" comprised of orchard prunings and urban residues.

PRESENT AND FUTURE AVAILABILITY

The present and future availability of wood residues generated annually are shown in Table 11-3.

The estimates and projections shown in Table 11-3 are based upon the following general assumptions:

We can assume a "business-as-usual" scenario; i.e., the forest

TABLE 11-2

CURRENTLY PLANNED OR PROPOSED WOOD-FIRED ELECTRICAL CAPACITY ADDITIONS
1985 and 2000

	INSTALLED MEGAWATT CAPACITY, 1978	PLANNED OR PROPOSED CAPACITY ADDITIONS	
		1985	2000
Forestry Products Industry(1)	123.5 MW	45 MW	47 MW
Utility(2), including Joint Industry Projects	Ø	115 MW	110 MW
Government(3)	Ø	50 MW	Ø
Sub Total	123.5 MW	210 MW	157 MW
Cumulative Total	123.5 MW	333.5 MW	490.5 MW

(1) The 1978 mill survey data used for Table 11-1 also includes proposed projects. These projects were classified into a particular year category based on estimates of which additions would be operational by that particular period.

(2) Based on data from PG&E's March 1979 Status Report and telephone contacts with Southern California Edison and the Sacramento Municipal Utility District.

(3) California Department of Water Resources.

products industry and the electric utilities will continue to operate under present conditions, with government intervention at a minimum.

Wood residues "potentially available" for energy are defined as those amounts that are:

* Physically attainable and collectable, but not including biomass such as twigs and leaves.

* Economically available at competitive prices.

The percentage of the gross amounts potentially available for energy will increase over time due to:

* The increasing price of conventional fuels.

* Technological innovation and improvements in wood residue collection and processing systems which will increase the levels of economically available residues. It is assumed that major developments will occur between 1985 and 2000.

The gross figures of residues for all categories project annual total production. They do not reflect any backlog of residues from previous logging and/or milling activities.

A more detailed explanation of the specific assumptions made for each residue category is given in Appendix Item X.

TABLE 11-3

ANNUAL AVAILABILITY AND ENERGY POTENTIAL OF WOOD RESIDUES IN CALIFORNIA

1978 to 2030

	1978			1985			2000			2030		
	GROSS AVAILABLE ANNUALLY 10^6 DRY TONS	ACTUALLY UTILIZED FOR ENERGY 10^6 DRY TONS	ACTUAL INSTALLED MEGAWATT CAPACITY MWe-YR	GROSS AVAILABLE ANNUALLY 10^6 DRY TONS	POTENTIALLY AVAILABLE FOR ENERGY 10^6 DRY TONS	POTENTIAL INSTALLED MEGAWATT CAPACITY MWe-YR	GROSS AVAILABLE ANNUALLY 10^6 DRY TONS	POTENTIALLY AVAILABLE FOR ENERGY 10^6 DRY TONS	POTENTIAL INSTALLED MEGAWATT CAPACITY MWe-YR	GROSS AVAILABLE ANNUALLY 10^6 DRY TONS	POTENTIALLY AVAILABLE FOR ENERGY 10^6 DRY TONS	POTENTIAL INSTALLED MEGAWATT CAPACITY MWe-YR
MILL RESIDUES	6.7	2.6	123.5	6.3	2.5	299	5.8	2.5	299	5.8	2.7	322
FOREST RESIDUES												
• SOFTWOOD SLASH	5.7	ø	ø	5.6	.56	67	5.4	1.5	179	5.7	2.1	251
• HARDWOOD SLASH	1.9	ø	ø	2.0	.20	24	2.1	.59	70.	2.4	.86	103
• PRE-COMMERCIAL THINNINGS	.5	ø	ø FOR	1.6	.19	23	2.8	.67	80	1.4	.42	50
• DEAD and DYING	2.4	ø	ø	1.5	.03	4	1.5	.11	13	1.5	.27	32
Subtotal	10.5	ø	ø	10.7	.98	118	11.8	2.87	342	11.0	3.65	436
NON COMMERCIAL												
• SOFTWOODS	1.0	ø	ø	1.0	.01	1	1.0	.02	2	1.0	.05	6
• HARDWOODS	1.6	ø	ø	1.6	.02	2	1.6	.03	4	1.6	.08	10
Subtotal	2.6	ø	ø	2.6	.03	3	2.6	.05	6	2.6	.13	16
CHAPARRAL	7.6	ø	ø	7.6	.38	45	7.6	1.1	131	7.6	1.5	179
OTHER												
• URBAN RESIDUES	1.7	ø	ø	2.0	.06	7	2.0	.16	19	2.0	.34	41
• ORCHARD PRUNINGS	2.2	ø	ø	2.4	.24	29	2.8	.98	117	3.5	1.9	227
Subtotal	3.9	ø	ø	4.4	.30	36	4.8	1.14	136	5.5	2.24	268
TOTALS	31.3	2.6	123.5	31.6	4.19	501	32.6	7.66	914	32.5	10.2	1221

Mill Residues

Mill residues are generated on-site by sawmills, and plywood and veneer mills in the production of finished wood products. Actually, about half of the volume of a log ends up as processed wood product -- the rest becomes mill residue in the form of bark, edgings, shavings, trim, sander dust and sawdust. If a forest products mill does not have sufficient uses and/or markets for its residues, then it has an expensive disposal problem. Past and present disposal methods of mill residues include incineration or burial in costly landfills; these are methods which pose safety and environmental problems.

Consequently, the forest products industry has developed new, economical end-uses for wood residues to solve the disposal problem. These new end-uses, which compete for the available supply of wood residues, include particleboard, hardboard, insulation board, pulp chips for paper, and hogged fuel for energy production. Wood residues can also be converted to chemical derivatives, charcoal, decorative bark for landscaping, mulch for soil conditioning, litter and bedding for animals, manufactured fireplace logs, and firewood for home heating.

Mill residues now are the major source of supply for these competing uses. Of the mill residues generated in 1976, 43 percent went to the board and pulp industry, 27 percent was used as boiler fuel to produce steam and/or generate electricity for mill operations, 12 percent was used for miscellaneous purposes, and 18 percent was unused (Hiserote and Howard 1978; Lucarelli 1978). For 1976, Table X-1 in Appendix Item X shows used mill residues by type and use, and Tables X-2 and X-3 in the same Appendix show unused mill residues by type and county/subregion. Estimates of the annual gross quantities of mill residues for 1978 as well as for future year periods are shown in Table 11-3.

Since most large forest products processing facilities require both process steam and electricity for operation, rapidly increasing energy prices have made it attractive for many mills to begin to use more mill residues as a boiler fuel. In fact, pulp and board mills in the three Pacific Coast States obtain 43 percent of their energy consumption from spent pulping liquors and wood and bark chips (Bergvall, et al. 1978). The forest products industry can probably best utilize residues for energy production because these plants have equipment and capabilities for transporting and handling wood. They also can use residues at many locations and avoid the additional transportation costs needed to concentrate residues at central points. Finally, this industry can use residues as raw material for other wood products or fuel.

Forest Residues

Forest residues are comprised of logging residues, pre-commercial thinnings, and dead and/or dying material.

Logging residues are any material that is left as a result of harvesting operations. This "slash" includes large branches, tops, chunks, and cull materials which are nonmerchantable. Table X-4 in Appendix Item X shows the estimated amounts of softwood slash generated in 1976 by county and subregion. Estimates of the annual gross quantities of both softwood and hardwood slash for 1978 and future year periods are shown in Table 11-3.

The quality and quantity of forest residues are highly variable from site to site. They depend on a wide range of factors such as: tree species and size; topography, or slope of the logging site; logging method and type of harvesting equipment used; understory vegetation and volume of down material on the site prior to harvesting; harvesting contract specifications; time of year harvesting occurs; and weather condi-

tions. Forest residues are dispersed and are usually located at some distance from the point of potential use, so that the major constraint on utilizing these residues is the high cost of collection, preprocessing and transportation. Therefore, virtually none of this material is currently used except for salvage and firewood.

This category also includes the residues generated from forest management operations. The CDF estimates that more than 30 percent of the State's commercial timberland, or over five million acres, are in need of replanting and other stand improvements on both public and private forest land (Forest Improvement Program, CDF 1978). These potentially productive timberlands could support commercial sawtimber species if replanted and managed. This intensive management would include: reforestation of logged areas; site preparation for such reforestation; pre-commercial thinnings; and removal of dead and dying trees.

Utilizing forest residues for energy, or any other purpose, accompanies improved forest management practices, which strive to attain the highest valued wood products while at the same time maintaining the forest ecosystem. The effects of producing and collecting forest residues for any use as an aspect of good forest management can:

Provide a market value for wood and thus defray some of the costs of reforestation and other improved silvicultural practices.

Improve fire control and fuel management, as well as reduce air pollution from hazard reduction burning and forest fires.

Reduce the threat of insects and disease.

Optimize forest growth, by decreasing competition between the remaining trees for soil nutrients, light and water.

Improve wildlife habitat. Adequate brush and dead trees should be left in place to provide dens and nests for birds and animals (see Chapter Six, "Fish and Wildlife Resources").

Cause environmental impacts such as reduced vegetation cover, soil compaction and erosion, water runoff and stream sedimentation, and disturbed nutrient recycling.

Noncommercial Forest Lands

This category includes noncommercial softwoods and hardwoods, or stands that are not productive enough to be considered commercially harvestable. These stands are currently not used for any purpose other than the limited amount of hardwood that is cut and sold by individual firewood operators.

Noncommercial softwood stands include such species as juniper, pinyon and digger pine, as well as the poorer stands of commercial species such as ponderosa pine and Douglas-fir. Noncommercial hardwood stands include such species as tan oak, alder and madrone. Additionally, an oak woodland exists within California in the low-lying valleys and in the higher foothills of the mountains.

Current estimates and future projections of the annual gross quantities of noncommerical wood residues are shown in Table 11-3.

There are other potential residues not specifically obtained from forest land that nevertheless represent a significant source of wood for energy.

Chaparral

In southern California today there are millions of acres of chaparral and other brushland. Land clearing for firebreaks

and the conversion of chaparral covered lands to agricultural and other uses may provide a potential source of wood residue. However, its utilization depends upon the development of equipment designed specifically for collecting chaparral and processing it into a usable form. Current estimates and future projections of the annual gross quantities of chaparral residue are shown in Table 11-3.

Other

Orchard prunings are generated from California's nut and fruit orchards. These acreages are usually pruned every winter and this results in residues of limbs, branches, trunks and sometimes whole trees. Today, unused prunings are burned in the field since pests will infest the prunings. Urban residues include waste material from tree-trimming companies, demolition wastes, tree maintenance prunings, construction wastes and pallets. Today, some of the material is recycled and utilized but most of the unused portions are disposed of in landfills. Current estimates and future projections of the annual gross amounts of prunings and urban residues are shown in Table 11-3.

ENERGY PLANTATIONS

Another potentially reliable source of wood fuel is the silvicultural energy plantation -- the planting of relatively fast growing species of trees for short-rotation harvesting to produce wood fiber for use as a fuel source. Currently in California, wood energy plantations are in the feasibility and development stage, with small experimental plots being established to determine the precise silvicultural requirements to produce a maximum amount of wood fiber in the shortest period of time.

While some native species have been considered for use as energy plantation stock, most attention has been directed toward the eucalyptus. These introduced species have thrived in California and are presently managed for windbreaks or landscaping.

The development of energy plantations will not be a near-term source of significant wood energy supplies because of a reluctance to commit land and water resources to this relatively long-term, exclusive use. However, the trend for further development of wood energy technologies may create a favorable climate for the more extensive development of energy plantations as a reliable fuel source.

ENERGY POTENTIAL OF WOOD RESIDUES

Also estimated in Table 11-3 were those residue amounts that would be potentially available for energy. Since energy production is just one of many competing uses for wood, the applicable competing uses for each residue category were identified and an estimate of the percentage of the gross quantities going to that end use quantified. Then by applying the specific energy-use percentages estimated for each category (see Appendix Item X) to the associated gross quantities, the amounts available for energy were identified. Once the amounts of residue potentially available for energy were determined, they were converted into potential megawatt-years of cogenerated electrical capacity (see Appendix Item X for specific assumptions).

Comparisons

The theoretical megawatt-years of full-capacity cogeneration plants of Table 11-3 can be compared with the cumulative installed wood-fired megawatt capacity proposed for the future in Table 11-2.

The megawatt-years shown in Table 11-3 reflect the "outside potential" megawatt capacity (at any point in time) produced by combusting the indicated annual

amount of wood fuel in a cogeneration facility with a 100 percent capacity factor. The additional and cumulative installed megawatt capacities shown in Table 11-2 reflect the future plans of the forest products industry, utilities and State government with respect to wood energy projects.

For any particular year period, the difference between the total megawatt-years in Table 11-3 and the proposed cumulative installed megawatt capacities in Table 11-2 represents the potential of utilizing wood residues to produce energy that could be realized with the proper action by government, industry, and the utilities.

By using a renewable and domestic resource such as wood residue for energy, the State's (and industry's) consumption of petroleum can be reduced. This will not only conserve vital oil reserves but will also present the forest products industry with a way to become totally energy self-sufficient.

To show the potential benefits of substituting wood fuel for low sulfur fuel oil typically used by California utilities to generate electricity, some general assumptions must first be made. Assume that a typical wood-fired cogeneration plant operates at 21 percent overall efficiency and at 85 percent capacity, and uses wood fuel with a heating value of 8500 BTUs per dry pound. If this plant burns 7100 dry tons of wood to produce one megawatt-year, 11,700 barrels of fuel oil (at 6.2 million BTUs per barrel) could be conserved that would have been used to produce the same megawatt-year by an oil-fired plant operating at 35 percent efficiency and at 85 percent capacity.

From Table 11-2, it can be seen that if current proposals for wood-fired electrical capacity additions are realized by 1985, then approximately 333 megawatts of capacity may be installed. Using the conversion noted above, burning two and one-half million dry tons of wood annually to fuel 333 megawatts would save almost four million barrels of fuel oil per year. But, Table 11-3 shows that an estimated 417 megawatt-years of capacity may be potentially available by 1985 if only mill and forest residues are considered. If the additional 84 megawatt-years of potential capacity over and above the currently proposed 333 megawatts could be realized, an extra one million barrels of fuel oil could be saved annually. But, if the total outside potential (including all categories) of 500 megawatt-years of capacity could be installed by 1985, then the potential savings or benefits could be almost six million barrels of fuel oil per year by using three and one-half million dry tons of wood fuel annually. Furthermore, according to Department of Water Resources' figures, if one megawatt of installed capacity can service approximately 600 people, than the 500 megawatts of outside potential could service about 300,000 people annually.

FUEL COSTS

Wood fuel costs depend upon not only the heating value and moisture content of the wood used for combustion, but also on the collection and transportation costs necessary to deliver the residues to a central power plant site.

Heating Value is a measure of the heat released by directly combusting a given quantity of fuel. The typical heating value of moisture-free, or bone-dry wood ranges from 8,000 to 9,000 BTUs per pound compared to 11,000 to 14,000 BTUs per pound for coal. As shown in Table X-5 and X-6 in Appendix Item X, the BTU content of wood varies and depends upon the species and whether bark or wood chips are burned. Also, resinous wood has a greater heating value than resin-free wood. For further comparisons, Table X-7 in the same Appendix shows

heating values for conventional fossil fuels.

Moisture Content is the amount of moisture or water included with the combustible substances of wood and bark fuel. Moisture content of wood is expressed either on an ovendry (O.D.) basis or original wet weight (O.W.) basis. A comparison of O.D. and O.W. basis is shown in Figure X-1 of Appendix Item X.

Moisture reduces the heating value of wood because the energy required to evaporate it is actually lost during combustion. Therefore, moisture directly reduces power plant boiler efficiency and performance by retarding combustion and reducing the steam capacity.

Collection and Transportation Costs result from moving residues from the forest to a roadside landing for loading onto a log truck or for chipping and loading into a van for transport to a central site. This yarding, loading and hauling process is the first phase of preparing wood for use in an energy-producing power plant.

Collection and transportation costs depend on topography, stand composition, harvesting system and equipment operator efficiency, as well as the mode and distance of transportation. Table 11-4 shows the costs of yarding, loading, processing, and transporting wood residues 40 to 50 miles to a central conversion point. While these costs were based on earlier data adjusted for inflation, nonetheless the actual costs today may be different. The earlier data were based on the utilization of modified conventional harvesting/collection equipment. Today, although some equipment prototypes have been designed specifically to harvest and collect wood for energy, this type of equipment has not yet been fully developed for commercial use.

Unyarded logging slash is the most expensive source of wood residue since its collection usually requires complete relogging of the previously harvested area. The collection cost of unyarded slash is a function of the logging equipment used, terrain, the slash yield per acre, and the size of the residue collected.

Other than complete relogging, there are two other feasible collection methods that can be used to harvest forest residues. Complete whole-tree harvesting systems have been used on a limited basis in pulpwood operations to produce pulp-quality wood chips, but could also be used to process forest residues into wood chips. Forest residues can also be recovered as part of the original logging operation. Although this method is not presently being utilized, it may represent the most efficient and possibly the most economical way to collect forest residues.

Yarded Unmerchantable Material (YUM) is another potential supply of available wood residue. The YUM is usually piled on landings and burned, but may also be considered available for any use at no cost to the potential user other than for loading and transportation. Thus YUM can be viewed as an appealing near-term source of wood for fuel. The delivered cost of YUM only includes the cost of loading and transportion to a conversion site because the collection costs are absorbed in the previous timber operation. Also, utilization of YUM reduces the air pollution problem of hazard-reduction burning.

The least expensive source of wood material is unused mill residues. If converted into boiler fuel at the mill, this material has no collection and transportation costs. Even if the mill residues have to be moved to an off-site energy facility, the haul distance will probably be shorter than for forest slash. The mill generating the residue will likely be closer to populated areas

TABLE 11-4

COSTS OF COLLECTING AND TRANSPORTING WOOD RESIDUES TO AN ENERGY CONVERSION SITE (1)

RESIDUE TYPE	DELIVERED COST (1978 $ PER DRY TON)
UNYARDED SLASH (2)	
Complete Relogging (3)	$37 - $54
Complete Whole Tree Harvest (4)	$27 - $37
As part of Sawlog Operation (5)	$21 - $33
YUM (6)	$11 - $14
MILL RESIDUE (6)	$ Ø - $14

(1) Assumes a 40 to 50 mile hauling distance when residues are transported.

(2) Assumes a minimum collection size of four inches in diameter and four feet in length.

NOTE: The following referenced costs were based upon sources using older data ('73, '74, '75), and were adjusted to 1978 dollars using a Crown-Zellerbach timber harvesting cost index developed for the Pacific Northwest.

(3) .$37 (CDF, 1978)
.$41 (PNW Exp. Station, 1974, adopted by CDF, 1978)
.$43 (State of Washington, 1978)
.$54 (Johnson, University of Idaho, 1978)

(4) .$27 (State of Washington, 1978)
.$37 (Johnson, 1978)

(5) .$21 (State of Washington, 1978)
.$33 (Johnson, 1978)

(6) (Estimated by Lucarelli, CDF, 1978)

and power plant facilities. Also, if the unused residue represents a disposal problem to the mill, the actual cost may be negative to a potential user, i.e., the mill will pay for disposal of the residue.

FUEL COSTS COMPARISON

To put wood fuel costs in perspective, a comparison can be made between wood fuel and other conventional fossil fuels delivered to a conversion point and burned in a boiler to produce steam. When comparing different fuels, the costs are usually expressed in equivalent heating value terms. This can be represented as the ratio of dollar cost per million (10^6) BTUs.

For example, from Table X-5, X-6 and X-7 in Appendix Item X, fuel oil has a heating value of about 19,000 BTUs per pound whereas wood has less than half this value at about 8,500 BTUs per dry pound. The heating value of green wood with 50 percent moisture content (O.W.) drops to 4,250 BTUs per pound when allowing for the heat required to vaporize the moisture. Assuming that wood has a heating value of 8500 BTUs per dry pound, a ton of dry wood is equivalent to about 2.7 barrels of fuel oil (at 6.2 x 10^6 BTUs per barrel).

Since wood is heavier and bulkier than fuel oil for an equivalent amount of heat energy, transportation, handling and storage costs are usually higher for wood fuel than fuel oil.

The cost comparison in Table 11-5 shows delivered costs of conventional fuels consumed by utilities and large industrial users in northern California, together with the delivered wood costs from Table 11-4. To consistently compare these different fuel costs requires an adjustment of the fuel heating value to reflect the boiler efficiency corresponding to each fuel type. The adjusted costs then reflect the efficiency of the fuel to produce steam from a boiler.

POWER GENERATION COSTS

It is incomplete to consider only the above fuel cost comparison; a power generation cost comparison is needed to determine the cost competiveness of using wood to produce electrical power. The power generation costs for a wood-fired power plant are a function of the plant's size, generating equipment, overall thermal efficiency, and the type of fuel used. This section considers three different power generating system arrangements that use wood as fuel.

First, a wood-fired cogeneration system can be owned and operated by private industry to satisfy their own process steam/heat requirements as well as produce electricity for their own use or sale. Today, a few forest products mills cogenerate process steam and electricity efficiently and economically using mill residues (see Table 11-1). Thus an actual case history is included in this section describing an existing wood-fired cogeneration facility operated by a large forest products firm in northern California.

Also, an electric utility can own and operate a wood-fired cogeneration system in a joint venture with private industry. This system arrangement can produce reliable electricity for the utility's own grid and also supply process steam to industry. A utility can also own and operate a wood-fired power plant that produces electricity only. Although such systems do not yet exist in California, similar generating system arrangements do exist in Oregon and are operated by the Eugene Water and Electric Board (Hunt & Brown, E.W.E.B. 1977). This section includes a theoretical analysis that compares the costs of conventional electricity-producing technologies used by utilities with the estimated costs of producing electricity

TABLE 11-5

DELIVERED FUEL COSTS

FUEL TYPE	BOILER EFFICIENCY(1)	DELIVERED COSTS(2) (1978 $ per 10^6 BTUS)
CONVENTIONAL FUELS:		
#6 Fuel Oil @ 6.2 x 10^6 Btu/Bbl.	90%	$2.80(3)
Natural Gas @ 1000 Btu/Cu. Ft.	85%	$2.70
Coal @ 12,000 Btu/lb.(4)	85%	$2.05
WOOD FUELS: @ 8500 Btu/lb. (M.C. 50% O.W.)	70%	
Unyarded Forest Residues:		
Complete Relogging		$3.10 - $4.55
Complete Whole Tree Harvest		$2.25 - $3.10
As part of Sawlog Operation		$1.75 - $2.75
YUM		$ .90 - $1.20
Unused Mill Residues		0 - $1.20

(1) Average boiler efficiencies come from utility sources in northern California, and are based upon actual boiler performance.

(2) Delivered Cost:
   a) Includes any associated collection, processing, and transportation costs.
   b) Uses boiler-adjusted heating values.
   c) Uses conventional fuel costs from northern California utility sources, and wood fuel costs from Table 11-5.

(3) Oil costs include California sales or use taxes of 6 percent (or 6 1/2 percent in a BART district), while natural gas is exempt from such taxation. This tax amounts to approximately 15¢ per 10^6 Btu.

(4) This heating value is based upon the assumption that Utah coal will be delivered and used in California.

from wood-fired power plants owned by a utility.

INDUSTRY OWNED COGENERATION

For many years, the concept of cogeneration has been applied with considerable economic success in industries such as lumber, pulp and paper, chemicals, petroleum refining, and food processing. The volume of a commercial processing plant's steam requirements have the greatest impact on the feasibility of cogeneration. Since steam can only be transported for short distances the cogeneration equipment must be near the industrial plant that utilizes the process steam.

In California, the Louisiana-Pacific Corporation (L-P) has developed an extensive cogeneration facility at its Samoa plant (Taylor, Louisiana-Pacific, 1979). This large forest products complex includes both a saw and pulp mill, dry kilns, a glueboard manufacturing plant, an export dock and a small townsite of 100 homes. Since the original sawmill and townsite were built, mill waste generated on-site has been used to produce process steam and electricity for industrial operations and for the power needs of the town.

Due to higher waste disposal and power costs, L-P decided in 1976 to improve the existing facility (at that time, two hog fuel boilers, two recovery boilers, one eight MW condensing turbine, and one double extraction 20 MW turbogenerator), thus becoming more energy self-sufficient. An additional hog fuel boiler and a 20 MW condensing turbogenerator were installed, including a new fuel handling system and air pollution equipment. The total cost of this project (including emission control improvements on the two existing boilers) was $11 million or about $775 per installed kilowatt in 1976 dollars. Financing was done 100 percent from L-P assets. It required about two and one-half years from plant inception to completion.

To fuel the present system of three hog fuel boilers, two recovery boilers, and three turbogenerators, L-P utilizes its own mill waste and obtains hog fuel from two other L-P facilities and about 20 smaller mills within a range of 100 miles. Daily consumption is about 600 dry tons to actually produce 30 to 35 MW on average.

For a cogeneration power plant of this size (about 48 MW installed capacity), the operating costs are over $3 million per year (for the condensing portion of the system) with an average power generation cost (using condensed steam) of $34 per megawatt-hour, or 34 mills (one tenth of a cent) per kilowatt hour.

In 1978, the Samoa plant produced a total of about 230,000 MW-hours. All of this power was used by the plant itself except for about 35,000 MW-hours (15 percent) that was sold to the Pacific Gas and Electric Company at a gross purchase price of $20 per MW-hour (20 mills/kwh). This excess power is available because L-P originally designed significant excess capacity into its power generation system over and above its maximum requirements to allow for future plant expansion.

The L-P plant is both a supplier and a consumer of power. The plant sells excess power to the Pacific Gas and Electric Company over 95 percent of the time. The rest of the time the plant buys power from PG&E when a mill and/or boiler is shut down due to maintenance or other problems. For the approximately 780 MW-hours purchased from PG&E in 1978, the plant had to pay standby charges, as well as demand and energy charges.

COMPARATIVE POWER GENERATION COSTS

The following analysis estimates the installed capital costs, the fixed annual costs, operating and maintenance (O&M) expenses, fuel costs and total busbar generation costs of three util-

ity-owned 45 MW wood-fired power plants. Busbar costs include the cost of producing electricity within the generating plant but exclude transmission and distribution costs. For consistency, all generating plants considered are assumed to begin commercial operation in 1985. Electrical costs are shown in mills per kilowatt hour (mills/Kwh).

This analysis considers three hypothetical 45 MW wood-fired power plants (A, B and C) centrally located within a lumber producing area. Plant A is assumed to be a utility-owned cogeneration plant that has an overall thermal efficiency of 21 percent. Plant B and C are assumed to be utility-owned power plants that produce electricity only and have overall thermal efficiencies of 25 percent. All three plants are assumed to have the same capacity factor of 80 percent. Installed capital costs for all three plants are escalated from 1978 to 1985 at a rate of 10 percent annually. The higher installed cost of Plant C is based on the assumption that additional costs can arise after construction begins that were not anticipated initially, especially since such a plant has not yet been built in California.

O&M costs and wood fuel costs are escalated from 1978 to 1985 at a rate of 10 percent annually. O&M costs are escalated at 5.9 percent from 1985 on, whereas fuel costs are escalated at 8.5 percent from 1985 on. These rates include a 5.9 percent general inflation rate and a "real" escalation rate attributed directly to the item itself, over and above the general rate of inflation.

Table 11-6 includes installed capital costs, total fixed annual charges and O&M costs for all three hypothetical wood-fired plants. Cost estimates are based on currently available, high pressure utility equipment, including emission control technology.

The cost of a power generating unit is a function of the size of the unit and its associated capital and operating costs. During past decades, generating units have increased in size and the capital and operating costs per kilowatt hour have decreased. To minimize costs, the power industry has developed larger central-generating units typically ranging from 800 to 1000 MW capacity. In contrast, the maximum commercial sized wood-fired plant is approximately 50 MW, due to localized fuel supply.

Table 11-7 shows the fuel costs for all three wood-fired power plants. The wood fuel costs (in 1978 dollars per dry ton) chosen for this analysis came from the delivered wood fuel cost ranges noted previously in Table 11-4.

Both the O&M costs in Table 11-6 and the fuel costs in Table 11-7 are "levelized." Levelization is a method that converts the total of all the actual, annually escalated costs of a power plant over its lifetime into a single, uniform cost figure. This analysis assumes that the hypothetical wood-fired plants will start operation in 1985 and operate for at least 30 years. Thus, the O&M and fuel costs are levelized over a 30 year period and given in current 1985 dollars. Since the annual fixed charge is actually a levelized cost, it can be added to the levelized O&M and fuel costs. By comparing the total levelized costs for different plants, an estimate can be made as to which alternative is cost-competitive over the assumed plant life.

Table 11-8 reflects the total busbar costs for the three 45 MW wood-fired power plants using four types of wood fuel with varying costs. These total costs can be compared to the busbar costs for three conventional power generating alternatives shown in Table 11-9 (also assumed to begin operation in 1985). The methodology used to calculate Tables 11-6 through 11-8 was the same methodology used by the California

TABLE 11-6

45 MW WOOD-FIRED POWER PLANTS
CAPITAL COSTS AND OPERATION AND MAINTENANCE COSTS

	COGENERATION PLANT A		ELECTRICITY ONLY PLANTS	
	STEAM	ELECTRICITY	PLANT B	PLANT C
1. Capital Costs: (1)				
a. $/KW (1978 dollars)	169	1013	1090	1365
b. $/KW (1985 dollars) (2)	329	1974	2124	2660
2. Capacity Factor: (3)	80%	80%	80%	80%
3. Fixed Charge Rate: (4) or Annualization Factor	18.4%	18.4%	18.4%	18.4%
4. Fixed Charges: (5) or Amortized Capital Costs (1985 $, mills/kwh)	8.6	51.8	55.8	69.8
5. Operation and Maintenance Costs: (6)				
a. Mills/Kwh (1978 dollars)	0.1	8.9	9.0	9.0
b. Mills/Kwh (1985 dollars)	0.2	17.3	17.5	17.5
c. Levelized O&M Costs (1985 $, mills/kwh)	0.4	31.7	32.1	32.1
Fixed Capital Charges and Levelized O&M Costs (1985$, mills/kwh)	9.0	83.5	87.9	101.9

1) Cost estimates based upon high-pressure utility boilers and turbine generators which can produce electricity on a more reliable basis. The installed capital costs in 1978 include: (a) direct costs of the equipment and construction, (b) indirect costs such as payroll additives and non-productive time, and (c) overhead costs such as administrative expenses and ad valorem taxes.

2) Installed capital costs for all three plants are escalated to 1985 at a rate of 10 percent annually.

3) The "capacity factor" is the percentage of electricity a power plant actually produces relative to what it would produce at full capacity at all times. Capacity factors for wood-fired power plants typically range from 70 percent to 90 percent; this analysis assumes the mid range figure.

4) The "fixed charge rate," or the "annualization factor," distributes capital costs equally over the lifetime of the plant and reflects the return on capital investments, depreciation, insurance and taxes. This analysis assumes a rate applicable to an investor-owned utility.

5) This cost is calculated using the formula:

$$\text{Fixed charge (Mills/Kwh)} = \frac{(1985\ \$/KW) \times \text{Fixed charge rate}}{8.760 \times \text{Capacity Factor}}$$

6) Assumed O&M costs for all three plants are escalated at a rate of 10 percent annually from 1978 to 1985, and at 5.9 percent from 1985 on.

TABLE 11-7

45 MW WOOD-FIRED POWER PLANT'S LEVELIZED FUEL COSTS
(IN 1985 DOLLARS, MILLS PER KILOWATT-HOUR)

	PLANT A (1)		PLANTS
	STEAM	ELECTRICITY	B & C (2)
1. DELIVERED FUEL COSTS: (3) (1978 dollars)			
a. Mill Residues:			
@ $3 per dry ton	3.0	11.2	12.2
@ $5 per dry ton	4.7	17.9	19.4
@ $7 per dry ton	7.2	25.2	27.2
@ $10 per dry ton	10.2	36.4	39.4
b. Y.U.M.			
@ $11 per dry ton	11.2	39.9	43.1
@ $14 per dry ton	14.0	50.6	54.3
c. Forest Slash-as part of sawlog operations:			
@ $21 per dry ton	21.4	76.3	82.5
@ $27 per dry ton	27.7	97.7	105.9
@ $33 per dry ton	33.4	118.9	129.1
d. Forest Slash-complete relogging:			
@ $37 per dry ton	37.9	134.1	145.3
@ $41 per dry ton	41.9	148.0	160.2
@ $43 per dry ton	44.1	155.5	168.5
@ $54 per dry ton	55.3	195.1	211.8

(1) Plant A is assumed to have a net heat rate (4) of 16,230 BTUs/Kwh with a boiler efficiency of 69 percent; wood fuel is assumed to have 50 percent moisture content (O.W.). The heat rate associated with steam production is 3,580 BTUs/Kwh and the heat rate associated with electricity production is 12,650 BTUs/Kwh. NOTE: The heat rate of steam is actually the amount of heat delivered as steam to the mill per Kwh electrical output of the power plant. Thus, although the cost of steam production is shown in mills/Kwh, it should actually be interpreted as the cost of fuel to produce steam per Kwh of electrical production.

(2) Plants B and C are both assumed to have a net heat rate (4) of 13,700 BTUs/Kwh with a boiler efficiency of 69 percent; wood fuel is assumed to have 50 percent M.C. (O.W.).

(3) Wood fuel costs for all three plants are escalated at 10 percent annually from 1978 to 1985, and at 8.5 percent from 1985 on.

(4) A Plant's net heat rate is the BTU input required to produce one kilowatt hour of electricity. This determines the plant's overall efficiency.

TABLE 11-8

45 MW WOOD-FIRED POWER PLANT'S TOTAL BUSBAR[1] GENERATION COSTS
(IN 1985 DOLLARS, MILLS PER KILOWATT-HOUR)

	COGENERATION PLANT A		ELECTRICITY ONLY PLANTS	
	STEAM	ELECTRICITY	PLANT B	PLANT C
1) FUEL TYPE AND DELIVERED COST: (1978 dollars)				
a. Mill Residues:				
@ $ 0 per dry ton	9.0	83.5	87.9	101.9
@ $ 3 per dry ton	12.0	94.7	100.1	114.1
@ $ 5 per dry ton	13.7	101.4	107.3	121.3
@ $ 7 per dry ton	16.2	108.7	115.1	129.1
@ $10 per dry ton	19.2	119.9	127.3	141.3
b. Y.U.M.:				
@ $11 per dry ton	20.2	123.4	131.0	145.0
@ $14 per dry ton	23.0	134.1	142.2	156.2
c. Forest Slash-as part of sawlog operations:				
@ $21 per dry ton	30.4	159.8	170.4	184.4
@ $27 per dry ton	36.7	181.2	193.8	207.8
@ $33 per dry ton	42.4	202.4	217.0	231.0
d. Forest Slash-complete relogging:				
@ $37 per dry ton	46.9	217.6	233.2	247.2
@ $41 per dry ton	50.9	231.5	248.1	262.1
@ $43 per dry ton	53.1	239.0	256.4	270.4
@ $54 per dry ton	64.3	278.6	299.7	313.7

(1) Busbar costs exclude transmission and distribution costs.

Energy Commission's staff to prepare the cost figures in Table 11-9.

Comparing Table 11-8 and 11-9 shows that wood-fired power plants that generate electricity using mill residues appear to be cost competitive with both coal- and oil-fired conventional plants. Although YUM and the lower cost forest slash used to generate electricity appear to be marginally cost competitive with oil-fired plants, the more expensive forest slash associated with complete relogging does not appear to be cost competitive with conventional sources at this time.

TABLE 11-9

CONVENTIONAL ELECTRICITY GENERATION:
COMPARATIVE LEVELIZED BUSBAR COSTS (1)

	COAL-FIRED (500 MW)	COMBINED CYCLE (500 MW)	OIL-FIRED (500 MW)
1) Installed Captial Costs			
a. $/KW (1977 dollars)	792	463	580
b. $/KW (1985 dollars) (2)	1698	993	1244
2) Capacity Factor	65%	70%	80%
3) Fixed Charges (3) (in 1985 $, mills/kwh)	54.9	28.0	32.7
4) Levelized O&M (in 1985 $, mills/kwh)	1.8	1.4	1.8
5) Levelized Fuel (4) (in 1985 $, mills/kwh)	60.2	130.0	133.0
**TOTALS (3,4, & 5) (in 1985 $, mills/kwh)	116.9	159.4	167.5

(1) These generic costs were taken from a California Energy Commission staff draft, "Volume I: Technical Assessment Manual - Electrical Generation - Version One," September 1979.

(2) The 1977 installed capital costs for all technologies are escalated to 1985 at a rate of 10 percent annually.

(3) The fixed charge rate is assumed to be 18.4 percent for both the coal- and oil-fired plants, and is assumed to be 17.3 percent for the combined cycle plant.

(4) Coal costs are assumed to escalate at a rate of about 10 percent annually from 1978 to 1985; at 7.2 percent from 1985 to 1990; and at 6.5 percent from 1990 to 2000. The costs of the distillate fuel oil and natural gas used in the combined cycle plant are assumed to escalate at an average rate of 8.8 percent annually. The cost of the residual fuel oil used in the oil-fired plant is assumed to escalate at an average rate of 9 percent annually.

REGULATORY AND INSTITUTIONAL CONSTRAINTS FACING WOOD ENERGY PRODUCTION

Despite the apparent benefits of cogeneration and wood energy production, its widespread use is hampered by regulatory and institutional problems. Since many problems effect both wood energy production and cogeneration similarly, these two terms will sometimes be used interchangeably. These problems are perhaps more difficult to solve since they require institutional change, coordinated governmental policies, and at times present genuine conflicts between two or more established government policies. For example, the Legislature's declared preference for cogeneration confronts State air quality efforts. The Energy Commission's efforts to promote cogeneration confront the Public Utilities Commission's efforts to protect the rate-payer and preserve utility service levels. However, these same institutional problems should be more responsive to clear policy direction and are within the direct control of the State's political bodies.

RATES

A major element of the investment decision for cogeneration is the rates offered by utility companies for purchases of electricity produced or cogenerated from wood products. In the past, purchased power rates were insufficient to generate substantial interest in investing in the necessary equipment for electricity production. Recently, there has been substantial improvement in the rates offered by utilities for the purchase of cogenerated electricity. In addition, standby charges, or the charge levied upon an industrial customer for having the capability to accept electric service in the event the cogeneration equipment requires service and is out of operation, have been dramatically reduced by all major utilities.

While utilities are offering more reasonable rates for purchased power and standby, there remains the question of what, if any, credit should be given for the capacity which is added to the system by cogenerated power. Basically, if a cogenerator is providing reliable power during peak periods, some credit for the capacity that power displaces should be offered. If there were a substantial number of wood-fired cogeneration plants, the likelihood that a certain percentage of these facilities would be operating during peak periods is increased.

The major reason for the absence of substantial capacity credits is the limited amount of electricity produced from cogeneration projects to date. Offering a substantial capacity credit will increase the attractiveness of the investment and shorten industry's payback period.

AIR QUALITY

The major air quality obstacle to cogenerated electricity is the Clean Air Act's New Source Review requirements for Best Available Control Technology and pollution "tradeoffs" in non-attainment areas (most urban areas).

New Source Review rules require any new stationary source emitting in excess of 250 pounds of NO_x per day (or other pollutants) to produce air basin tradeoffs of at least one to one. Reducing NO_x from another source by at least 250 pounds of NO_x per day causes the air basin's NO_x level to at least remain unchanged and in most cases improve since the requirement is usually more than one to one.

Cogeneration, using wood or other fuels, offers improved efficiency and improved aggregate air quality relative to separate electric process heat gener-

ation. The trade-off requirement does not recognize the aggregate improved air quality and efficiencies from cogeneration. Many cogenerators do not have the facilities to produce these trade-offs and therefore must purchase trade-offs from other industries (pay the cost of control equipment and other fees). This can be prohibitively expensive and time consuming and may cause abandonment of the project. Trade-offs, even for those industries that have facilities to produce trade-offs, may simply make the project too complicated and expensive. Those industries with trade-offs may wish to preserve them for their primary manufacturing process and those without trade-offs may not wish to incur the expense of purchasing them.

Also, the New Source Review requirements present an uncertain obstacle for cogeneration projects since the requirements change as more data is gathered and as the State's implementation plan becomes operational. These problems are compounded by the numerous agencies involved in permits for projects and the increasing belief that many projects cannot secure permits. This problem of securing the necessary permits and the uncertain nature of governmental permits tend to reinforce the belief that cogeneration projects require too much time and effort with too uncertain a result to be good investments.

INDUSTRY AND UTILITY CONCERNS

One of the major concerns for the industrial entity is the impact cogeneration will have on its manufacturing process. The manufacture of a specific product is the primary concern of the industrial entity and often the production of electricity is seen by management and plant operators alike as something which might interfere, retard, or reduce the output of the primary product. Also, industrial producers of wood-fired electricity fear regulation and classification as "utilities."

On the utility side, the stated view is that it takes the same contract negotiations, engineering, management, and general staff effort to bring a relatively small (30-40 megawatt) cogeneration or wood energy project on line as it does for a large (300-800 megawatt) conventional project.

Utilities also express a concern for the possible uncertain reliability of cogeneration facilities. Small facilities are difficult to plan for and usually cannot be included in utility resource plans, making them uncertain capacity additions. In addition, there is relatively little experience with cogeneration facilities deployed in a large number of locations and their reliability may be less than required.

Also, the issue of wheeling, i.e., the transmission of non-utility generated electricity from one point to another using utility transmission facilities, has been identified as a major constraint to the development of cogeneration. The issue is closely related to price since most utilities find themselves in a monopsonist's position and therefore control the price offered for cogenerated electricity. If the market for electric power could be more competitive, some industrial entities or the municipal utilities might be willing to pay higher prices for cogenerated power and thereby stimulate development. In order to do so, the use of existing utility transmission facilities are needed to transmit or "wheel" power from one location to another. The utility in this instance would act like a common carrier and charge a fee or tariff for the transmission of power.

The issues involved in wheeling are too complex to discuss here. They involve complicated federal-State regulations, use of utility property, effects on the utility system, rates for transmission, and possible service difficulties for existing customers.

CHAPTER TWELVE

FOREST LANDS AND THE MINERAL, FOSSIL FUELS AND GEOTHERMAL ENERGY RESOURCES

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MINERAL WEALTH

HISTORY AND IMPORTANCE

Development of California's mineral industry played an important part in the early history of the State, and it continues to play a significant role in the overall economy of the State and the Nation. California ranks third among the states in annual mineral production. It is surpassed only by Texas and Louisiana, both of which are sources of great quantities of oil and natural gas.

No other state produces such a wide variety of mineral commodities as does California, which is the source of about 40 minerals, some of which are found on forest lands. The State's mineral production was, according to the September, 1978, "California Mining Review," valued at $3,483,373,000 in 1976. In 1977 the value was set at $4,311,393,000 according to data developed by the U.S. Bureau of Mines (McWilliams, January 1979). California has the largest production in the nation of asbestos, boron, diatomite, sand and gravel, and rare-earth minerals. It is also a major source of cement, lime, natural gas, liquefied petroleum, gases, natural gas liquids, petroleum, stone, magnesium compounds, gypsum, iron, salt, talc, potassium and sodium compounds, and tungsten (Clark, September 1978).

Mineral production statistics indicate that approximately 60 percent of the State's asbestos, 45 percent of the cement, 15 percent of the stone, and almost all of the tungsten and dolomite are produced from sources on California's forest lands. Minor amounts of sand and gravel, silver, gold, copper, lead, zinc, and talc are also produced from these areas.

Although California once was a major source of gold, only a few thousand ounces are now produced annually. California's geology makes the State an ideal place to search for gold. Over 25,000 mines and many thousands of prospects exist, most of which are in forested areas. Some of these date back to the Gold Rush; some are still producing today. Although gold prospecting activity is carried on Statewide, the largest number of prospectors are working in the western Sierra Nevada foothills, particularly in the regions drained by the Feather, Yuba, and American Rivers and their tributaries. There is prospecting activity in the streams in the Klamath Mountains, especially in the watersheds of the Klamath, Trinity and Salmon Rivers. In addition, there is prospecting activity in the desert regions in eastern and southeastern California and in the forest areas of the San Gabriel, San Bernardino, and Santa Ana Mountains in southern California. The Alleghany district in the forest lands of western Sierra County probably has the largest number of active prospecting and development operations in the Sierra Nevada (Clark, September 1978).

THE FUTURE

National and State industrial needs have led to a number of significant and important changes in the nature of California's mineral industry in the past few years, changes which are expected to continue. For instance, if the price of metals goes up it would become profitable to mine the low-grade deposits of copper, nickel, chrome, uranium, and mercury found on forest lands. California was once a major source of the latter metal, however production ceased in 1978. One of the forest land areas, Lake Britton in Shasta County, could be-

come an important source of diatomite which is used extensively in filters and insulation (Grew 1978). Production of various industrial minerals such as diatomite and boron, used in glass production, has shown a marked increase.

Economic recovery from the recession of 1974 and 1975 resulted in increased demand for construction materials. Most cement, sand and gravel, and building-stone plants in the State are operating at or near capacity.

Production projections indicate a 55 percent growth in the mineral economy of California between 1965 and 2020. The output of metals is expected to double and the production of nonmetallic minerals should triple.

It is expected that the State's mineral production will be adequate to meet expected demands to 1980 and in many cases to 2020, since the known reserves of many minerals currently being produced in California are large. Deposits not now considered as resources will become usable because of advancing technology. The geologic conditions in California are such that future discoveries of new mineral deposits and fields can be anticipated within California's forest lands.

Diversions of water for mineral extraction in California are expected to increase over 160 percent, to 307,000 acre-feet per year, between 1965 and 2020. The industry's water requirements will increase throughout most of California, including the forested areas, but the most critical problems are expected to be in the water-short southeastern part. This section of the State should have the largest increase in mineral production since geologists believe there are large, as-yet-undiscovered quantities of minerals still in the forested and unforested desert areas (Framework Study, Appendix XII, June 1971).

MINERAL EXTRACTION SITES

In August 1978 the Division of Mines and Geology of the California Department of Conservation prepared an inventory map showing existing and potential mineral extraction areas which necessitate surface disturbance of 100 acres or more within the forest lands of California (see Figure 12-1). The 1975 State Surface Mining and Reclamation Act defines "disturbance" as the displacement of at least 1,000 cubic yards of minerals, ores, and overburden per acre per location. Table 12-1 lists nineteen identified, existing, surface disturbance areas totaling roughly 8,500 acres. Thirteen thousand acres of potential disturbance are also shown. Seven additional sites are shown on the table for which no average data were available.

Mining and drilling activities impact the forest lands by disturbing the forest surface. They can also leave the land difficult to reclaim. In some cases they contribute to air and water pollution and may necessitate the creation of access roads. They may render the affected lands unproductive for trees and aesthetically unattractive for a long time after extraction is completed. Such impact must be considered in planning for future mining and drilling use of the State's forest lands.

Surface land disturbances caused by mineral and fuel extractions are expected to increase over 180 percent by 2020, which, if occuring on forest land would disturb an additional 15,300 acres.

Using map overlays, it was determined that the mining and drilling operations shown on Figure 12-1 and Table 12-1 generally are having no significant effect on threatened and endangered species or critical wildlife habitat. The Juniper Mine uranium assessment work and claims would, however, have an impact on a Roadless Area Review and Evaluation

FIGURE 12-1

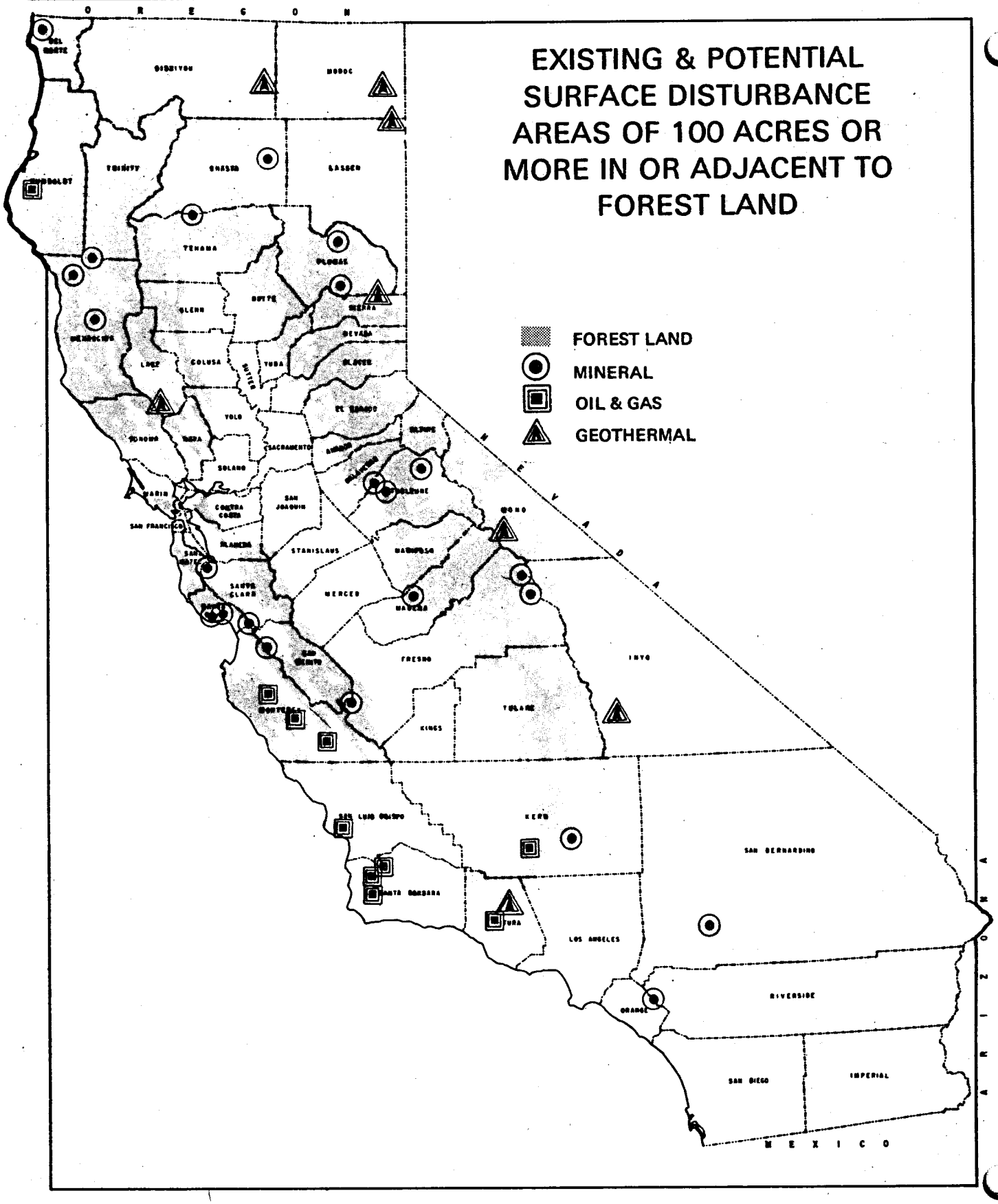

EXISTING & POTENTIAL SURFACE DISTURBANCE AREAS OF 100 ACRES OR MORE IN OR ADJACENT TO FOREST LAND
FOREST LAND
MINERAL
OIL & GAS
GEOTHERMAL
OREGON
NEVADA
ARIZONA
MEXICO
SISKIYOU
MODOC
TRINITY
SHASTA
LASSEN
HUMBOLDT
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
MENDOCINO
NEVADA
LAKE
COLUSA
YUBA
PLACER
YOLO
EL DORADO
SONOMA
NAPA
SACRAMENTO
AMADOR
ALPINE
SOLANO
CALAVERAS
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
SAN FRANCISCO
ALAMEDA
MONO
STANISLAUS
MADERA
SAN MATEO
SANTA CLARA
MERCED
MARIPOSA
SAN BENITO
FRESNO
INYO
MONTEREY
TULARE
KINGS
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
RIVERSIDE
ORANGE
SAN DIEGO
IMPERIAL

TABLE 12-1

STATUS OF MINERAL OPERATIONS ON CALIFORNIA FOREST LANDS

	ESTIMATED ACRES		NUMBER OF EXISTING SITES
MATERIAL	EXISTING	POTENTIAL	NO DATA
Copper	266	3,000	1
Nickel-Chrome		8,400	
Cement	4,600		4
Sand/Gravel	675	1,100	
Granite	2,300		
Asbestos	300		
Tungsten			1
Marble			1
Uranium	40	600	
Diatomite	300		
	8,481	13,100	7

Note: Blank spaces in the data columns indicate that no figures were available.

(Rare II) area within the Stanislaus National Forest.

The map overlay technique also indicates that there appears to be no direct conflict between existing and potential mineral operations and prime timber and range lands (see Figure 3-1).

ENERGY RESOURCES IN OR NEAR FOREST LANDS

Oil and gas, primary geothermal energy, and uranium are the principal energy producing commodities in California. Many of the sites for these resources are in, or close to, forest lands. Wood as an energy source is assessed in Chapter Eleven, "Wood Energy."

OIL AND GAS

Oil and gas is produced from sedimentary basins principally located near Los Angeles, Santa Barbara, Taft, Coalinga and Bakersfield. The potential for future discoveries is greatest in these and similar sedimentary basins which are, for the most part, located on the fringes of the forest lands. The surface disturbance caused by oil and gas exploration and production is not as great as that caused by surface mining. The requirement for environmental impact reports should help mitigate adverse impacts by itemizing proper operating procedures.

GEOTHERMAL ENERGY

Geothermal energy sources occur throughout the State, usually in or near

areas of recent volcanic activity. Geothermal potentials also exist in the Inyo and Mendocino National Forests. Geothermal energy is now used to produce electricity at the Geysers Geothermal Field north of San Francisco (Rare II, June 1978).

REGULATORY RESPONSIBILITIES

The 1975 State Surface Mining and Reclamation Act applies to mining disturbance on private forest lands. This act requires the State Mining and Geology Board to adopt a policy for the reclamation of mined lands. That policy is for the guidance of local governments required by the act to obtain reclamation plans for surface mining operations as a condition of granting the permits, specified in the act, which are necessary before surface mining may proceed. The act also requires the Board to adopt policies relative to mineral resource conservation through appropriate land use planning by local governing agencies (CDMG Special Publication 51, April 1977).

In addition to the policy direction stipulated in the Surface Mining and Reclamation Act, the State's role is one of guidance and technical assistance to California's counties in the implementation of the act. To date, the counties have adopted, or are proceeding to adopt, their own relevant ordinances which require mining permits and reclamation plans. Also, the State Lands Commission administers leasing and royalty interests from all mining on State lands.

When surface mining, oil and gas, or geothermal disturbance is anticipated on federal lands a cooperative effort is usually effected between the federal agency administering the land, the involved county, and possibly the State and the U.S. Geological Survey. This cooperative effort is directed toward preparing an environmental impact report or statement (EIR/EIS), preparing permits, leases, and in performing inspections. A February 1979 memorandum of understanding between the State, the Forest Service, and the BLM spells out the working relationships between these agencies and the counties and, when fully implemented, should result in satisfactory land reclamation from mining activities.

As is the case with the mineral industry, oil, gas, and geothermal exploration and production are not expected to impact forest land significantly. Counties assume the lead-agency role in preparing any EIR necessary for significant environmental impacts on private lands; however, beginning January 1, 1979, the State Division of Oil and Gas became the lead agency for geothermal exploratory projects. Geothermal exploration is preceded by a notice of intent filed with the Division. Where geothermal resources exist, counties are encouraged to add a geothermal element to their County Plan (Reid, November 1978).

CONCLUSIONS

California produces a wide variety of minerals, and ranks third in the nation in annual mineral production. It is also a major producer of oil and natural gas. The present drilling and geothermal energy production activity, and that which is expected in the future as society's needs dictate, is not anticipated to have a great direct, and/or detrimental, influence on forest lands since many of the present and potential sites lie outside the forested areas.

Research indicates that there appears to be no major conflict between existing and potential mineral operations and high-yield timber and range lands.

Mining activities which now exist, and those which may occur in the future, do, however, disturb forest lands and can leave that land difficult to reclaim; can contribute to aesthetically unattractive areas; and can possibly necessitate road building which may lead to water quality degradation.

An indirect, detrimental influence on air and water quality may result from mineral, and oil and natural gas processing plants if these plants are located in or near the forested areas.

Water diversions necessary for the mineral extraction industry are expected to increase in proportion to the growth of the industry. These diversions might, if they are located in forested areas, create some adverse impact within forested lands.

These factors must be considered in granting permits for future growth of the minerals and oil and natural gas industry.

MELLER - CHUBB Sc.

CHAPTER THIRTEEN

MATHEMATICALLY MODELING CALIFORNIA'S FOREST LANDS

PAGE NO.

INTRODUCTION

COMPETING USES OF CALIFORNIA'S FOREST LANDS: RESULTS OF THE MODEL 298

DEVELOPMENT OF THE FRAP LINEAR PROGRAMMING MODEL 301

INTRODUCTION

The complexities of California's forest ecosystems present myriad options for the land manager. The sheer magnitude of these forest land management options led FRAP to choose the use of linear programming as an assessment tool. Linear programming (LP) is one relatively noncomplex mathematical method of analyzing problems. When a given acre of land is managed in different ways the costs and results of that management naturally vary. When several kinds of land are considered, numerous combinations of management techniques may be used to produce the hoped-for results whether they be for increased forage or timber production, for greater recreational use, as undisturbed wildland, or some combination of these. Interactions between the quantities of the various outputs produced occur as different acres are shifted from one management scheme to another.

Uses considered by the model include recreation, timber, wilderness, and forage. This chapter presents the results obtained from the model and a discussion of the data and assumptions used in it. The Appendix contains a simplified example of the LP which shows how such models are formulated and what they contain.

Models, by their very nature, do not precisely represent reality. The objective of modeling, in fact, is to abstract from reality in such a way that the essential features for the desired purpose are retained while the less significant detail is dropped. The FRAP model is only intended to identify forest use interactions at a regional level in order to address policy issues of forest land use. The model is not a management tool applicable to any specific property but rather combines land into large units and assumes average rates of production for these aggregate land units. It is most likely that within smaller subunits practices will be highly variable around this average. Results are also only as good as the current, often crude, data permit.

COMPETING USES OF CALIFORNIA'S FOREST LANDS: RESULTS OF THE MODEL

The results of several runs of the FRAP LP model are shown in Table 13-1 Column 1 shows the objective of the particular run. The "Base" run assumes that the desired level of outputs of the selected categories of "Timber," "Forage," "Recreation," and "Wilderness" are those currently being produced. Specifically: 1.9 billion pounds of forage per year; 45 million visitor-days per year; 4,100 "Wilderness Attribute Points;" and 900 million cubic feet of timber per year. The timber level is that projected for 1980 by the Adams/Haynes model described in Chapter Ten, "The Timber Resource."

From this "Base" level a series of other LP runs were made in an attempt to double the desired level of each output above the base amount as called for by the federal RPA, while maintaining the others. The results in the table show the acreage which would need to be managed for "Multiple Use" or "primarily for" timber, forage, recreation, or wilderness if the combined outputs were to be produced and assuming lands would be "efficiently" allocated to the various managements. These management categories are described in more detail elsewhere in this chapter. (Manage "primarily for" does not mean "exclusively for.")

TABLE 13-1

MILLIONS OF ACRES OF FOREST LAND
DEVOTED TO VARIOUS TYPES OF MANAGEMENT
BY ALTERNATE FRAP LINEAR PROGRAMMING RUNS

		Managed primarily for:				
	MULTIPLE USE	TIMBER	FORAGE	RECREATION	WILDERNESS	UNUSED
Base	20.3	*	.5	.5	2.2	8.8
Increase Timber 45 percent	12.2	11.4	.5	.6	2.8	4.7
Increase Forage 100 percent	24.3	*	.7	.5	2.2	4.7
Increase Recreation 100 percent	20.6	*	.5	1.5	2.3	7.5
Increase Wilderness 90 percent	19.0	.2	.5	.7	5.9	6.1
Simultaneous Increase Timber 45 percent, Forage 100 percent, Recreation 100 percent, Wilderness 78 percent	13.9	11.4	.5	1.9	3.8	0.8
Simultaneous Increase Timber 18 percent, Forage 100 percent, Recreation 100 percent, Wilderness 90 percent	11.9	11.4	.5	1.9	5.9	0.7

* Less than 50,000 acres

Notes: See the text for a discussion of the terms used. "Multiple Use" management produces substantial amounts of timber, forage, and recreation outputs. Areas shown are those allocated by the model and do not necessarily coincide with current land use patterns. In the first five rows of the table "Unused" lands were not needed to satisfy the constraints of the particular LP run. In the remaining two rows "Unused" lands were unable to satisfy the deficits of wilderness and timber constraints respectively.

While the Timber Chapter suggests growth could be doubled, it was only possible to increase timber outputs 45 percent. The difference is mainly based on the effects of more intensive management which were modeled at only 10 percent increase in growth. Higher model results might also involve timber production on lands yielding less than 50 cubic feet/acre/year. Vaux (1973) suggests these lands will not be an important component of California's future timber base. Data limitations did not permit inclusion of these factors.

Results of this LP run also illustrate how land uses change as a result of increased requirements for a particular output. Under the "Base" the timber requirement can be satisfied by multiple-use management which the model applies on private as well as on public lands. As the requirement is raised more intensive timber management is needed and the model allocates almost all of the high-site timber land to the "primarily for" timber management category. Lands assigned to wilderness are also increased because some Site 5 lands are shifted to timber management, and greater acreages of areas having lower wilderness ratings are required to maintain the Wilderness Attribute Point total. The model also indicates regional shifts as requirements are changed. For example, as timber requirements are raised, much of the increased production comes from the Northern Interior Region. The model suggests that half of the wilderness points previously obtained in the Northern Interior should then instead be produced in the San Joaquin Region.

Allocating all of the forested acreage identified as "Reserved and Wild" (see Chapter Three, "Classifications of the Forest Lands" to wilderness produced a 90 percent increase in Wilderness Attribute Points and somewhat more than a doubling of the wilderness area. (Wilderness Attribute Points are discussed in Chapter Eight, "The Wilderness." They attempt to recognize values such as naturalness and outstanding scenic features.)

Forage is probably not well modeled in the LP. The estimated current livestock consumption level of 1.9 billion pounds per year from the forested range of California is probably about a third of that actually grown. Many factors limit the use of forage on these lands. Animals must be fed throughout the year and not simply when forage is at its best. Much of the forested rangeland is only seasonally available so other feed sources may represent the essential constraints on herd sizes. Forage production levels also apparently vary substantially from year to year so that average outputs are not reliably available. Some forage is excessively utilized and range conditions in these areas have deteriorated. Other areas are not used at all. Thus additional considerations such as water developments, fencing, distance of transport, and size of a particular area may be as important as the forage production capability in determining livestock use of these lands. Future modeling efforts should obviously focus on the critical factors of forage usage.

To the extent that total forage production is a useful variable, the model suggests the consumption level can readily be doubled. This would be accomplished by increasing the land managed for multiple use and removing lands from the "Unused" category rather than by allocating land primarily to forage production.

Recreation also could be increased 100 percent fairly readily according to the model. The area managed for recreation would be tripled to achieve this result but still would constitute only about five percent of the State's forest land. Three-quarters of the output would come from these lands while most of the remainder would be produced on lands under multiple-use management.

The LP was also used to investigate the effect of simultaneously increasing all output levels to the limits described above. The consequences are shown at the bottom of Table 13-1. Increasing forage and recreation outputs 100 percent while increasing wilderness or timber was still feasible according to these results. However, increasing wilderness to the +90 percent level would limit timber output increases to 18 percent while efforts to increase timber by 45 percent would limit wilderness increases to 78 percent. Under both these alternative scenarios much more land would be devoted to the "primarily for" managements directed at specific uses than occurs under the "Base." The monitary costs of achieving the outputs would consequently also be higher.

It is important to recognize the limitations of these results: the model is not comprehensive because it leaves out many uses. It assumes that efficiency is the criterion for land allocation. The data on outputs per acre for each "Product" category (Timber, Forage, Recreation, and Wilderness) that can be obtained for each type of land considered in the model are only estimates. The area of each type of land is not accurately known. And, the modeled variables may not represent the essential considerations. For instance, livestock usage may be limited not by total forage production, but instead by water availability, and wilderness values may not be well represented by "Attribute Points." Nevertheless, the model is useful in providing considerable insight. The forest's capacity to produce greater forage and recreation outputs do not appear to be critically limited. On the other hand, if substantial increases in wilderness occur, growth in timber production will be limited without more intensive timber management practices. Doubling timber production in any case would involve substantial commitments.

DEVELOPMENT OF THE FRAP LINEAR PROGRAMMING MODEL

Note: The Appendix presents a very small parallel linear programming problem. This sample problem requires only a basic knowledge of algebra for understanding the example. This section describes the data for the full model and the model's structure as it relates to that which appears in the Appendix.

The linear programming model developed for this Report contains 357 land categories. The acres and the region, owner, and site of each are shown in Table 3-1. The two land categories in the Appendix example are counterparts to these 357.

Five kinds of land use are considered but only one at a time can be assigned by the computer to any specific acre. The land uses included are:

Multiple-use
Timber
Forage
Recreation
Wilderness

Multiple-use considers a mix of forest outputs which would generally result if lands were managed to produce timber, forage, and recreation on the patches most suited to each, at current levels of investment. Thus, small campgrounds, grazing in some meadows and/or under the trees, and timber production might all be produced on a one-thousand-acre tract if this management were assigned. The levels of timber, forage, and recreation outputs for multiple use management are shown in Tables 13-2, 13-3 and 13-4. For example, the annual output per acre of recreation is 0.48 visitor days when land is managed by the activity: for multiple-use, in the North Coast on the "Public Unreserved" ownerships, land of Timber Site 5, Forage Site E, and Recreation Site E (see Table

TABLE 13-2

OUTPUTS (VISITOR-DAYS PER ACRE PER YEAR) USED IN THE FRAP LINEAR PROGRAMMING MODEL FOR RECREATION BY REGION, OWNER AND RECREATION SITE

NC =	North Coast
NI =	Northern Interior
SM =	Sacramento
SJ =	San Joaquin
SC =	Southern California
CC =	Central Coast

OWNER	SITE	REGION					
		NC	NI	SM	SJ	SC	CC
		Regular or Multiple-Use Management					
All Public	O	.40	.50	1.00	2.00	4.00	.70
	E	.48	.60	1.20	2.40	4.80	.85
All Private	O	.04	.05	.10	.20	.40	.07
	E	.05	.06	.12	.24	.48	.08
		Intensive Management, i.e., that "primarily for" recreation					
Public Unreserved/ Reserved and Wild	E	30.	15.	35.	30.	50.	50.
Public Reserved	E	45.	22.	52.	45.	75.	75.
All Private	E	27.	14.	32.	27.	45.	45.

3-1, "Estimated Forest Land Areas in Thousands of Acres by Region, Owner, and Site.") This coefficient is found in Table 13-2. The forage output would be 250 pounds per acre per year, as shown on Table 13-3. The annual timber output would be the 60 cubic feet per acre as shown in Table 13-4.

The other management categories are also not considered exclusive. For example, management "primarily for" recreation assumes higher expenditures to increase recreation outputs, accompanied by somewhat decreased timber and forage outputs. The per acre outputs for these managements are those of "Multiple Use" management adjusted by percentages shown in Table 13-5. Thus, if the model simulates the selection of forage as the management method for a specific land category, the assumed timber outputs will be 80 percent of what they would have been under "Multiple Use" management for the same land. Forage productivity values would be increased because of the more intensive management implied by selecting it as a "primary" management. Since output estimates for more intensive managements could not be obtained for this assessment a straight percentage increase was assumed; in other words it was assumed that some management practices could be undertaken which would increase forage outputs by five percent.

Only the multiple use management is assumed possible on each type of land. The "primarily for" managements are considered possible on the best lands (see Table 3-1) for forage and recreation, and on the best three timber site classes. In fact as was described previously it is assumed no timber is produced on sites of less than 50 cubic feet per acre per year. Only reserved and wild

TABLE 13-3

OUTPUTS (POUNDS PER ACRE PER YEAR) USED IN THE FRAP LINEAR PROGRAMMING MODEL FOR FORAGE MANAGEMENT BY REGION, OWNER, AND TIMBER-FORAGE SITE

REGION	OWNER	SITE= 1-4E	1-40	5E	50	6E	60	7E	70
North Coast	FI	0.	0.	65.	0.	122.	5.	326.	104.
	OP	0.	0.	65.	0.	122.	5.	326.	104.
	PU	50.	0.	250.	0.	625.	200.	0.	0.
	PR	0.	0.	18.	0.	43.	13.	0.	0.
	XX	0.	0.	0.	0.	0.	0.	875.	300.
Northern Interior	FI	0.	0.	0.	0.	168.	39.	250.	128.
	OP	0.	0.	0.	0.	200.	50.	300.	150.
	PU	0.	0.	0.	0.	151.	37.	227.	116.
	PR	0.	0.	0.	0.	41.	10.	64.	37.
	XX	0.	0.	0.	0.	0.	0.	0.	0.
Sacramento	FI	0.	0.	200.	0.	375.	150.	625.	225.
	OP	0.	0.	200.	0.	375.	150.	625.	225.
	PU	0.	0.	180.	0.	357.	144.	570.	221.
	PR	0.	0.	25.	0.	30.	12.	38.	16.
	XX	0.	0.	0.	0.	0.	0.	0.	0.
San Joaquin	FI	0.	0.	150.	0.	300.	120.	500.	200.
	OP	0.	0.	150.	0.	300.	120.	500.	200.
	PU	0.	0.	126.	0.	271.	114.	455.	188.
	PR	0.	0.	23.	0.	24.	11.	31.	12.
	XX	0.	0.	0.	0.	0.	0.	0.	0.
Southern California	FI	0.	0.	0.	0.	0.	0.	0.	0.
	OP	0.	0.	0.	0.	0.	0.	0.	0.
	PU	0.	0.	0.	0.	146.	22.	169.	42.
	PR	0.	0.	0.	0.	8.	3.	9.	2.
	XX	0.	0.	0.	0.	175.	24.	240.	50.
Central Coast	FI	0.	0.	0.	0.	0.	0.	0.	0.
	PI	0.	0.	220.	0.	500.	175.	750.	247.
	PU	0.	0.	0.	0.	0.	0.	26.	13.
	PR	0.	0.	0.	0.	0.	0.	2.	9.
	XX	0.	0.	0.	0.	0.	0.	360.	125.

FI = Forest Industry
OP = Other Private
PU = Public Unreserved
PR = Public Reserved
XX = Unknown

TABLE 13-4

ANNUAL TIMBER OUTPUTS (feet^3 per acre) USED IN THE FRAP LINEAR PROGRAMMING MODEL

Region/Owner	Site 1-3	Site 4	Site 5
North Coast Counties			
Forest Industry	200	112	78
Other Private	76	56	42
Public Unreserved	112	84	60
Public Reserved	268	--	--
Northern Interior			
Forest Industry	88	63	27
Other Private	77	55	24
Public Unreserved	97	90	57
Public Reserved	--	86	--
Sacramento			
Forest Industry	88	63	27
Other Private	77	55	24
Public Unreserved	118	87	55
Public Reserved	--	88	--
San Joaquin			
Forest Industry	88	63	27
Other Private	77	55	24
Public Unreserved	118	88	57
Public Reserved	--	88	--
Southern California			
Public Unreserved	--	--	55
Central Coast			
Other Private	74	56	--
Public Unreserved	126	91	--

Note: Estimates were not obtained where missing entries occur in this table. Ordinarily the area data used in the FRAP LP indicated less than 1000 acres existed for these missing categories.

TABLE 13-5

PERCENT OF SCHEDULED OUTPUTS (IN TABLES 13-2, 13-3, AND 13-4) ASSUMED FOR EACH POSSIBLE MANAGEMENT IN THE FRAP LINEAR PROGRAMMING MODEL

MANAGEMENT	OUTPUTS OF:			
	Timber	Forage	Recreation	Wilderness
Multiple Use	100	100	100	---
Timber	110	80	80	---
Forage	80	105	80	---
Recreation	50	80	"Intensive"	---
Wilderness	--	50	10	100

lands may be managed for wilderness (see Chapter Three, "Classifications of the Forest Lands").

When each of the 357 land categories is considered for all the managements for which it qualifies, 888 combinations of land management, owner, region, and site are included as columns of the LP--i.e., the six shown in the Appendix example are increased to 888 here. These columns are also commonly referred to as "activities" from which the LP makes selections.

Requirements for minimal outputs of forage, recreation, timber, and wilderness constitute the major constraints. It is the levels of these constraints that are varied to produce different solutions. The LP produces the required amount of an output by "allocating" acres to the various activities.

In addition to these output quantity constraints 357 area constraints are included to ensure that lands are not assigned to several uses at once.

How sophisticated is the model?

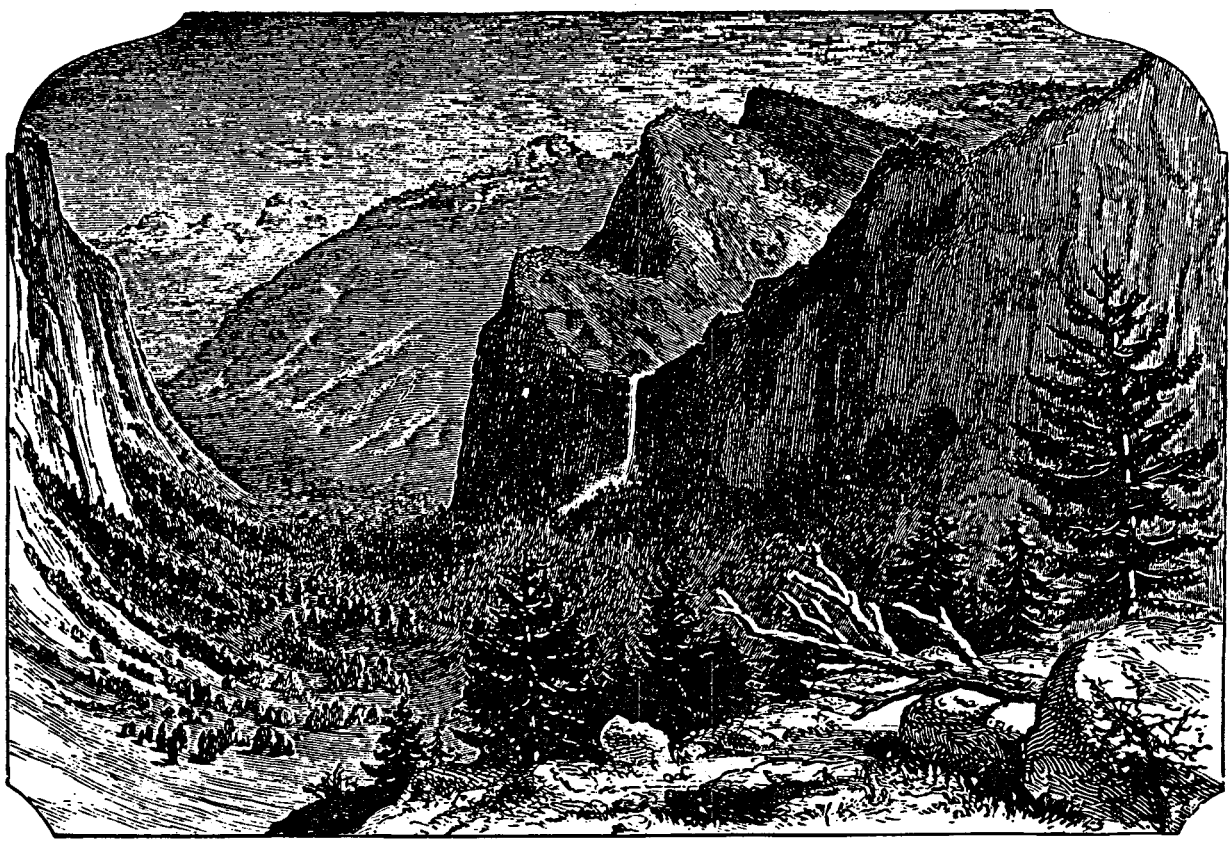
In spite of about 900 variables and almost 400 constraint equations used in the model it is conceptually rather simplistic. However obtaining data for even this model has proven to be a major obstacle. The model results should help identify major data weaknesses and better data can lead to more useful models in the future. Limitations notwithstanding, the results of the LP discussed above provide some insights into the forest resources which would not otherwise be available.

Mention of conceptual improvements in the model, which were originally to be included but which were omitted pending the development of data, may be of interest.

Forage as modeled is that utilizable for livestock. Deer also use forage and represent the single predominant wildlife species. Within the model forage could be allocated to deer or livestock thus incorporating competition between

them as well as other resource outputs. This portion of the model and the deer component were omitted because forage is apparently not generally constraining on deer populations. The critical variable may be forage availability in a particular season or some special habitat requirement. Determining the variable and finding its quantitative relationships to various mangements are necessary prerequisites to including deer in the model.

Efforts to include water quality, uneven-aged timber management, and measures of economic welfare in the present model were also abandoned because of time and data limitations.



CHAPTER FOURTEEN

VEGETATION MAPPING USING REMOTE SENSING TECHNOLOGY

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HISTORY OF MAPPING EFFORTS IN CALIFORNIA

In May of 1886 the Chairman of the California State Board of Forestry, Abbot Kinney, made the statement to the Board that:

> "... one of the most important acts to be done by the Board, should be the preparation and publication of a forest map of the entire State, showing the amount and kind of timber standing in the different counties, and its commercial uses and value." (California State Board of Forestry 1886)

A.W. Kuchler wrote in 1977:

> "The vegetation is the tangible, integrated expression of the entire ecosystem, and mapping the vegetation is the only effective method to present the ecological order of our living space." (Barbour 1977)

Both of these men saw the need, on one hand specfic and on the other all encompassing, to know what exists on the ground and where it is located. FRAPA instructs the Director of the Department of Forestry to prepare a forest resources assessment and analysis. The necessity of knowing the location, extent and condition of the forest lands within the State to satisfy the directives of this Bill is obvious. Although the Board of Forestry, to this day, does not have a map of, or a comprehensive program to map, the forest lands of the State, there have been many attempts to map California's vegetation in the years since Abbot Kinney was Chairman.

Undoubtedly the earliest vegetation delineations were simply notations made by surveyors or explorers on new routes, trails, or survey lines. The U.S. Geological Survey recorded broad vegetation classes as early as the 1870's. Also, Abbot Kinney appointed an engineer to the Board of Forestry in 1886 who began mapping the forested areas of the State on small-scale county maps.

A more organized effort was begun by the Pacific Southwest Forest and Range Experiment Station (PSW) in Berkeley in the late 1920's and early 1930's. The chaparral belt in Southern California was mapped in 1927 and 1928 under this project and in 1928 the McSweeney-McNary Research Act authorized the nationwide Forest Survey (Wieslander 1935a). This latter effort also began in the chaparral belt of Southern California, but soon spread to the forests. During the 1930's the Forest Service prepared vegetation type maps on several of the National Forests under the McSweeney- McNary Act. Although many changes have ensued, this legislation is the current basis for the Forest Service Forest Survey on lands outside of the National Forest. Under the Forest and Rangeland Renewable Resources Planning Act of 1974, this Survey was changed to collect and analyze data on all renewable resources. It is now called the Renewable Resources Evaluation Research Unit.

A. E. Wieslander headed a Vegetation Type Map Survey in the late 1930's and 1940's which served as a precursor to the Forest Survey (Wieslander 1935b). He did not complete all the areas intended for mapping but did publish many detailed maps of the central Sierras and southern chaparral areas. In 1945 he also published a small scale Statewide (1:1,000,000) map of the "Vegetation of California" (Wieslander 1945) with 12 predominantly physiognomic vegetation classes. Prior to World War II approximately 40 million acres of the State's vegetation had been mapped in some way.

A cooperative Statewide mapping effort was begun in 1947 by PSW, CDF, and the University of California. This was the Cooperative Soil-Vegetation Survey which was designed to map both vegetation and soils, primarily on State and privately owned lands. The effort is continuing today under the direction of CDF. Maps have been published on approximately 9.28 million acres which are predominantly in the northwestern part of the State (Malain 1979).

Between 1962 and 1973 the Forest Service published maps of some of the national forests in California showing soils and vegetation information. These mapping efforts have been discontinued. Currently soils are being mapped on several Forests under the National Cooperative Soil Survey.

The Forest Service today, in Region 5, does conduct a mapping of forest types on National Forest lands in the course of which they collect information on land status including those that are commercial, noncommercial, non-forest lands, forest types, dominant species, size classes, stocking density, and decadence ratings. Based on these typemaps they conduct timber resource inventories using a double sampling system involving aerial photography and ground plots (Bolsinger 1976). Today, the Forest Survey is conducted on lands outside of the National Forests. Forest acreage estimates used in this Report have been derived from Forest Survey data. More detail on the procedure can be found in Chapter Ten, "The Timber Resource."

The Forest Service has also experimented with remote sensing technology in attempts to map vegetation for specific management or planning purposes. For example, cooperative mapping efforts have been conducted through Operation FIRESCOPE in Southern California between the Forest Service, CDF, and the Remote Sensing Research Program at U.C. Berkeley in an effort to map fuels for fire control. Currently the U.C. Santa Barbara Geography Remote Sensing Unit is working with the Forest Service to map homogeneous classes and determine timber volume classes on the Klamath National Forest from Landsat data and from digital terrain data derived from maps.

The vegetative cover on most of the national parks, monuments, and recreation areas has been mapped at one time or other. This has been done in a variety of scales and classifications. Many of these efforts have involved the use of aerial photography.

The Bureau of Land Management, overseeing extensive scattered areas of the State's chaparral, rangelands, and deserts, does not have a comprehensive mapping program. They perform on-site "eyeball estimate" reconnaissance surveys on much of their lands. In the past several years BLM has been involved in experiments with the universities and the National Aeronautic and Space Administration (NASA) to utilize aerial photography and satellite imagery to create vegetation maps for management of their lands. Extensive areas of the northeastern rangelands and southeastern deserts of the State are being mapped.

A. W. Kuchler has published a Statewide map of the "natural" vegetation of California (Barbour 1977). Kuchler defines "natural vegetation" as that vegetation that is not appreciably disturbed by man, or the vegetation which would cover the area if it were not impacted by man.

Many of the privately owned timber companies which have extensive land holdings in California have mapped and inventoried their forests. They have done this with successive sampling, observations, and, in some instances, the use of aerial photography.

The U.S. Geological Survey has developed a national system for mapping and classifying the country's lands according to land use and land cover. This is

being done at a variety of mapping scales including 1:250,000, 1:100,000 and 1:24,000. The scale used depends on the availability of completed U.S. Geological Survey base maps, and in some instances the existence of cooperative agreements. The mapping principally involves the photointerpretation of high altitude photography and some use of Landsat data, and concentrates on land use (Anderson 1976). Urban areas (three dwellings per 10 acres), surface water, mines, quarries, gravel pits, and certain agricultural areas are mapped to a 10-acre minimum. This means that areas of these activities smaller than 10 acres are not delineated. All other categories including forest land, rangeland, wetland, barren land, tundra, and snow are mapped to a 40-acre minimum. In California, as of March 1979 eighteen 1:24,000 quadrangles (7 1/2'), four 1:100,000 quads, and seven 1:250,000 quads were available.

None of these efforts has managed to produce a vegetation or forest land map of the entire State at a scale useful for most management purposes. Wieslander's and Kuchler's Statewide maps were both published at a scale of 1:1,000,000.

In 1978 an effort was completed by the Forest Service in which the vegetation of the complete State was mapped at a scale of 1:250,000. This is the CALVEG map which has been mentioned in previous chapters. This system is the source of the forest land base map, Figure 1-1, found in Chapter One, "Introduction To The Forest Resources Assessment Program," and referred to throughout this Report.

Attempting to use CALVEG in an assessment and inventory as mandated by FRAPA may prove difficult. The CALVEG maps were created by human photointerpretation of satellite imagery, which was geographically uncorrected. That is, the distortion due to rotation or curvature of the earth that occurs in the location of ground features when photographing or imaging them from space was not compensated for systematically. Therefore, it is difficult to know exactly which areas are represented on the ground by the map. Secondly, the size of the minimum mapping unit for any vegetation type was 800 acres. This does not provide detail on smaller areas. However, CALVEG does provide an excellent data base for management efforts not requiring detail and area estimates for various vegetation types such as have been used in this Report.

DATA NEEDS

FRAPA requires an analysis of the need to develop and maintain systems for data collection, analysis, and display; the identification of data base needs; and an evaluation of the accuracy and completeness of existing data. FRAP has identified the need for a Statewide, geographically referenced forest information base which will identify the vegetation and the associated resource values. There is a definite need for the data to be compatible. That is, a standardization of mapping units, map bases, classifications, terminology, and so forth is necessary if data for all forest resources identified in FRAPA are to be correlated, compared, analyzed, and used within a multi-resource inventory system.

LANDSAT DATA

In light of this section of the law and the anticipated needs, FRAP has initiated an examination of the possibility and feasibility of using information derived from Landsat data as a resource data base to improve future assessment capabilities.

ORIGIN

Landsat, previously called ERTS, is a system in which two observational imaging satellites orbiting 575 miles above the earth in a sun-synchronous orbit. This means that the satellite moves with the sun and each point on the earth is observed at nearly the same time of day; or approximately 10:30 a.m. Landsat passes over the earth's surface in a polar orbit, nearly north to south, approximately 14 times a day. There are currently two Landsat satellites in orbit. Each satellite has a view of the earth approximately 100 miles wide, scanning each 1.1 acre area on the ground. It takes each satellite 18 days to cover the entire earth and the satellites are 180 degrees apart, therefore every spot on the earth's surface is "imaged" once every nine days. Landsat does not take photographs of the earth in the common use of the word. There is no film and no camera. Each satellite uses an oscillating mirror and a photo cell as a sensing device to capture light reflected from the earth's surface. Different areas and features on the earth reflect varying amounts of solar light. The mirror directs the reflected light to four sensors in each satellite which are sensitive to four different wavelengths of light, or more technically, four different bands of the electromagnetic spectrum; green and red bands in the visible spectrum and two infrared bands. These are commonly called Bands 4, 5, 6, and 7. For example, Band 7 represents the longer wavelengths of infrared light which measure 0.8 to 1.1 microns.

The area of the earth which is "sensed" at any instant of time is called a "pixel" (a contraction of the term "picture element"). On original (or "raw") Landsat data a pixel represents approximately 57 x 79 meters or 1.1 acres on the ground. For this CDF project, the data have been processed so that a pixel represents 80 x 80 meters or about 1.6 acres on the ground. This essentially indicates the resolution of Landsat. That is, 1.6 acres is the smallest area for which data exist, or it is the smallest area which is interpretable.

Every pixel on the earth's surface is recorded as a pattern of lights and darks which are coded as a numerical value from 1 to 127 in Band 4, 5, and 6; and 1 to 63 in Band 7. Thus, each pixel is represented by four digital numbers, or "dn" values. For example, a feature such as a body of water tends to absorb most wavelengths, thus the water would appear dark and its dn values as recorded by the sensors would be low in each band. The dn or reflectance values recorded by the sensors are sent back to receiving stations on earth and stored as digital information on magnetic tapes. The data for each band of the spectrum can be used to make images, or pictures, on photographic film. The examples in this Report which are labeled as "false color composites" (see Figure 14-6) are such renditions of Landsat imagery. They are created by photographing each band through a different color filter onto film. Bands 6 or 7, the infrared bands, are normally photographed through a red filter. Because green healthy vegetation reflects much infrared light, the areas of vegetation on pictures made from Landsat data will appear red. Each band can also be photographed separately on black-and-white film.

APPLICATION

The advantages of using Landsat data as an information base were seen to be:

Landsat data are digital, making it possible to process them with a computer.

Landsat data are available for the entire State within a nine-day time span and can be "mosaicked" together to form an image of the entire State.

Landsat data are repeated on a nine-day cycle.

Landsat data provide resource information on every acre.

The hypothesis was that the development of these features could provide an information base that was current, could be easily updated, could facilitate addition and use of other information, and would be geographically accurate.

Landsat essentially represents an image of what exists on the ground at a specific point in time. The first step in developing the information base using Landsat data is to provide consistent identification of the cover type for every acre Statewide.

A project was designed by NASA Ames Research Center (NASA-ARC) and FRAP to classify the entire State into basic forest and nonforest classes. This application would provide a test of the Landsat information technology in terms of land cover discrimination, geographic accuracy, and bulk data processing, as well as reveal potential problems. Analysis of other criteria, such as updating, necessary for an information base will be examined at a later date.

OVERVIEW OF THE PROJECT

A formal agreement between the California Department of Forestry and NASA-ARC was negotiated in June 1978. The Jet Propulsion Laboratory (JPL) in Pasadena and Technicolor Graphic Services, Inc. (TGS) were the primary subcontractors to NASA-ARC to support this project. The mandate of this contract was to create ground cover data for the entire State. Landsat data were acquired from NASA-Goddard Space Flight Center (GSFC) and digital terrain data were acquired from the Defense Mapping Agency/National Cartographic Information Center (DMA/NCIC). This terrain data can be registered to the Landsat data pixel by pixel and can be processed to provide information on elevation, slope, and aspect. This entire task was completed by July 1, 1979. Final products include:

One digital data tape for each 1° longitude by 1° latitude quadrangle (see Figure 14-1) throughout California consisting of the following files:

Landsat raw data, Bands 4, 5, 6, and 7,
DMA terrain data--elevation
DMA terrain data--slope gradient
DMA terrain data--slope aspect
Landsat data classified to CDF's needs

The geographic reference system and code for all quadrangles conforming to the Lambert Conic Conformal projection, which is the method by which Landsat data are registered to a map base.

A 4" x 5" photographic negative of a false-color composite of raw Landsat data from Bands 4, 5, and 6 for each quad.

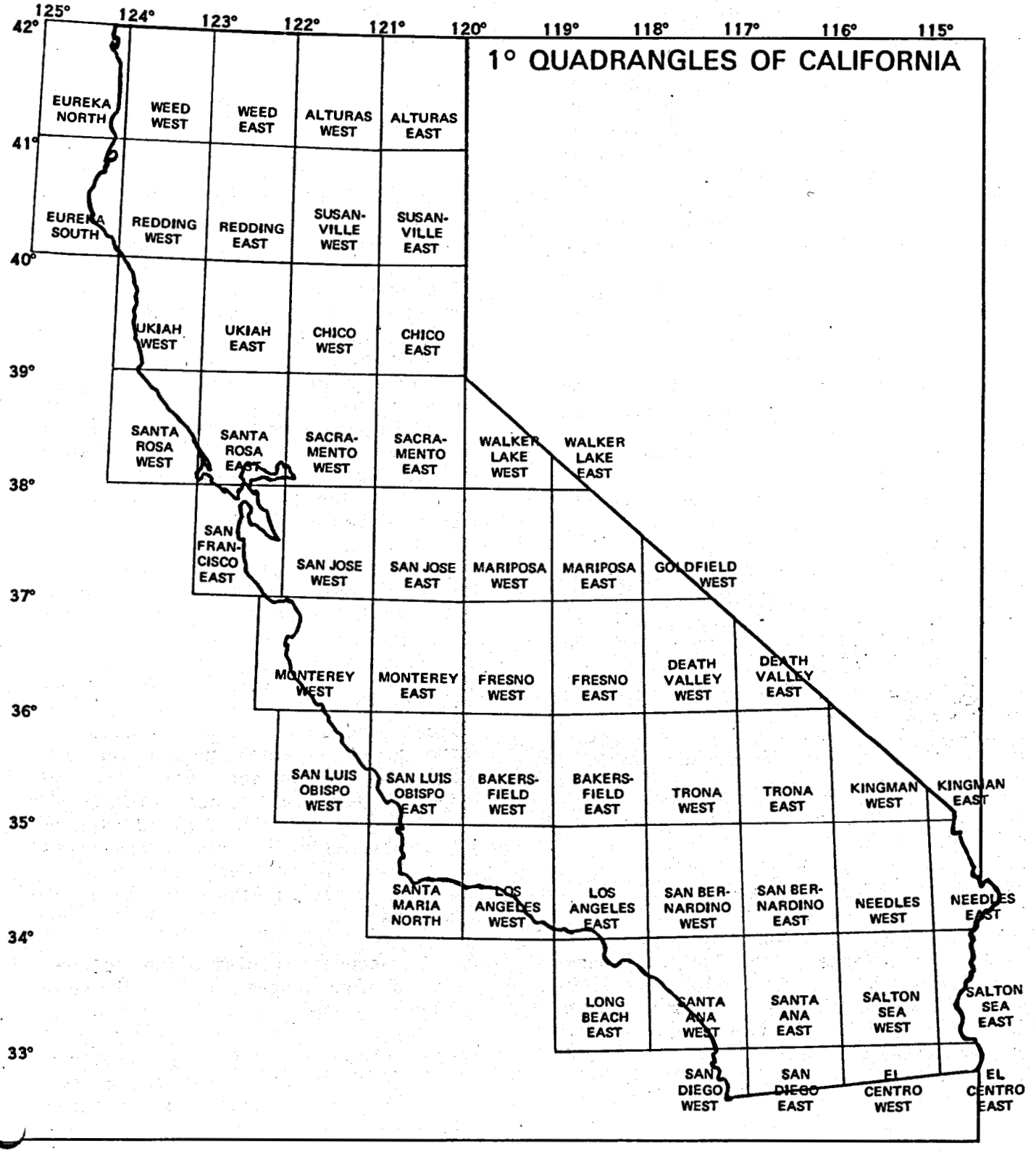
A 4" x 5" black-and-white negative and proof print of Bands 5 and 7 for each quad.

A 4" x 5" negative and proof print of the color-coded classification for each quad.

A 4" x 5" black-and-white negative and proof print of the terrain data (elevation, slope, aspect) for each quad.

A summary of the classification by 1° x 1° quadrangle boundaries, and by county boundaries.

A black-and-white print of the digitally mosaicked Landsat data for the entire State.


1° QUADRANGLES OF CALIFORNIA
125°
124°
123°
122°
121°
120°
119°
118°
117°
116°
115°
42°
41°
40°
39°
38°
37°
36°
35°
34°
33°
EUREKA NORTH
WEED WEST
WEED EAST
ALTURAS WEST
ALTURAS EAST
EUREKA SOUTH
REDDING WEST
REDDING EAST
SUSAN-VILLE WEST
SUSAN-VILLE EAST
UKIAH WEST
UKIAH EAST
CHICO WEST
CHICO EAST
SANTA ROSA WEST
SANTA ROSA EAST
SACRA-MENTO WEST
SACRA-MENTO EAST
WALKER LAKE WEST
WALKER LAKE EAST
SAN FRAN-CISCO EAST
SAN JOSE WEST
SAN JOSE EAST
MARIPOSA WEST
MARIPOSA EAST
GOLDFIELD WEST
MONTEREY WEST
MONTEREY EAST
FRESNO WEST
FRESNO EAST
DEATH VALLEY WEST
DEATH VALLEY EAST
SAN LUIS OBISPO WEST
SAN LUIS OBISPO EAST
BAKERS-FIELD WEST
BAKERS-FIELD EAST
TRONA WEST
TRONA EAST
KINGMAN WEST
KINGMAN EAST
SANTA MARIA NORTH
LOS ANGELES WEST
LOS ANGELES EAST
SAN BER-NARDINO WEST
SAN BER-NARDINO EAST
NEEDLES WEST
NEEDLES EAST
LONG BEACH EAST
SANTA ANA WEST
SANTA ANA EAST
SALTON SEA WEST
SALTON SEA EAST
SAN DIEGO WEST
SAN DIEGO EAST
EL CENTRO WEST
EL CENTRO EAST

Compilation and documentation of the results of the verification tests.

Color-coded assemblage of Statewide classification results.

The magnitude of the task is enormous. The State of California comprises approximately 100 million acres. This is equivalent to roughly 62.5 million pixels. Twenty-nine Landsat scenes acquired over a nine-day period are required to cover the State (see Figure 14-2). Each scene represents approximately 115 x 115 miles on the ground and contains 7.5 million pixels. The first step in a project involving Landsat data is to select the scenes for use. Criteria to be considered in this process are: cloud coverage; quality of the data; missing or bad data; seasonal time of imagery relative to the parameters of interest; area covered; sun angle.

This project was built upon an existing JPL mosaic of the desert areas and data acquired from the same satellite were considered essential. This involved scenes from Landsat-1, taken in August of 1976. The Eureka scenes recorded during this time contained fog and it was necessary to choose imagery from May 1977 to obtain fog-free coverage. Some fog exists on several of the other coastal scenes, but was not prevalent enough to make them unacceptable.

PROJECT IMPLEMENTATION

The Landsat data were acquired from NASA-Goddard Space Flight Center. There were necessary data corrections and some problems with copying the data, which caused a delay in data acquisition. JPL processing began in July, however, a full set of data tapes were not available until October 30, 1978. At this point processing began at the Jet Propulsion Laboratory. The simplified flowchart in Figure 14-3 displays the major steps involved in the project. The agency responsible for completion of each step is noted in each box of the flowchart.

Data processing at JPL involved the following procedures:

1) Establishment of a map projection for the Landsat mosaic.

All of the 29 Landsat scenes were fitted together into one large Statewide image. This is called a "mosaic" of the Landsat data. In doing this the image base was established to a certain map projection. In this case the projection chosen was a Lambert Conformal Conic. A mathematical formula was developed that allowed conversion between Landsat pixel coordinates on the mosaic and the latitude and longitude coordinates on the map base.

2) Accurate geographic registration of the Landsat data to ground control points.

JPL chose approximately 20 identifiable, prominent points on 1:250,000 USGS maps for each individual Landsat scene and identified the points on the scene. The map coordinates for each point on the Landsat scene were then determined. Applying the formula derived in Step 1 of this list yields a conversion between the coordinates of the individual scenes and the coordinates of the mosaic.

3) Accurate registration between overlapping edges of individual Landsat scenes.

JPL chose edge matching tie-points on adjacent Landsat scenes. By registering the coordinates of these to the mosaic coordinates and aver-

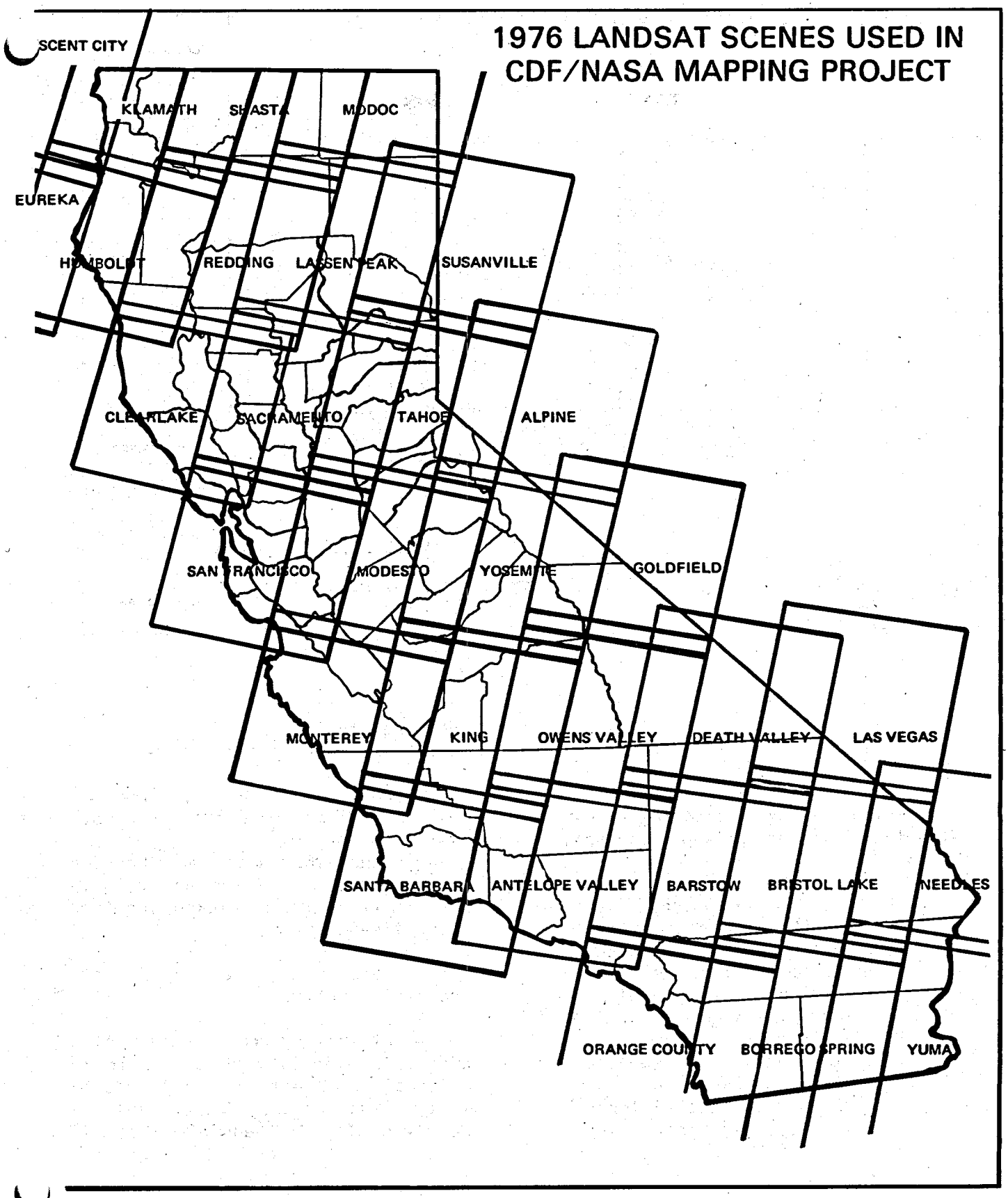
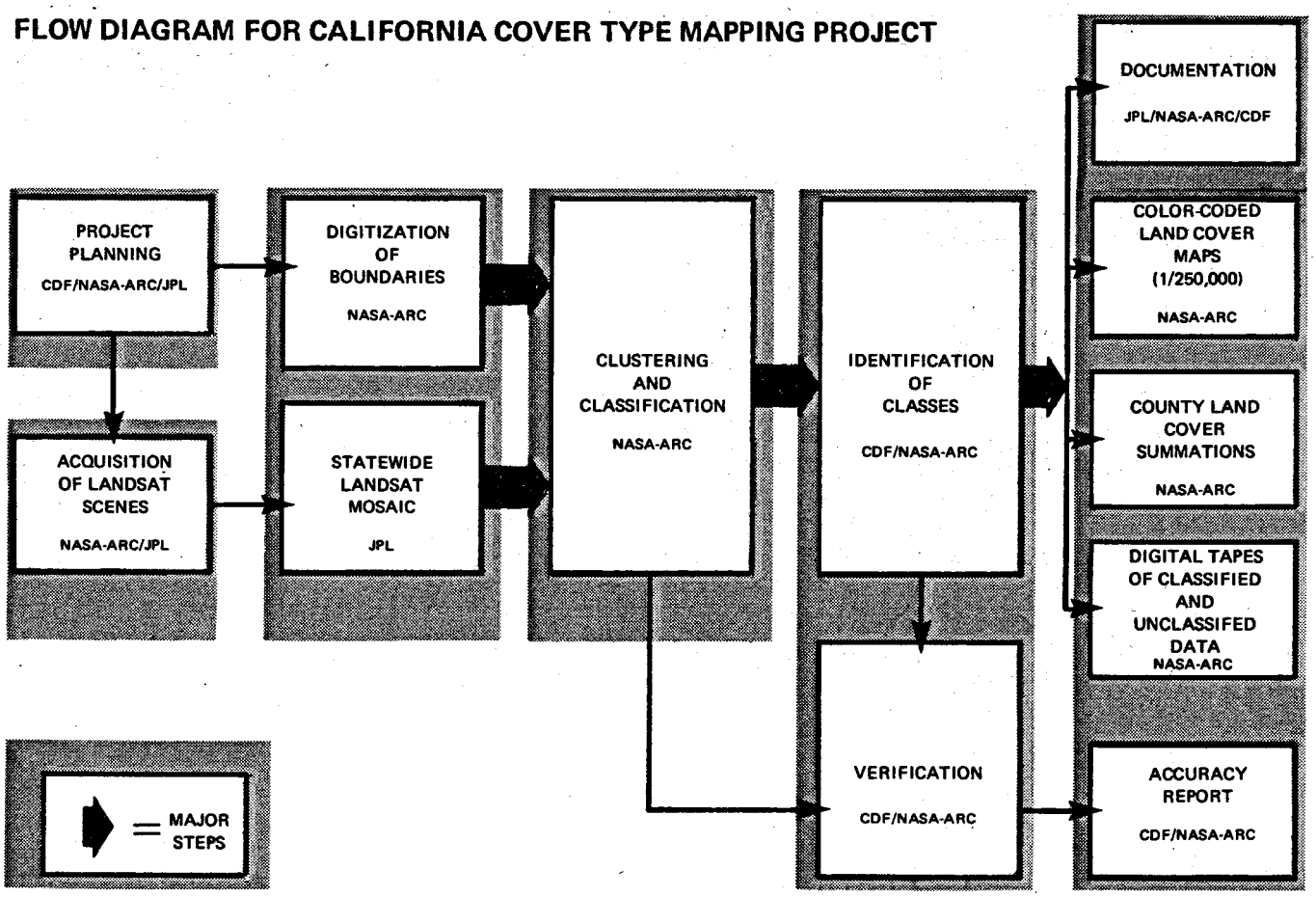

1976 LANDSAT SCENES USED IN
CDF/NASA MAPPING PROJECT
SCENT CITY
KLAMATH
SHASTA
MODOC
EUREKA
HUMBOLDT
REDDING
LASSEN PEAK
SUSANVILLE
CLEARLAKE
SACRAMENTO
TAHOE
ALPINE
SAN FRANCISCO
MODESTO
YOSEMITE
GOLDFIELD
MONTEREY
KING
OWENS VALLEY
DEATH VALLEY
LAS VEGAS
SANTA BARBARA
ANTELOPE VALLEY
BARSTOW
BRISTOL LAKE
NEEDLES
ORANGE COUNTY
BORREGO SPRING
YUMA

FIGURE 14-3

FLOW DIAGRAM FOR CALIFORNIA COVER TYPE MAPPING PROJECT



aging all values, it was possible to match adjacent scenes to each other.

4) Brightness correction of pixel reflectance values between Landsat scenes.

Because the Landsat scenes were acquired on different dates, variations can exist in pixel reflectance values due to such things as atmospheric conditions and satellite tilt. JPL performed what they called a "rubber sheet" correction on the data which essentially equalized brightness values at all tie points and tended to give a smooth interpolation of values elsewhere. This process eliminated lines between scenes that would have been visible photographically and digitally due to changes in brightness levels.

5) Creation of the Statewide mosaic from corrected Landsat scenes.

The scenes that had been corrected for geographic position and brightness values were mosaicked together using tie-points.

6) Division of the mosaic into processing units.

The digital terrain data (discussed in Step 7) were available in a format representing 1° latitude by 1° longitude areas. The Landsat mosaic was also divided into these 1° quads, with a magnetic tape and photograph generated for each quad.

7) Registration and correction of DMA/NCIC digital terrain data to Landsat data corresponding to elevation, slope, and aspect files.

JPL corrected the terrain data to the 80 x 80 meter pixel format in the Lambert Conformal Conic Projection, computed the slope aspect and slope gradient from the elevation file, and registered all terrain data to the Landsat 1° quad data.

JPL supplied to NASA-ARC in six parts all of the corrected, smoothed, and registered Landsat and terrain data in a 1° latitude by 1° longitude format. All together there were 57 1° quads represented. NASA-ARC had responsibility for classification of the JPL data into cover type classes designated by CDF.

CDF divided the State into units called "ecozones" to facilitate classification of the data (see Figure 14-4). The ecozones, of which there are 32, were an attempt to separate different resource values from each other to prevent confusion and aid in the discrimination of classes. They helped to confine the statistics to a smaller range of resource values. Figure 14-5 shows the overlap of Landsat scenes, 1° quads, and ecozones.

The classification process actually involves four overall steps. The bulk processing of the JPL-corrected data was conducted by Technicolor Graphic Services, Inc. (TGS) on-site at NASA-ARC. The identification of classes, using field knowledge and U-2 photography was the responsibility of CDF in cooperation with NASA-ARC and TGS. The third step was the generation of final products. NASA-ARC and TGS produced final photographic and tape products. The last step is verification of the classification, a step which will not be completed until after July 1, 1979. CDF has completed photointerpretation of U-2 aerial photography. Contingency tables showing the correlation between the photo and Landsat classes, and statistical analyses, will be developed to check classification accuracy. These steps are briefly outlined in this chapter. More specific information is available from FRAP or NASA-ARC.

BULK PROCESSING

Bulk processing consisted of five major processes:

- Reformatting
- Digitization
- Data compaction
- Clustering
- Classification.

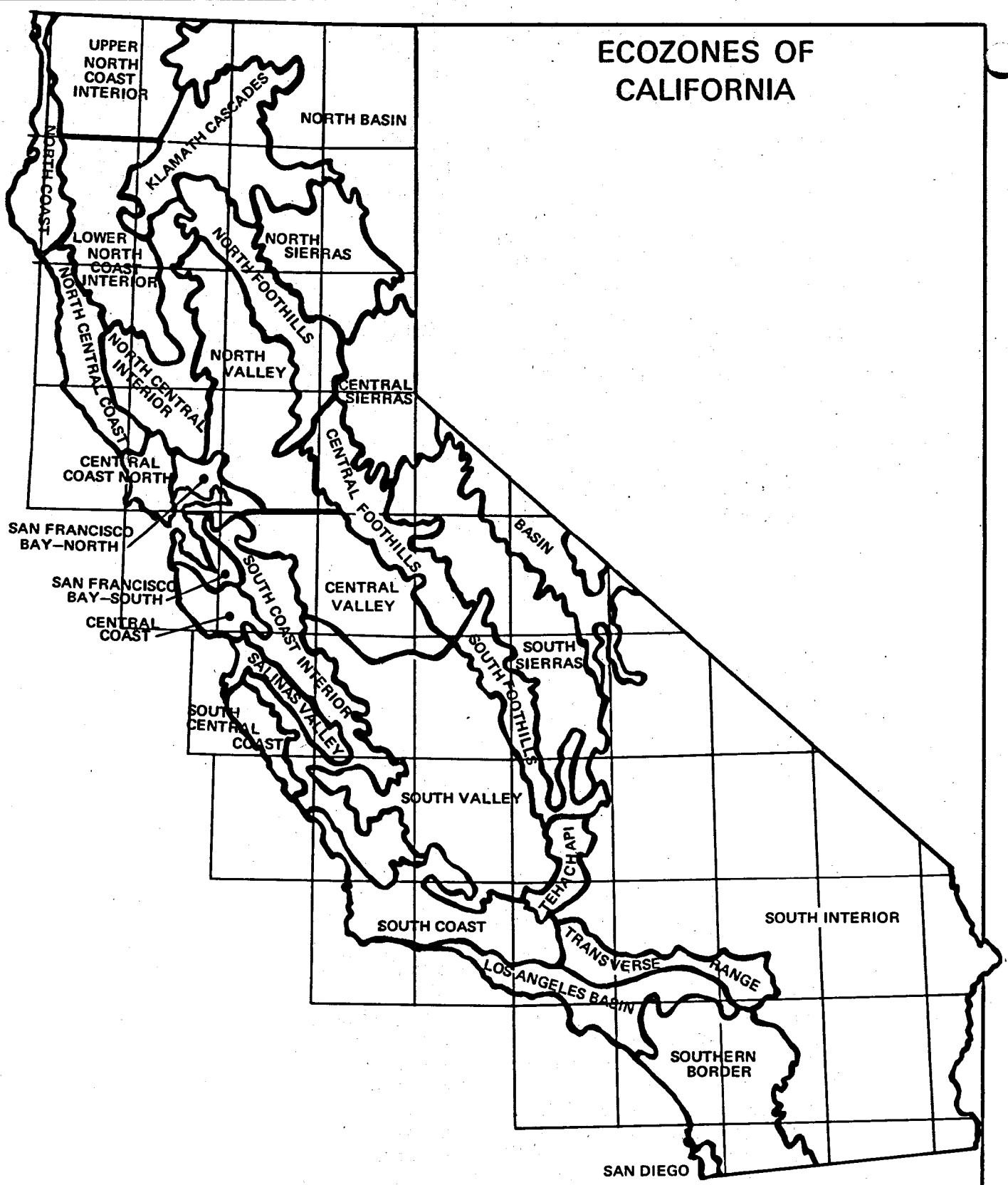
REFORMATTING

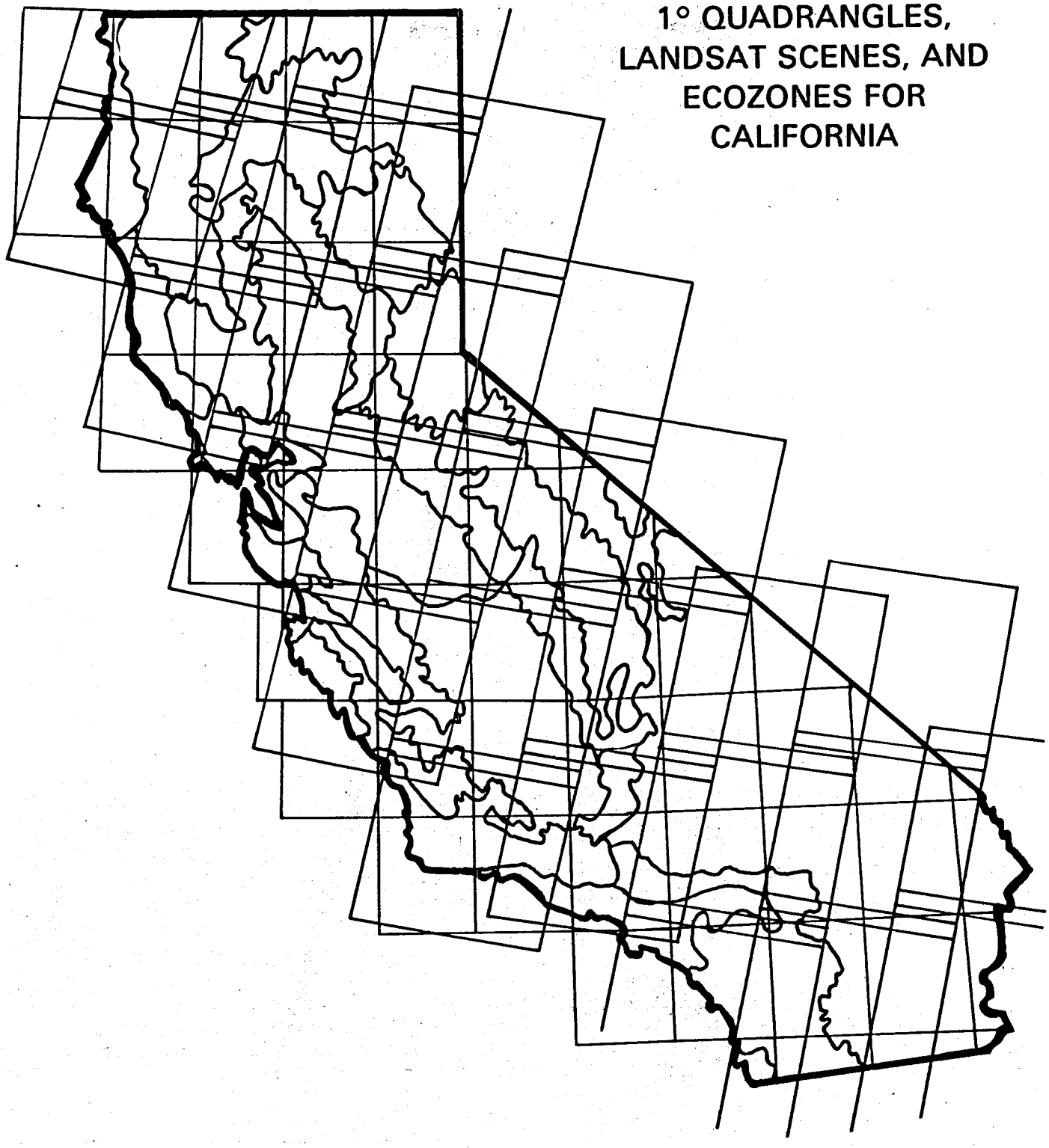
"Reformatting" is the term applied to the process of changing or reorganizing the data format as necessary to provide for compatability between computers. The amount of data to be processed in this project necessitated the use, at some stage, of every computer available for image processing at NASA-ARC. The bulk processing, requiring many millions of individual operations, was basically performed on the ILLIAC IV, one of the largest computers in the world. At least six other computers were also used.

DIGITIZATION

Digitization of boundary data occurred concurrently with reformatting. This is the process by which boundary data, such as ecozone or county lines, are put into digital form to be used with the digital Landsat data to delineate areas for processing. The ecozone boundaries were drawn on 31 topographic maps at a scale of 1:250,000 which also included county lines. Half of each of these maps rep-

FIGURE 14-4


ECOZONES OF CALIFORNIA
UPPER NORTH COAST INTERIOR
NORTH COAST
KLAMATH CASCADES
NORTH BASIN
LOWER NORTH COAST INTERIOR
NORTH SIERRAS
NORTH FOOTHILLS
NORTH CENTRAL COAST
NORTH CENTRAL INTERIOR
NORTH VALLEY
CENTRAL SIERRAS
CENTRAL FOOTHILLS
CENTRAL COAST NORTH
SAN FRANCISCO BAY–NORTH
BASIN
SAN FRANCISCO BAY–SOUTH
SOUTH COAST INTERIOR
CENTRAL VALLEY
CENTRAL COAST
SOUTH SIERRAS
SOUTH FOOTHILLS
SALINAS VALLEY
SOUTH CENTRAL COAST
SOUTH VALLEY
TEHACHAPI
SOUTH COAST
SOUTH INTERIOR
TRANSVERSE RANGE
LOS ANGELES BASIN
SOUTHERN BORDER
SAN DIEGO


OVERLAP OF
1° QUADRANGLES,
LANDSAT SCENES, AND
ECOZONES FOR
CALIFORNIA

resents a 1° quad. A digitization file was created for each boundary type on a 1° quad. A geographic reference equation was established between the digitization file and the Landsat data.

DATA COMPACTION

Data compaction involved a reorganization of the pixel spectral data into smaller, better organized units for ease of processing.

CLUSTERING

Clustering analysis divided Landsat data into unique reflectance types, or "clusters," that relate to cover types. The digitization file allowed the analysis to be conducted individually on each ecozone. For example, land covered with a certain percentage of trees has a different spectral reflectance than grasslands. The clustering analysis in an ecozone will separate the different reflectance values from each other into different clusters. Each ground cover type (grass or trees) should appear consistently the same throughout the ecozone. The computer, without prior training for cover types, developed 40 to 65 clusters within each ecozone. The procedure used in this project was an "unsupervised clustering." This means that the computer was directed to differentiate the clusters without previous resource "training."

CLASSIFICATION

The classification analysis determined the cluster to which each pixel most likely belonged based on similarity in reflectance statistics. This is called a "maximum likelihood classification." The pixels were then assigned to these clusters. A classified image in which each cover type must be identified was created on tape using this procedure.

CLASS IDENTIFICATION

The identification of classes involved assigning each of the spectral classes to a ground cover class. A ground cover classification system was created by CDF with assistance from NASA-ARC. Table 14-1 contains a list of classes and descriptions of each. Table 14-2 shows the key which was developed to aid in the discrimination of vegetation classes. There were more spectral classes than cover classes, meaning that some cover classes are likely to be characterized by two or more clusters. The use of ecozones reduced the number of expected classes within an ecozone, confining the spectral classes to a narrower range of cover types. For example, "urban" or "agriculture" classes will probably not be found in the South Sierra; or conversely, "conifer" in the Los Angeles Basin. On the other hand, some cover classes are so broad, "brush" for example, that several spectral classes will undoubtedly fall into it.

The identification of classes was accomplished in a series of workshops conducted between mid December and late April at NASA-ARC. Six CDF Foresters were placed on half-time assignment to the project for the period from October 1978 to May 1, 1979. They each had knowledge of the vegetation and land forms of different regions of the State. They worked with NASA-ARC personnel on the Interactive Digital Image Manipulation System, called "IDIMS", and used U-2 photography and field knowledge to identify spectral classes by cover class. IDIMS has a Cathode Ray Tube (CRT) display, similar to a TV screen, which allows for visualization of the data. In this way over 1,200 spectral classes were classified as to existing ground cover.

FINAL PRODUCT GENERATION

The result of the identification of all spectral classes is a Statewide map

TABLE 14-1

CLASSIFICATION

1. ALKALI FLATS - Areas essentially devoid of vegetation, highly alkaline.
2. BARE ROCK
3. BARREN - Areas with less than 5 percent vegetation, predominantly bare soil.
4. WATER
5. OTHER - Ice or snow, clouds.
6. GRASSLAND - Areas where the cover is predominantly grass. Vegetative cover is greater than 5 percent. Less than 10 percent tree canopy. There may be intermixed herbaceous species.
7. OPEN SHRUB - 5 to 24 percent of vegetative cover is shrub species. Less than 10 percent tree canopy. Substratum dominates the landscape. Shrubs are often xeric.
8. BRUSH - 25 percent or greater of vegetation is shrub species. Less than 10 percent tree canopy. May have herbaceous understory. Includes riparian vegetation.
9. CONIFER - Conifers create equal to or greater than 25 percent of the tree canopy closure. Hardwoods comprise less than 20 percent of the tree species present.
10. CONIFER-HARDWOOD - Greater than 25 percent tree canopy closure, with conifers comprising greater than 50, but less than 80 percent of the stand. Hardwood species comprise 20 to 49 percent of the stand.
11. HARDWOOD - Greater than 25 percent canopy closure of hardwood species. Less than 20 percent conifer species present.
12. HARDWOOD-CONIFER - Greater than 25 percent tree canopy closure, with hardwoods comprising greater than 50, but less than 80 percent of the stand. Conifers comprise 20 to 49 percent of the stand.
13. CONIFER-WOODLAND - Conifers create 10 to 25 percent tree canopy closure. Hardwood species comprise less than 50 percent of the species present. Herbaceous or brush understory may be present.
14. HARDWOOD-WOODLAND - Hardwoods create 10 to 25 percent tree canopy closure. Conifer species comprise less than 50 percent of tree species present. Herbaceous or brush understory may be present.
15. AGRICULTURE - Crops, irrigated fields, orchards, etc.
16. URBAN - Concentration of buildings, structures, roads, and other man-made items. May be residential or commercial.

DEFINITIONS

Grass or herbaceous - vegetation with no significant woody structure in the stem.
Brush - woody vegetation less than 5 meters tall.
Tree - woody, non-climbing vegetation, greater than or equal to 5 meters tall.
Hardwood - broad leafed, most species deciduous.
Conifer - needle leafed, most species evergreen.

TABLE 14-2

VEGETATION KEY

1.	Less than 5 percent vegetation present, background is not rock or alkali . . .	BARREN
1.	Greater than or equal to 5 percent vegetation present.	2
2.	Trees, if present, create less than 10 percent crown closure	
	Less than 5 percent shrubs present. Predominant vegetation is grass. May be other herbaceous species present. Grasses may be annual or perennial. May be sparse or dense.	GRASSLAND
	Greater than or equal to 5 percent, but less than 25 percent cover is shrub. There may be scattered herbaceous or grass vegetation. The substratum dominates the landscape	OPEN SHRUB
	Greater than or equal to 25 percent cover is shrub. Herbaceous or grass species may be present.	BRUSH
2.	Trees create greater than or equal to 10 percent crown closure	3
3.	Trees create less than 25 percent crown closure. Shrubs and/or herbaceous species may be present.	
	Predominant tree species are hardwoods.	HARDWOOD WOODLAND
	Predominant tree species are conifers	CONIFER WOODLAND
3.	Trees create greater than or equal to 25 percent crown closure	4
4.	Predominant tree species are hardwoods. Shrub and/or herbaceous species may be present.	
	Conifers comprise less than 20 percent of the species present.	HARDWOOD
	Conifers comprise 20 to 49 percent of the species present.	HARDWOOD-CONIFER
4.	Predominant tree species are conifers. Shrub and/or herbaceous species may be present.	
	Hardwoods comprise less than 20 percent of the species present	CONIFER
	Hardwoods comprise 20 to 49 percent of the species present	CONIFER-HARDWOOD

of the ground cover classes. The total acreage of each class by county within the State is listed in Table 14-3. The total acreage of forest land has been calculated on a county basis and is listed in Table 14-4, with the CALVEG and Forest Survey forest land estimates. Forest land from Landsat estimates includes the conifer, hardwood, conifer-hardwood, hardwood-conifer, conifer woodland and hardwood woodland classes which represent land with standing trees.

The differences between the acreages of the three estimates is probably due to a number of factors. First of all, the techniques used to derive the estimates are completely different. The Forest Survey derives its total acreage estimates through a determination of percentage of commercial forest plots, adjusted by an acreage-per-plot factor. These numbers were also adjusted to remove the chaparral component that had originally been included in total area estimates. In many instances this involved an educated guess because chaparral estimates existed only for the entire resource area. The CALVEG and CDF-NASA estimates are both derived from Landsat data, but through the use of very different techniques as described in detail previously in this chapter. CALVEG used a manual interpretation, 800-acre minimum, mapping unit approach and CDF-NASA used a computer interpretation, 1.6-acre minimum mapping unit approach.

An example of the JPL-created image showing unclassified or raw Landsat data is displayed in Figure 14-6. This image represents the 1° quadrangle called Weed East. Figure 14-7 shows this same area, Weed East, after the data were classified. Figure 14-8 shows how it is possible to emphasize one class. All of the conifer classes on the Fresno East quad are displayed as black and all other classes are grey. Figure 14-9 is an example of an enlargement of a portion of the data, from the northeastern corner of the Redding East quadrangle. Other final products produced or being produced, by NASA-ARC and TGS for CDF include those listed in the Overview of the Project Section of this Chapter.

VERIFICATION

The final step in the project is a verification of the classified data. The verification was designed to answer the following questions: Are the pixels that were called "conifer" (or any ground cover class on the Landsat data) actually conifer on the ground? What percentage of the time was the class identified correctly by the classification? What classes are being confused? What are the characteristics, such as composition, represented by each cover type and/or spectral class?

The verification is based entirely on photo intepretation of the largest available scale of U-2 photography (ideally about 1:30,000) of the chosen areas. At least three plots, each containing 144 pixels, were chosen randomly within an ecozone as an initial verification. These data should indicate how many plots would actually be necessary to have a statistically valid sample.

The CDF foresters performed the photo interpretation, identifying the cover class and percentage of the various types present (i.e., hardwood, conifer, brush, and grass). Line-printer maps of the classified data were generated for the plot and a designated amount of the surrounding area at the scale of the photography used for interpretation. The plot corners are found on the line-printer maps using IDIMS; and the results of the photo interpretation and computer classification are compared. Using this technique contingency tables will be developed which should provide answers to the indicated questions.

TABLE 14-3

TOTAL ACRES BY CLASS BY COUNTY

COUNTY	1 BARE ROCK	2 WATER	3 AGRIC.	4 URBAN	5 ALKALI FLATS	6 BARREN	7 GRASSLAND	8 OPEN SHRUB	9 BRUSH	10 HWD. WLD.	11 CON. WLD.	12 HWD.	13 HWD. CON.	14 CON. HWD.	15 CON.	16 OTHER	17 UNCLAS-SIFIED	TOTAL
Alameda		73,596	12,102	101,131		21,439	154,106		120,576	24,472		12,645	2,622			504	171	523,364
Alpine	10,433	12,582	5,640		182	12,090	48,232	16,986	69,183	24	156,387	17,535	12,328	18,982	85,425		3,113	469,122
Amador	2,115	3,085	1,646			7,849	57,547		50,163	74,797	16,699	92,326	8,788	33,028	33,306		573	381,922
Butte	1,127	16,518	222,012			10,219	265,278	528	196,168	67,752	3,119	71,464	46,722	79,862	111,847		1,450	1,094,066
Calaveras	296	5,216	948			4,225	79,813		95,987	129,411	12,984	169,841	16,810	69,230	74,380		792	659,933
Colusa	179	689	209,384			25,805	295,995		33,794	143,498	3,759	3,645	5,018	5,639	5,666	99	6,663	739,833
Contra Costa		53,145	62,608	54,279		19,548	195,578		91,379	23,937		15,997	1,184			31	2,204	519,890
Del Norte		61,962	11			10,099	110,409	963	30,792	22,561		42,260	76,807	115,970	208,578	517	1,962	682,891
El Dorado	10,918	48,640	1,324			12,230	68,891		111,044	84,988	92,910	213,089	52,354	210,679	229,092		5,055	1,141,214
Fresno	198,128	43,311	751,826			421,796	902,766	2,234	317,010	147,574	259,912	208,559	59,379	23,152	567,060		12,911	3,915,618
Glenn	231	1,624	174,217			25,366	386,675		49,707	109,795	14,370	8,152	10,952	22,076	39,920	520	1,155	844,760
Humboldt		83,732	5			29,026	400,833	1,490	146,324	125,395	41,751	219,951	235,167	404,193	509,615	20,703	5,699	2,223,884
Imperial	179,971	188,835	175,774		375,468			1,740,480	136,078						42,552		4,036	2,843,194
Inyo	1,402,081	8,884	38,445		178,996	107,305	17,803	4,240,547	165,807	2,385	122,876	123		8,053	120,109		111,467	6,524,881
Kern	59,845	7,848	629,319		113,314	515,660	1,439,359	1,355,597	285,218	144,731	6,632	161,230	346,874	28,754	87,087		11,019	5,192,487
Kings		3,452	312,584			136,401	410,714		18,246	7,101		2	123				2,897	891,520
Lake	567	36,436	6,504			8,359	117,974		171,439	233,474	34,646	59,234	77,650	38,503	62,687	1,135	1,894	850,502
Lassen	1,221	34,413	3,226			401,269	199,121	1,241,319	501,126	25,790	177,392	6,262	11,025	32,473	354,282		5,354	2,994,275
Los Angeles	4,413	149,931	20,145	562,418	15,396	15,847	404,258	588,383	791,278	23,991	11,385	546	2,608	2,084	22,023	22,958	3,930	2,641,594
Madera	38,160	6,699	250,924			106,556	195,493	2	78,224	117,528	77,992	129,828	8,904	19,628	255,192		1,968	1,287,098
Marin		48,108	10,976	19,657		16,264	133,635	12,272	13,812	46,255		31,498			11,274	61,132	46,327	451,210
Mariposa	18,770	8,095	1,875			16,384	159,669		168,689	92,123	38,365	130,312	8,251	23,119	262,491		1,662	929,805
Mendocino	143	2,626	9,142			20,908	305,953		249,971	247,479	297,169	158,026	356,742	233,997	316,224	65,874	40,641	2,304,895
Merced		10,708	514,608			107,357	528,883		74,157	15,968		2,010	397	33	340		3,490	1,257,951
Modoc		104,359	13,614			237,783	344,375	1,121,661	292,484	3,116	10,955	151	923	2,275	566,732		2,242	2,700,670
Mono	45,913	43,558	87,517		68,434	81,149	30,245	889,557	118,935	11,665	360,630	6,369	1,168	23,786	202,345		18,743	1,990,014
Monterey		2,874	165,560			77,879	658,604		884,110	41,583	19,836	115,026	80,520		52,069	6,608	33,413	2,138,082
Napa		22,806	5,138	6,941		9,433	122,585		84,383	156,716	11,615	39,358	39,405		7,042			505,422
Nevada	3,484	5,658	536			10,908	35,019	7	181,390	53,549	68,418	34,006	17,709	120,668	88,611		860	620,823
Orange		2,013	12,477	97,722		4,919	123,413	12,145	103,703	35,520		13,396				117,452	4,894	527,654
Placer	3,342	53,339	33,723	1,932		32,128	121,259		147,735	16,864	69,437	72,158	73,122	173,149	152,245		2,218	952,651
Plumas	254	33,026	845			55,080	32,816	87,769	548,867	7,539	65,280	120,429	81,867	117,095	510,093		4,137	1,665,097
Riverside	375,521	68,488	104,345	47,612	211,009	33,323	342,306	2,480,344	716,554	84,332	6	55,451			80,645	32,753	7,365	4,640,054
Sacramento		10,692	180,455	84,230		7,631	340,690		3,947	9,210		2,978						639,833
San Benito		68	21,450			12,480	313,135		489,946	24,576		14,050	7,246		44,684	5,606	31,409	964,650
San Bernardino	825,967	15,324	34,760	138,045	959,982	997,733	392,846	8,619,205	515,518	25,775	12,561	10,942	1,580		236,941	2,411	16,634	12,806,224
San Diego	29,817	76,851	19,220	87,984	68,926	25,532	453,565	560,621	902,272	212,725		141,046			27,552	186,251	11,720	2,804,082
San Francisco		31,814		23,049		2,633	2,687					838						61,021
San Joaquin		5,795	507,811			61,134	298,634		30,386	1,077		289	63				3,830	909,019
San Luis Obispo		67,259	99,094			138,182	1,083,842		616,317	119,022		40,436	17,085		2,053	925	8,715	2,192,930
San Mateo		46,923	1,286	54,468		13,036	63,157	6,899	11,222	48,775		28,015	12,130	21,789	15,314	35,200		358,214
Santa Barbara		35,390	40,723	31,068		31,241	701,489		616,423	170,499		60,473	1,501			14,109	43,349	1,746,265
Santa Clara		9,230	15,488	135,561		8,682	140,592	4,515	313,782	113,902		46,552	13,127	16,428	13,675	65	1,901	833,500
Santa Cruz		66,672	6,179	23,014		14,090	29,923	2,725	17,415	30,950		15,370	8,701	15,623	9,829	23,059	17,941	281,491
Shasta	1,547	23,146	7,684			54,373	264,869	21,885	404,019	349,640	177,164	218,254	300,109	290,468	338,728	169	3,844	2,455,899
Sierra	225	2,700	101			21,159	51,110	16,227	92,722	6,482	81,878	54,574	28,884	82,925	175,129		539	614,655
Siskiyou		76,189	24,546			159,663	871,897	308,417	290,597	199,489	183,064	118,749	305,558	360,587	1,121,353	7,812	6,568	4,034,489
Solano		45,587	158,848	11,683		12,823	318,941		11,974	9,671	1,252	5,765	2,530				77	579,151
Sonoma		13,609	34,808	18,409		50,265	319,697	7,652	78,738	116,144	38,693	58,617	124,925	101,166	39,391	43,411	28,952	1,074,477
Stanislaus		4,056	399,895			42,314	372,895		140,995	1,615		111	1,726				807	964,414
Sutter		798	233,658			6,932	151,746		3,836								433	397,403
Tehama	207	2,915	70,151			30,246	647,832	923	344,271	375,722	32,714	44,745	84,686	66,435	159,207	394	3,926	1,864,374
Trinity	11	21,084	10			19,509	238,865	2,115	238,443	186,685	107,711	98,865	184,431	296,527	633,795	13,102	3,206	2,044,359
Tulare	209,182	11,851	415,417		434	269,646	402,273	27,486	188,960	298,301	298,301	257,421	31,334	64,088	607,258		7,809	3,089,761
Tuolumne	89,528	23,964	598			41,572	61,172		210,666	111,196	198,561	99,181	6,658	73,750	534,455		5,384	1,456,685
Ventura		12,312	10,564	180,078		18,069	421,268	2,430	467,681	65,210	2,836	4,675			417	4,739	1,057	1,191,336
Yolo		1,843	183,668	3,723		28,984	338,489		26,095	58,867	90	1,166	1,911				75	644,911
Yuba	2,025	3,977	75,365			10,334	107,792	124	90,560	22,389	202	15,212	14,600	38,049	19,726		388	400,743
TOTAL ACRES	3,515,621	1,856,305	6,380,779	1,683,004	1,992,141	4,672,867	17,079,013	23,373,508	13,151,118	4,879,835	3,109,552	3,549,203	2,784,204	3,234,263	9,038,439	667,539	548,870	101,516,260

TABLE 14-4

CALIFORNIA FOREST LAND ESTIMATES
(IN ACRES)

RESOURCE AREAS/ COUNTY	CALVEG	BASED ON FOREST SURVEY	LANDSAT NASA-CDF
North Coast (Totals)	5,107,300	4,467,000	4,090,821
Del Norte	610,350	607,000	466,176
Humboldt	2,008,100	1,824,000	1,536,072
Mendocino	1,905,950	1,585,000	1,609,637
Sonoma	582,900	451,000	478,936
Northern Interior (Totals)	8,706,500	9,389,000	6,662,553
Lassen	1,151,950	1,232,000	607,224
Modoc	1,095,150	1,241,000	584,152
Shasta	1,699,050	2,007,000	1,674,363
Siskiyou	2,776,300	3,089,000	2,288,800
Trinity	1,984,050	1,820,000	1,508,014
Sacramento (Totals)	7,104,300	6,598,000	5,616,718
Butte	475,900	494,000	380,766
Colusa	233,150	184,000	167,225
El Dorado	819,300	780,000	883,112
Glenn	363,900	266,000	205,265
Lake	530,950	441,000	506,194
Napa	285,550	260,000	254,136
Nevada	474,950	455,000	382,961
Placer	569,750	553,000	556,975
Plumas	1,354,400	1,314,000	902,303
Sacramento	10,200	14,000	12,188
Sierra	459,550	433,000	429,872
Sutter	00	20,000	00
Tehama	1,195,900	1,118,000	763,509
Yolo	135,600	91,000	62,034
Yuba	195,200	175,000	110,178

TABLE 14-4 (Continued)

CALIFORNIA FOREST LAND ESTIMATES
(IN ACRES)

RESOURCE AREAS/ COUNTY	CALVEG	BASED ON FOREST SURVEY	LANDSAT NASA-CDF
San Joaquin (Totals)	9,221,200	7,277,000	7,444,280
Alpine	336,100	357,000	290,681
Amador	208,400	192,000	258,944
Calaveras	323,650	389,000	472,656
Fresno	1,672,650	1,116,000	1,265,636
Kern	1,678,650	701,000	775,308
Kings	33,700	12,000	7,226
Madera	735,700	519,000	609,072
Mariposa	684,400	518,000	554,661
Merced	115,900	37,000	18,748
Mono	1,025,900	1,011,000	605,963
San Joaquin	26,350	28,000	1,429
Stanislaus	12,200	117,000	3,452
Tulare	1,513,200	1,289,000	1,556,703
Tuolumne	854,400	991,000	1,023,801
Southern California (Totals)	3,830,050	3,145,000	1,781,414
Imperial	186,950	00	42,552
Inyo	797,150	623,000	253,546
Los Angeles	356,750	527,000	62,637
Orange	18,050	44,000	48,916
Riverside	488,550	224,000	220,434
San Bernardino	659,000	370,000	287,799
San Diego	62,450	245,000	381,323
San Luis Obispo	625,550	153,000	178,596
Santa Barbara	298,450	508,000	232,473
Ventura	337,150	451,000	73,138
Central Coast (Totals)	3,256,050	1,698,000	999,710
Alameda	154,550	92,000	39,739
Contra Costa	165,650	62,000	41,118
Marin	90,200	112,000	89,027
Monterey	1,302,650	637,000	309,034
San Benito	730,800	218,000	90,556
San Francisco	00	00	838
San Mateo	104,350	109,000	126,023
Santa Clara	491,150	284,000	203,684
Santa Cruz	186,850	156,000	80,473
Solano	29,850	28,000	19,218
	37,225,400	32,574,000	26,595,496

SUMMARY OF THE PROJECT

A Statewide acre-by-acre map of the distribution of ground cover classes, current as of August 1976, was provided as a result of this project. The estimated cost is less than three-tenths of a cent per acre, including computer processing, personnel, and final product generation costs. Analysis on systems less extensive than the NASA-ARC computer facility would probably cost more, although some techniques developed in this project can be applied to other systems to increase their capabilities and efficiency.

The mosaicked raw Landsat data provides a geographically referenced information base. The addition of terrain data enlarges the capabilities of this information base for numerous uses in resource management. The ground cover classification adds another level of data to the base. In this manner essentially unlimited levels of resource information can be added, acre-by-acre, or region-by-region, Statewide, which will allow for vertical data integration for resource management decisions.

EVALUATION OF THE PROJECT

Evaluation of this project was incomplete at the time this Report was written. Verification is not yet complete and there has been insufficient time for analysis of all aspects of the project. However this section will attempt to briefly identify problems, needs, and further considerations that have become evident during the course of the project.

This project was limited to analysis techniques which could succeed in achieving the rigorous schedule requirements. Complete acquisition by NASA-ARC of Landsat data did not occur until October 30, 1978, more than four months after the project was initiated. Between that time and mid-April 1979 approximately 100 million acres were geographically registered and classified. This represents processing of nearly one million acres per day.

Problems with geographic registration of the data became evident when classified photo products were being produced. It was observed that edges of classified data, i.e., edges of quads, State boundaries, county boundaries, did not, in all instances, match with the boundaries which had been digitized separately from maps and superimposed onto the Landsat data. Exact registration was expected because of JPL's assurance that their techniques could provide an accuracy of better than plus-or-minus one pixel. Further investigation led to the conclusion that the amount and direction of mislocation varied throughout the State from a 3- to a 12-pixel error. The exact cause of this problem has not yet been identified. Possible contributing factors include:

> The 1:250,000 USGS maps used for registration are accurate only to plus or minus three pixels.
>
> Photographic enlargements of Landsat frames used for locating tiepoints may be distorted by the enlargement process.
>
> Mathematical equations used for transformations or the computer programs used for processing may contain, as yet, undetected errors.

JPL has been unable to identify the exact problem, and they have not published enough details of their programs for other organizations to isolate the issue. The technology for creating such large mosaics is in a state of development. The California mosaic is the largest digital mosaic of Landsat data that has been attempted to date. Geographic accuracy is sufficient for nearly every conceivable resource purpose, and the ability to exactly register

FIGURE 14-6

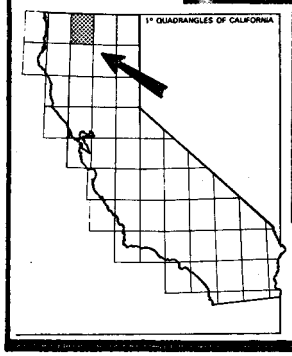


Image of the raw, mosaicked (unclassified) Landsat data for the 1° quadrangle called Weed East. Mount Shasta is the snow covered peak in the middle of the right side of the image.

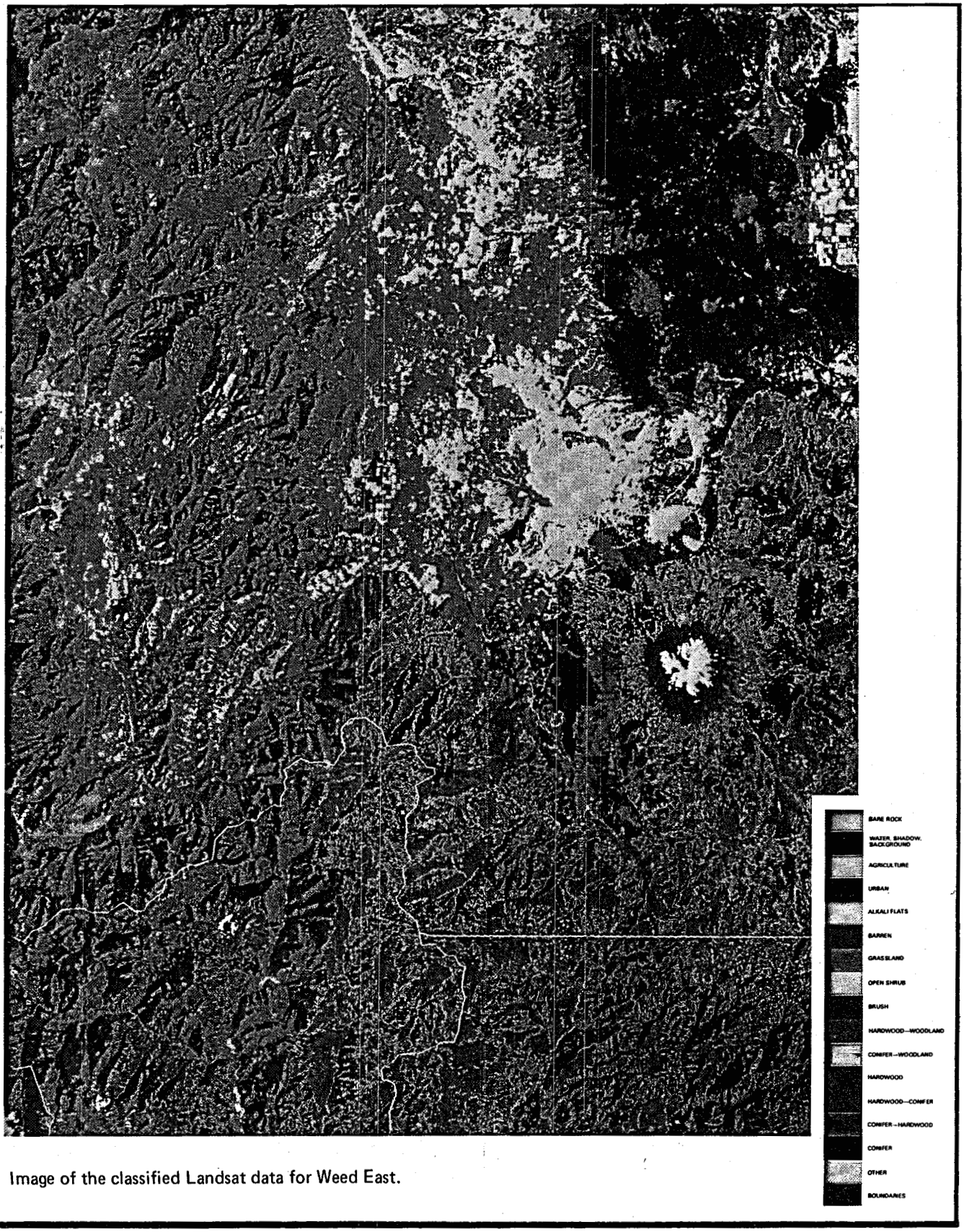


Image of the classified Landsat data for Weed East.

FIGURE 14-8

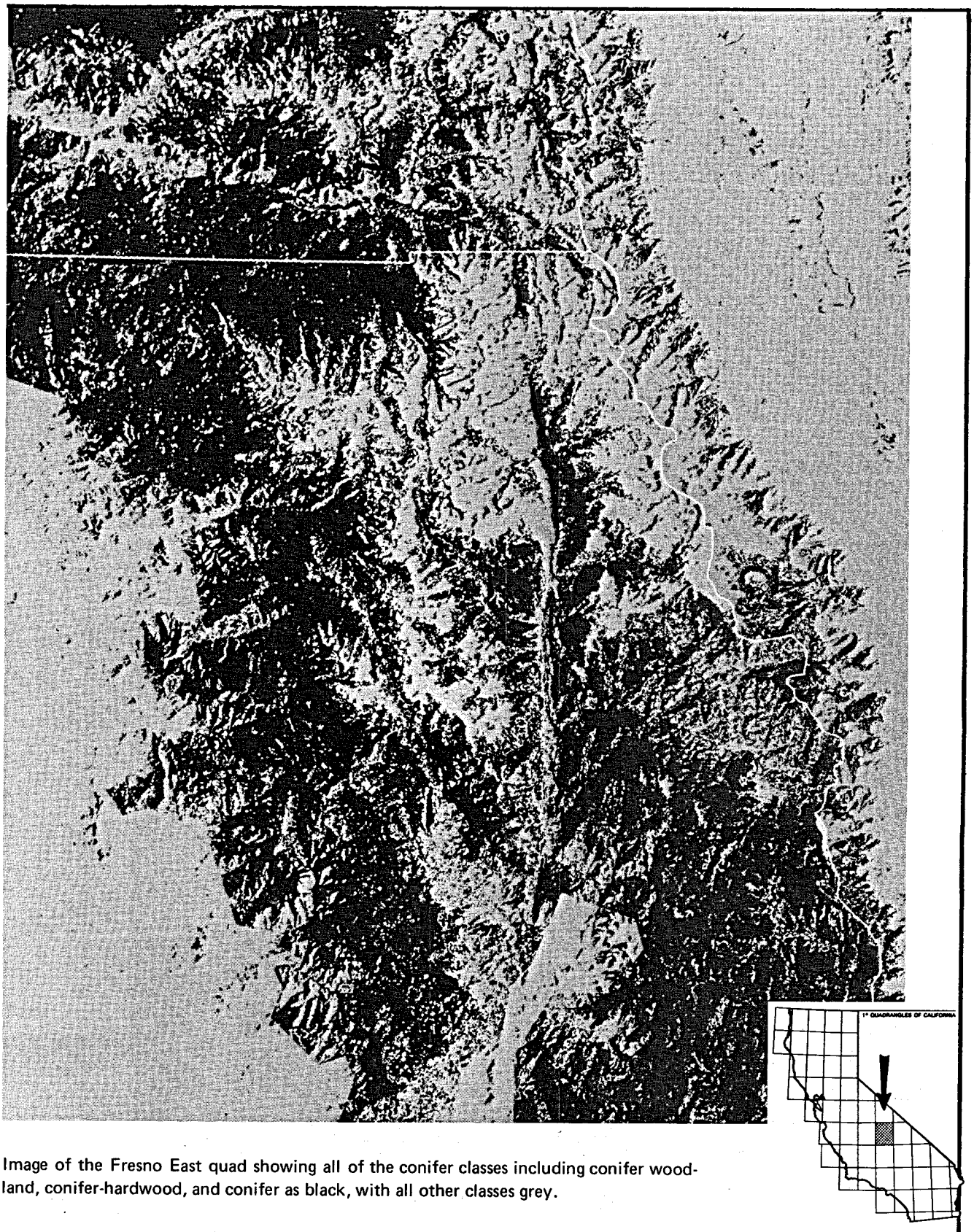


Image of the Fresno East quad showing all of the conifer classes including conifer woodland, conifer-hardwood, and conifer as black, with all other classes grey.

(plus-or-minus one pixel) data geographically on large areas can most likely be achieved with the use of 1:24,000 maps (7 1/2' quads). However, the expense of the project would also increase.

There were also some problems that became evident with the classification of the data into cover classes. In certain cases a spectral class appeared to be representative of more than one ground cover class. In some instances, this could be resolved with the use of terrain elevation data. For example, in some areas brush at low elevations appears very similar spectrally to the conifer type at higher elevations. This is true in parts of the South Sierra Ecozone. By using the elevation data contained in the digital terrain data the affected spectral cluster(s) can be split into two classes by defining an elevation at which a change in cover type might occur. For the brush and conifer ambiguity in the South Sierra Ecozone this elevation was at 5,000 feet. This technique is shown in Figure 14-10. While this is a fairly gross ecological assumption, it is one technique that provides an overall refinement in the classification. All ambiguities cannot be resolved with terrain data. Other ambiguities require other approaches. Future work in smaller areas can utilize slope, elevation, and aspect data to further refine results.

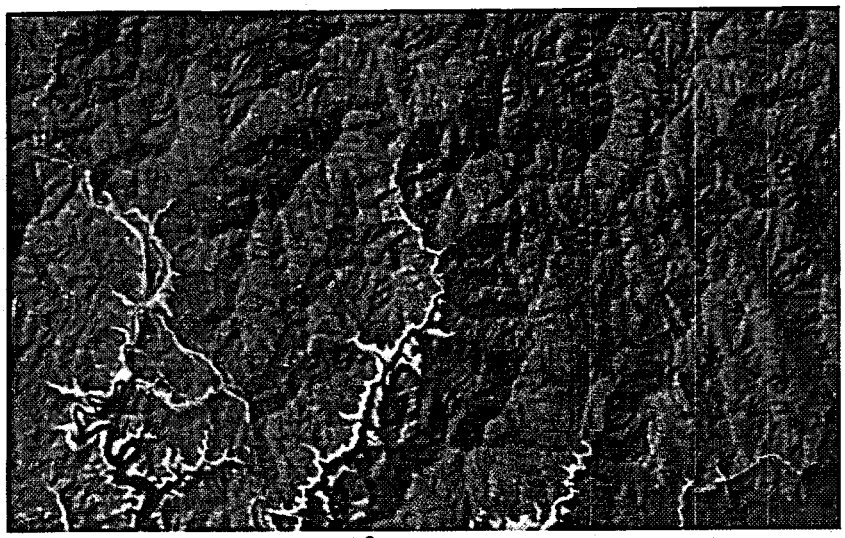
Use of "supervised" or "guided" clustering can resolve other class confusions and permit a finer definition and distinction of ground cover classes. An unsupervised clustering approach was used in this project because it is the fastest technique for classification. Supervised clustering involves identification of resource classes in the spectral data based on known ground conditions. The computer is "trained" to recognize these representative spectral classes or groups of pixels, and classifies other pixels accordingly. On small units of the State, this technique has demonstrated a clear capability to break down the cover types used in this project into species, crown closure, density, and brush classes.

Accuracy of the classification has yet to be determined, but evidence suggests that some cover classes are likely to be more accurate than others. The hardwood woodland and conifer woodland classes posed some problems. With a tree canopy closure range of 10 to 25 percent much of the background reflectance influences the spectral signature of the pixel. This means that spectral classes with a wide range of spectral values will represent woodland classes. The information being derived from the verification should provide an assessment of the class accuracy as well as an indication of the vegetation composition of the classes. That is, the definitions of the classes may not have been optimal in terms of Landsat's discriminatory ability. The percent cover-type data from the verification may indicate that different class definitions would have been more successful.

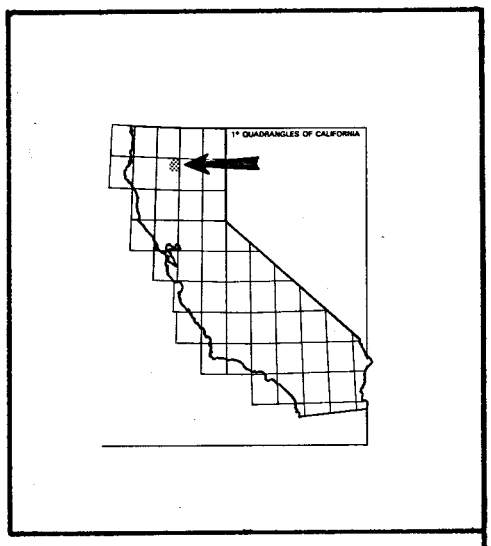
The ecozones which were delineated were the first attempt at a Statewide stratification. There was no prior knowledge as to how many such zones might be necessary or how large each should be in order to optimize both processing time and classification accuracy. The zones were based somewhat upon previous delineations of Statewide vegetation/climatic regions. In the identification of cover-type classes, classifications were made on the basis of the most correct identification for the ecozone as a whole because the zones were supposedly representative of similar cover-types throughout.

Nearly all the material in the data set was taken from one month, August 1976. One date cannot be optimum for identification of all the various resources of the State, but it does provide a datum upon which projections can be based. For instance, being in the midst of the 1976-77 drought the data

FIGURE 14-9



a.



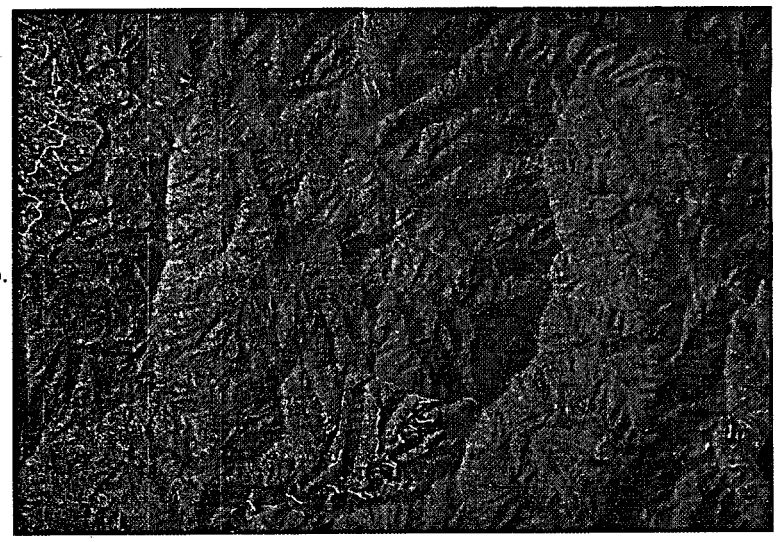
a. Unclassified Landsat Data

b. U-2 Photograph

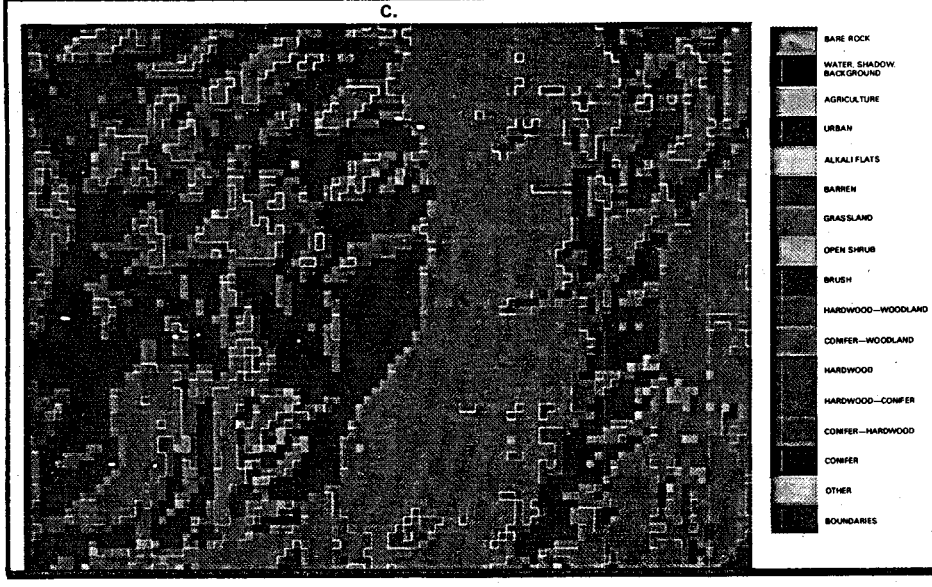
c. Classified Landsat Data

These are images of an area in the northeast corner of the Redding East quadrangle. Each of the small squares in (c) represents a pixel.

b.



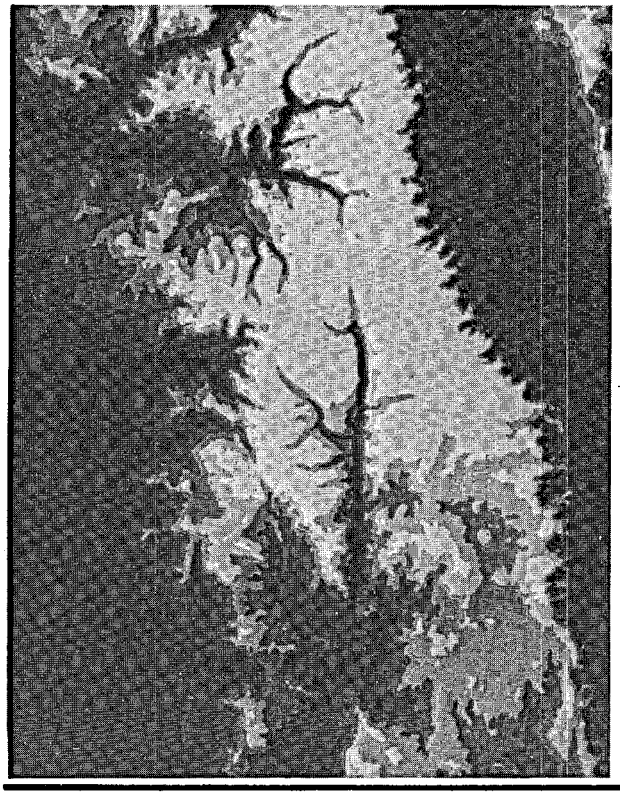
c.

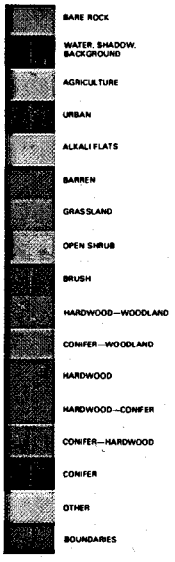


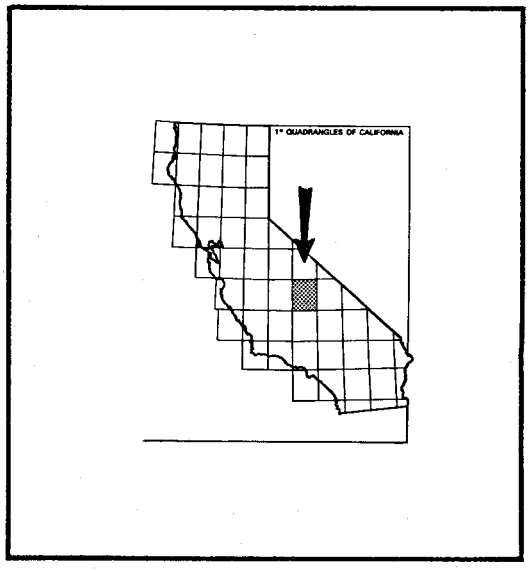
a.

c.

b.







A demonstration of the use of terrain data on the Fresno East quad. On the original classification (a) brush and conifer classes were confused. The terrain data (b) was applied to the Landsat data, changing the brush class to conifer above 5,000 feet. The final classification (c) displays the change.

set can indicate, in the long run, the extended effect of the drought. Mortality caused by drought stress was relatively insignificant in August 1976. Subsequent analyses have shown that the magnitude of the stress effects may be very important.

The data set can be updated with new data in the future using the same techniques employed in this project. Updates can provide very useful information on changes. For example, clear-cutting sites can be easily located with two dates. More subtle changes will be examined in the future.

Probably the greatest benefits to be derived from this data set will be its capability for vertical data integration and as an estimating tool for sample designs for resource inventories. Multistage sampling methods with Landsat data coupled to aerial photos and ground checking have proven valuable and efficient for conducting timber inventories on a research basis on small areas in California and the Pacific Northwest. Thus, Landsat has capabilities for resource utilization other than just cover type analysis. A great deal of information is provided in the current data set generated by the analysis of Landsat data, and future investigations into the utilization of the technology are likely to reveal many potentials for satisfaction of data needs as mandated by FRAPA.

CHAPTER FIFTEEN

IMPORTANT FOREST RESOURCES LEGISLATION

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POTENTIAL REGULATORY CONFLICTS	339

INTRODUCTION

The use, ownership, and management of forest and range resources is affected by hundreds of State and federal laws enacted during the past 100 years. To list all of them would be impracticable. Therefore, only the major laws, or the parts of them that most frequently impact on activities on California forest and range lands are included in this Assessment. Brief summaries of these laws are shown in Appendix Item XII and also on Table 15-1. They are classified into the three broad categories of:

Laws relating to protection and management.

Laws which regulate the use of forest lands.

Laws which authorize public assistance (incentives) to the private forest landowner.

The complete text of these laws, and others not listed in the Assessment, can be located in large libraries and legal offices in these publications:

United States Statutes-at-Large

United States Code

United States Code Annotated

California Codes (most State laws pertaining to forest and related lands are contained in the Public Resources Code, Government Code, Fish and Game Code, Revenue and Taxation Code and the Health and Safety Code.)

The staffs of various boards and departments within the Resources Agency were interviewed to discuss policy considerations, regulations, and management responsibilities associated with these laws. Agencies contacted included the:

Board of Forestry
State Water Resources Control Board
Department of Forestry
Department of Fish and Game
Department of Water Resources
Department of Parks and Recreation
Division of Mines and Geology
(Department of Conservation)
Division of Resource Conservation
(Department of Conservation)

ADMINISTRATION OR LEGISLATIVE CHANGES

Several matters which surfaced in these discussions seem to suggest the need for administrative or legislative changes. For example:

Jurisdictions overlap in the regulation of timber operations on privately owned land. Improper timber harvesting can result in violation of laws and regulations involving water quality control, fish and game, or other resources as well as the Forest Practice Act itself.

Under the Forest Practice Act a timber harvesting plan (THP) prepared by a Registered Professional Forester must be submitted to the Director of the Department of Forestry and found in concurrence with provisions of the act before timber operations may begin on any nonfederal timberland in California.

To assure a multidisciplinary approach, the Secretary for Resources has directed that the Department of Fish and Game, the State Water Resources Control or the Regional Water Quality Control

TABLE 15-1

LAWS	EFFECT OF LAWS ON RESOURCE USE									
	RECREATION	WILDERNESS AND OTHER RESTRICTED AREAS	WILDLIFE	FISH	RANGE	TIMBER	WATER	MINERALS	URBAN FORESTRY	ENERGY
LAWS RELATING TO PROTECTION AND MANAGEMENT State: - Prevention and Control of Forest Fires - Hazard Reduction - Prescribed Burning - Protection of Forest Lands - Range Revegetation and Improvement - Wildland Fire Prevention and Resource Management Act - Vegetation Management Study Bill	+1	+1	+2	+2	+2	+2	+2	0	+1	+1
State: - Organization of Department of Forestry - Professional Foresters Law - State Forests - California Resource Conservation Act - Forest Resource and Policy Act Federal: - Organic Administration Act (USFS) - Taylor Grazing Act - Multiple Use - Sustained Yield Act - Federal Water Project Recreation Act - Land and Water Conservation Fund Act - Renewable Resources Planning Act (RPA) - National Forest Management Act - Federal Land Policy and Management Act - Resource Conservation Act (RCA)	+2	0	+2	+2	+2	+2	+2	+1	0	0
State: - California Wild and Scenic Rivers Act - California Wilderness Act - California Coastal Zone Act Federal: - Wilderness Act - Wild and Scenic Rivers Act - Coastal Zone Management Act - Park Service Organic Act	+2	+2	+1	+2	-1	-2	+1	-2	0	-2

+2 Encourages +1 Moderate Encouragement 0 Neutral -1 Moderate Limitation -2 Discourages (Or Prohibits)

TABLE 15-1 (Continued)

LAWS	EFFECT OF LAWS ON RESOURCE USE									
	RECREATION	WILDERNESS AND OTHER RESTRICTED AREAS	WILDLIFE	FISH	RANGE	TIMBER	WATER	MINERALS	URBAN FORESTRY	ENERGY
LAWS WHICH REGULATE USE OF FOREST LANDS										
State:										
- Porter-Cologne Water Quality Act										
- California Environmental Quality Act										
- California Species Preservation Act										
- California Endangered Species Act										
- Native Species Conservation and Enhancement Act	+1	0	+2	+2	-1	-1	+2	-2	+1	-1
Federal:										
- Fish and Wildlife Coordination Act										
- National Environmental Protection Act										
- Endangered Species Conservation Act										
- Federal Water Pollution Control Act										
- Clean Water Act										
- Clean Air Act										
State:										
- California Land Conservation Act										
- Forest Practice Act	+1	0	+1	+1	+2	+2	+1	0	+1	+1
- Forest Taxation Reform Act										
Federal:										
- Anadromous Fish Conservation Act	+2	0	0	+2	0	0	0	0	0	0
- Wild Horse and Burros Act	+1	0	-1	0	-1	0	0	0	0	0
LAWS WHICH AUTHORIZE PUBLIC ASSISTANCE (INCENTIVES) TO THE PRIVATE FOREST LANDOWNER										
State:										
- California Forest Improvement Act										
- California Urban Forestry Act	+2	0	+2	+2	+2	+2	+2	0	+2	+1
Federal:										
- Cooperative Forestry Assessment Act										
- Agricultural Conservation Program										
- P.L. 566										

+2 Encourages +1 Moderate Encouragement 0 Neutral -1 Moderate Limitation -2 Discourages (Or Prohibits)

TABLE 15-1 (continued)

Boards, and other agencies as appropriate be a part of several review teams established to assist the Director of Forestry in reviewing timber harvesting plans as to environmental adequacy under the Forest Practice Act, District Rules, and related Board of Forestry regulations. This approach has worked very well in achieving better plans utilizing the expertise of many disciplines. However, participation by agencies such as the Department of Fish and Game and the Regional Water Quality Boards does not relieve the landowner of the need to comply with these agencies' own independent regulatory requirements.

Under the act the decision as to whether the THP is in concurrence is made by the Director of CDF. There have been a number of cases where non-concurrences have been filed by agencies participating in the review teams, which were then overruled by the Director in approving the plan. There is no appeal from the Director's approval of a THP except through the courts. However, when the Director has denied a plan, the applicant may appeal his decision to the Board of Forestry. Following a hearing, the Board may sustain the Director or it may approve the plan.

It has been suggested that the Director of the Department of Fish and Game, the Chairman of the State Water Quality Control Board, or other agency heads should be given a right to appeal to the Board of Forestry in the event of the Director's approval of a THP on which the other agency head filed a non-concurrence. This would require a change in the statute to provide a mechanism which does not now exist.

Such a change would provide other agencies with a statutory role in the Forest Practice Act, such as they presently have under the California Environmental Quality Act (CEQA) (Chap. 1433, Div. 13, Sec. 21000, P.R.C.). It might also result in better quality input by the review team participants if their statements of non-concurrence would be subjected to substantiation in a possible appeal process.

Another problem arises from the fact that attempts are sometimes made to use the regulatory powers of the Forest Practice Act for a purpose that is tantamount to land use classification, a purpose not authorized by the Act. Thus, there have been continual efforts before both the Board and the Director to secure, through their regulatory authority, a moratorium on cutting, or regulatory restrictions so severe as to essentially preclude cutting. The Board and the Director have authority to adopt special logging regulations for Special Treatment Areas such as designated Wild and Scenic Rivers, Coastal Zone Special Treatment Areas; and elsewhere. In the absence of any general land use classification authority, the Board and the Director may be pressured to deny THPs or to make inordinately restrictive logging rules as a means for achieving a de facto land use change; i.e., the prohibition of logging. Neither the Board's jurisdiction nor the procedures for forest practice regulation have been designed for the resolution of land use classification issues.

POTENTIAL REGULATORY CONFLICTS

A number of other current or potential conflicts have been identified in the course of discussions with Department of Forestry staff and others concerned with forest resource issues. They are raised here so that they may be monitored and studied to provide essential groundwork for appropriate legislative consideration at the proper time.

- The Section 208 Contract Study is the result of a cooperative effort of the State Water Resources Control Board and the Board of Forestry to

achieve coordination between Federal Water Law, State Water Law, and State Forest Practices Law. The recommendations resulting from that study will not be available until after completion of the FRAP Report and additional time may be required to implement some of those recommendations. The process for interagency coordination embodied in this contract appears to be both innovative and potentially effective. But the outcome of the contract should be evaluated after its completion in order 1) to identify any unresolved problems of coordination in the water quality area, and 2) to assess the extent to which the contractual method used in this instance may be an appropriate way to resolve other interagency coordination problems.

- Federal Clean Air Act provisions may conflict with certain State forest resource management objectives embodied in law. For example, existing air quality standards for national park and wilderness areas and State fuel management objectives for forest and wildlands may be incompatible where prescribed burning of private lands near park and wilderness areas is necessary for fuel hazard reduction. Consideration should be given to initiating a cooperative study of such problems, involving each of the concerned governmental agencies, and adapting the procedures embodied in the Section 208 Contract Study dealing with water quality.

- The National Forest Management Act of 1976 established a far-reaching and complex framework for establishing objectives and planning the use and mangement of the 14.2 million acres of forest land and associated rangelands on the national forests of California. It is by no means clear that the objectives and plans thus far developed for California's national forests give adequate attention to State interests. For example, the current federal procedures call for establishing timber harvest schedules for the national forests without reference to the timber supply outlook for related private lands. As a result, national forest timber harvest schedules are developed with inadequate attention to the State's concern for long term stability of forest-dependent industries. Problems of national forest policy from the standpoint of the State are currently being addressed by the U.S. Citizens Task Force on Forest Service Management in California appointed by the Secretary for Resources. When available, the report of the Task Force should provide more detailed identification of specific issues in this area and suggestions for achieving better coordination between national forest planning activities and State concerns.

- Rapid expansion of residential settlement into what previously had been forest land has created serious problems throughout the urban/forest interface in the State. One of the most important of these problems concerns the responsibility for providing structural fire protection in many of these situations where the land has been determined to be an area for which the State is responsible pursuant to existing statutes. But CDF has neither funds nor authority to provide structural protection within such areas, except in particular contractual situations. State and local jurisdictional issues in these situations are complex. The Board of Forestry is currently conducting a study of existing fire protection problems, programs, and policies in such areas. The results of its study should define specific State/local jurisdictional problems and suggest possible solutions. However, other aspects of the urban/forest land interface

besides fire protection ought to be promptly investigated.

- The Forest Taxation Reform Act of 1976 provides for the classification of all privately owned forest land into Timberland Preserve and non-timberland preserve zones. Both classification and assessment processes are carried out by county officials, opening the way to significant variation among counties as to how the forest land is classified and even as to assessment practice. The act has been in effect for sufficient time so that a review of the practices under the act should be undertaken to determine whether or not it is being applied in reasonably consistent fashion by the counties involved.

- The Z'Berg-Nejedly Forest Practice Act of 1973, as presently applied, regulates timber harvesting on private forest land. It is not comprehensive in its regulatory scope. As a matter of administrative practicality, the Board of Forestry has not required Timber Harvest Plans on operations of less than three acres in area; many forestry practices not conducted as part of timber harvesting operations are exempt from regulation; only that timber harvesting which involves "commercial operations" is regulated; and some species of trees that are cut have not been designated as commercial species by the Board. Although problems in this area do not appear to be severe at this time, they could well become more important as forest management practices become more extensive and as the use of wood for energy purposes expands. Any action to expand the scope of forest regulation to cover problems in these areas could lead to new or expanded jurisdictional and coordinating problems between the forestry agencies and those with responsibilities for pesticides, wildlife, water quality, and the like.

- There are statutory incompatibilities between FRAPA and the federal RPA and RCA functions. The FRAPA Assessment does not completely interface with the RPA and RCA which makes coordination of the process and interchange of data more difficult. The land area which FRAPA is charged to assess is limited to "forest land" as defined in the Act. The federal "Forest and Rangeland Renewable Resources Act of 1974" addresses the uses, demand for and supply of the renewable resource on all forest, range, and other associated lands. Therefore, a major purpose of FRAPA, to complement and augment data and analyses of the RPA, is blunted by a much smaller, statutorily-fixed, land and resource base. Similarly the Resource Conservation Act addresses soil, water and related resource problems on an area much larger than that considered by FRAPA.

STATE AND COOPERATIVE STATE/ FEDERAL FORESTRY PROGRAMS

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INTRODUCTION

Private and non-federal public lands provide a major part of the timber harvested in California, plus major portions of livestock grazing, hunting, and outdoor recreation. The cut of timber on these lands in 1977, for example, amounted to about 63 percent of California's total production (Stanley 1979). Rangeland in private ownership produces 13.1 million animal-unit-months (AUMs) of feed annually, or 94 percent of the natural range production of the State. This supply is more than half the total feed required for meat animals produced on California farms and ranches (Reed 1974).

In recognition of the importance of private forest and range resources and the problem faced by most small non-industrial owners, the Department of Forestry has long cooperated with the Forest Service, other federal agencies, and other groups, in a number of federal-State programs to encourage and assist in the management of these lands. Until recently, these programs have been executed under several laws or portions of laws; the Clarke-McNary Act of 1924, the 1950 Cooperative Forest Management Act, the Forest Pest Control Act of 1947, and others. These laws have been repealed and superseded by the Cooperative Forest Assistance Act of 1978 (PL 95-313). The act provides assistance to CDF to carry out the following programs on private land:

Rural Forestry Assistance: tree planting, tree improvement, forest management and utilization assistance, and specialized forestry assistance.

Forestry Incentives: cost sharing of forest practices.

Insect and Disease Control: surveys and technical assistance and suppression of insect infestations and disease epidemics.

Urban Forestry Assistance.

Rural Fire Prevention and Control.

Management Assistance, Planning Assistance, and Technology Implementation.

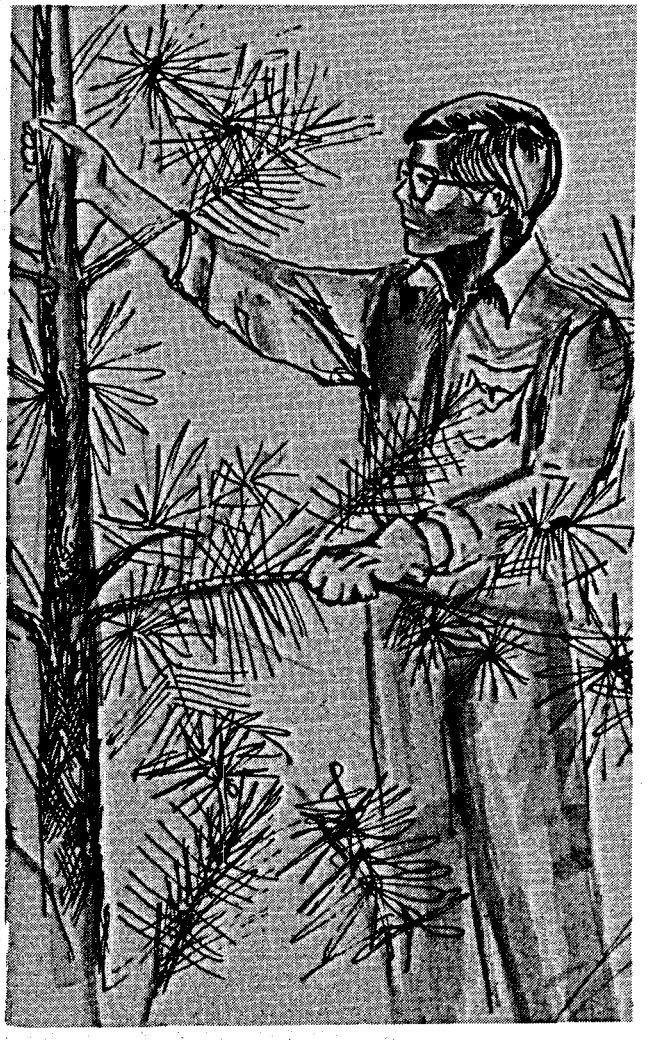
Some other Forest Service cooperative programs are funded under the General Forestry Assistance (GFA) Program, which was not incorporated into the Cooperatve Forestry Assistance Act of 1978. Dutch Elm Disease, FIRESCOPE, and other special projects are examples of GFA activities in which the CDF participates.

State participation in the Resource Planning Act Assessment is partially financed under the Forest and Rangeland Renewable Resources Research Act of 1978.

A number of other federal agencies also conduct closely related programs dealing with forest and range lands. Technical information and assistance, for example, are also provided by the Soil Conservation Service (SCS) and the Agricultural Extension Service. The SCS also administers several watershed, river basin, and resource conservation programs that involve forest and range lands. A program for cost sharing of forestry practices is administered by the Agricultural Stabilization and Conservation Service. SCS and ASCS programs depend on the Forest Service for technical assistance which in California is provided by CDF under agreements. A number of private groups including consultants and industry foresters also provide services and other assistance to improve management of private forest lands.

The relative importance of the State-federal cooperative forestry programs, as indicated by available federal and State appropriations in FY 1978, for example, is shown in Table 16-1.

The California Department of Forestry has primary responsibility for several other State forestry programs in addition to those associated with these State-federal cooperative programs. They include the administration of resource management programs including the Forest Practice Act; the Forest Resources Assessment and Policy Act; the California Forest Improvement Program; range improvement; forestry research; and managing State forests. Additional major program responsibilities include the review of Environmental Impact Reports; timber taxation; Conservation Camp Program; civil defense and other emergencies. These programs are briefly described at the end of this section, and the enabling legislation is summarized in the appendix of this Report.



RURAL FORESTRY ASSISTANCE

Reforestation is needed on two million acres of private commercial forest land in California. These lands are unproductive or reduced in productivity due to past fires, poor logging practices, or unsuccessful attempts to change land use. Increased stocking standards contained in the Forest Practice Act will also increase the need for reforestation on private lands.

TABLE 16-1

APPROPRIATIONS AVAILABLE FOR STATE-FEDERAL FORESTRY PROGRAMS IN CALIFORNIA, FY 1978

PROGRAM	AMOUNT (DOLLARS) STATE(1)	FEDERAL(2)	TOTAL
I. COOPERATIVE FORESTRY ASSISTANCE ACT PROGRAMS (PL 95-313)			
A. RURAL FORESTRY ASSISTANCE (SEC. 3)			
1. Rural Forestry Tree Planting and Improvement Assistance (formerly Title IV and CM-4)	81,697	67,800	149,497
2. Rural Forestry Management and Processing Assistance (formerly CFM)	184,600	123,600	308,200
3. Rural Forestry Specialized Assistance (formerly GFA coop. technical assistance)	3,750	15,000	18,750
B. FORESTRY INCENTIVES (SEC. 4)			
1. Forestry Incentives Program (FIP)	-0-	26,187(3)	26,187
C. INSECT AND DISEASE CONTROL (SEC. 5)			
1. I&DC Surveys and Technical Assistance (formerly Coop. Pest Action Program)	86,002	44,304	130,306
D. URBAN FORESTRY ASSISTANCE (SEC. 6)			
1. Urban Forestry Assistance (formerly Urban and Community Forestry - CFM)	158,000	219,900	377,900
E. RURAL FIRE PREVENTION AND CONTROL (SEC. 7)			
1. Rural Fire Prevention and Control (formerly CM-2 and RCFP)	81,936,800	2,177,900	84,114,700
F. MANAGEMENT ASSISTANCE, PLANNING ASSISTANCE, AND TECHNOLOGY IMPLEMENTATION (SEC. 8)			
1. Management Assistance (formerly GFA)	-0-	-0-	-0-
2. Planning Assistance (formerly GFA)	15,000	60,000	75,000
3. Technology Implementation Assistance (formerly GFA)	-0-	-0-	-0-
Total Cooperative Forestry Assistance Act Programs	82,465,849	2,734,691	85,200,540
II. OTHER STATE-FEDERAL COOPERATIVE PROGRAMS			
A. Agricultural Conservation Program (ACP)-Forestry Practices	-0-	40,000(3)	40,000
B. Resource Conservation and Development Program (RC&D)	3,750	15,000	18,750
C. Small Watershed Planning and Operation (PL-566)	66,490	36,700	103,190
D. Renewable Resource Evaluation (RRE)	2,777	25,000	27,777
E. Dutch Elm Disease (GFA)	300,000	244,000	544,000
F. FIRESCOPE (GFA)	137,018	55,000(4)	192,018
G. Special Projects (GFA)	-0-	55,000	55,000
Total Other State-Federal Cooperative Programs	510,035	470,700	980,735

(1) State funds shown are primarily from CDF, but include other State and local funds for insect and Disease surveys, Dutch Elm Disease, and FIRESCOPE.

(2) Federal funds shown are payments to State or local governments - Does not include USFS program administration.

(3) FIP and ACP funds shown are payments to States for providing technical assistance to landowners - Does not include cost share payments to landowners.

(4) An additional $1,108,200 of Federal funds appropriated for FIRESCOPE were used by the USFS for implementation and management of the program.

To help assure an adequate supply of good quality planting stock, some assistance is provided to CDF by the Forest Service to develop genetically improved tree seeds; procure, produce, and distribute tree seeds and trees; and plant tree seeds and trees for reforestation of non-federal forest lands, as authorized by Section 3 of the Cooperative Forestry Assistance Act of 1978 (formerly authorized by Section 4 of the Clarke-McNary Act of 1924 and Section 401 of the Agricultural Act of 1956). Seed orchards already developed by CDF through this program will produce sufficient seed for three million "genetically improved" trees annually. Current plans are to increase the total seed-producing capacity to obtain 5.5 million genetically improved trees. Use of this improved stock can increase fiber production up to 25 percent through faster growth rates. It is the goal of CDF to use seeds from these orchards to produce superior trees in State nurseries when the seed orchards come into full production.

Three nurseries are operated by CDF. In 1978 these nurseries produced almost six million trees. Much of the nursery stock is sold to nonindustrial private landowners. Many industrial forest owners are developing their own nurseries to supply their needs.

Department of Forestry foresters are available to advise and assist the 30,000 nonindustrial private forest landowners who control 43 percent of the private forest land in California. Federal funding to the State to partially offset the cost of this activity is also provided by Section 3 of the Cooperative Forestry Assistance Act of 1978 (formerly authorized by the Cooperative Forest Management Act of 1924). With current staffing, nearly 4,000 owners are given "on- the-ground assistance" each year. This service is designed to encourage multiple-use management of forests and related resources, and to increase timber growth and harvests while improving environmental values from forest lands. The workload in this program is increasing, and increased staffing would enable CDF to accelerate the effort to reforest unstocked commercial forest lands. An additional 2,000 assists per year, involving some 50,000 acres of timberland, can be expected to result in the improved harvesting of 50 million board feet per year and 5,000 acres seeded or planted. This would require additional staff.

The Rural Forestry Assistance section of the Cooperative Forestry Assistance Act of 1978 also provides authority for the Forest Service to assist in funding the CDF programs which provide technical information, advice, and related assistance to private forest operators and wood processors regarding the harvesting, processing, and marketing of timber, and the marketing and utilitization of wood and wood products.

FORESTRY INCENTIVES PROGRAM

The Forestry Incentives Program (FIP) is specifically designed for federal sharing of the costs of forestry practices with nonindustrial private landowners. It was authorized by the Agriculture and Consumer Protection Act of 1973, and updated by Section 4 of the Cooperative Forestry Assistance Act of 1978. The purpose of this program is to encourage improved forest management for the production of crops of industrial wood, along with other forest commodities and associated uses. The Agricultural Stabilization and Conservation Service has administrative responsibility for this program and handles eligibility, waiver procedures, and payments to participants. CDF, with cooperating private foresters and consultants, provide technical assistance to landowners in developing individual forest management plans, and inspecting installed

practices to insure compliance with guidelines and contracts. The Forest Service provides technical input such as specifications for forestry practices and recommendations on apportionments of available funds.

The FIP Program involves cost-sharing agreements with private landowners to plant trees or otherwise improve stands of forest trees by precommercial thinning, and release of desirable seedlings and young trees on suitable timber growing sites. Cost-sharing is provided for up to 75 percent of the cost of treatment, depending on the cost-share rate set in consultation with a committee of State Foresters or equivalent State officials. Maximum area and minimum site limitations apply and not all counties are included in the program.

INSECT AND DISEASE CONTROL

Losses from all forest pests are estimated to be 20 percent of the annual timber harvested in California (1.0 billion board feet). Forest pests are biological agents such as insects, diseases, animals, and weeds that cause losses to the total forest resource. Epidemics of forest pests do not respect property lines. They require a comprehensive State program to detect, evaluate, prevent, retard, or suppress outbreaks of destructive insects and diseases on, or threatening, forest lands of all ownerships.

Sections 4712-4718 of the Public Resources Code authorize the Department of Forestry to "control or eradicate forest insect or plant diseases damaging or threatening destruction to timber or forest growth." The Board of Forestry has established policy "that any control measure, including the use of pesticides, biological control, fire, or mechanical means, must be ecologically and environmentally sound; justified in terms of practicality, effectiveness, resource values threatened, and costs versus benefits."

The Cooperative Forest Pest Control Program is authorized by Section 5 of the Cooperative Forestry Assistance Act of 1978, which replaced previous authority under the Forest Pest Control Act of 1947. The new act also authorized programs to protect wood products, stored wood, and wood-in-use.

In California the program is carried out directly by the Forest Service on National Forest System lands, and indirectly on other lands through cooperative projects with other land management agencies and with the Department of Forestry. The Department's pest control program prevents and controls forest pest epidemics by:

Advising and assisting private forest owners about proper management procedures to prevent pest buildups.

Operating an effective system of detection and evaluation of pest damage to keep abreast of pest conditions.

Conducting pest suppression projects authorized by the Board of Forestry.

Acting as the Statewide lead agency to advise governmental agencies, private associations and individual landowners on forest pests.

URBAN FORESTRY ASSISTANCE

Through an urban forestry program, the CDF provides information and technical assistance to units of local government and others that will encourage management of the urban forests to enhance

the quality of life, while allowing the controlled utilization of timber crops. Emphasis is being placed in large population areas such as Oakland, San Francisco, and Los Angeles, creating conflicts and tensions between timber harvesting and the maintenance of a rural environment for homes. Federal funding and technical assistance in urban forestry is provided to the Department by the Forest Service under Section 6 of the Cooperative Forestry Assistance Act of 1978.

RURAL FIRE PREVENTION AND CONTROL

California annually faces the world's most difficult forest and watershed fire protection problem. The direct threat to environmental resources, life, and property and the indirect threat to social and economic well-being commands State and national attention.

In recognition of this threat, the State has assumed responsibility for fire protecton on 33 million acres of private and State-owned forest, brush and grass covered watershed lands legally delineated by the State Board of Forestry. Under the Board's direction, an efficient Statewide fire protection system has evolved to replace a fragmented system that was unable to cope with fires that do not respect jurisdictional boundaries.

The system is supported to a small extent by federal assistance under Section 7 of the Cooperative Forestry Assistance Act of 1978. This act updated prior authorities, enabling the Forest Service to provide financial, technical, and related assistance to the State and other cooperators in the prevention, control, suppression, and prescribed use of fires on non-federal forest and watershed lands. This act authorizes similar federal assistance in training and equipping local fire fighting forces in rural areas, and provides for the establishment of a special rural fire disaster fund to be used by the Secretary of Agriculture in emergencies.

The CDF's "Fire Protection Plan" includes goals and objectives, standards of performance for each element and unit of the plan, and measures of effectiveness. The plan is periodically adjusted to meet changes in hazards, risks, resources, land-use patterns, fiscal constraints, and social and political expectations of the people. To avoid duplication and to increase efficiency, the Department contracts with other fire protection agencies. The 33 million acres of State-responsibility lands are protected as follows: 24 million acres directly by the Department of Forestry, 4.2 million acres by the Forest Service; 0.4 million acres by the Bureau of Land Management; and four million acres by five counties. Coincidentally, CDF protects about 3.5 million acres of federally owned lands under contract.

Under California conditions and conflagration potentials, fire protection demands in-depth backup capability, coordination, and mobility. Since fire protection demands vary greatly with season and location within the State, forces in one region become the backup for other regions with critical conditions or large going fires. The flexibility of this Statewide system provides effective fire protection at much less cost than could be provided by independent local or regionally coordinated independent fire agencies.

Greatly increased development and use of wildlands coupled with significant accumulation of wildland fuels now constitute serious problems in fire protection. An expanded program of fuel management on wildlands is needed to reduce the total volume of flammable fuel and to break up large expanses of woody vegetation. Prescribed burning, a major treatment method to reduce fuel loading, has steadily declined in use over the

past 10 years due to greater liability and cost, changing land ownership patterns, and the increased wildland-urban interface. The Department of Forestry is giving increased emphasis to developing an expanded fuels management program as an integral part of the total fire protection system.

The fire prevention objective is to hold occurrence of man-caused fires to 7,200 per year; the 1971-74 average. This objective is difficult to attain because of escalating fire risks, lawlessness, and indifference. The number of man-caused wild fires has more than doubled during the past decade. To stem the increase, CDF has designed the prevention element of its plan to augment fire prevention staffing during high incident periods. Of the 62 permanent positions assigned to fire prevention, one works mainly in information and education programs. Other prevention personnel handle information and education programs as part of their overall prevention workload.

Each dollar the Department spends in this program is multiplied many hundreds of times through citizen and cooperative organization efforts. A conservation and fire prevention education program directed at the problem of children-caused fires (8 percent of the man-caused fires are caused by children) was partially funded through the Environmental License Plate Program. This program now pays for itself by returning to a revolving fund income from sales. Other prevention activities include the application of engineering practices and techniques to modify or eliminate sources of ignition, law enforcement, and special projects such as Red Flag Alert fire prevention project during periods of critical fire weather.

In order to hold fire control damages to an acceptable level, and realistically facing the fact that wildland fires do occur, the objective of the fire control operations element of the fire protection plan is to hold 94 percent of all wildfires in the State protection area to less than 10 acres, 99 percent to less than 100 acres, and to contain 99.5 percent at less than 300 acres.

PLANNING ASSISTANCE

To ensure that data regarding forest lands are available for, and effectively presented in, State and federal natural resources planning, Section 8 of the Cooperative Forestry Assistance Act of 1978 authorizes the Secretary of Agriculture to provide financial, technical, and related assistance to the State. This is for the assembly, analysis, display, and reporting of State forest resources data, for training State forest resources planners, and for participating in natural resources planning at the State and federal levels. Forest Service assistance to the CDF in meeting its responsibilities under the California Forest Resources Assessment and Policy Act is partially funded under this authority.

OTHER STATE/FEDERAL COOPERATIVE PROGRAMS

AGRICULTURAL CONSERVATION PROGRAM (ACP)

Under the Soil Conservation and Domestic Allotment Act of 1936, federal funds have been appropriated to provide cost-sharing to farmers for a variety of conservation and land treatment measures. This program has been administered by the Agricultural Stabilization and Conservation Service through a system of State and county committees. A limited part of the funds available in this program has been assigned for forestry

practices such as tree planting, stand improvement, wildlife habitat improvement, and fencing against livestock. This program provides nearly $200,000 for forest practices. The CDF provides advice and assistance in developing programs and in monitoring cost-sharing contracts with participating forest owners.

RESOURCE CONSERVATION AND DEVELOPMENT PROGRAM (RC and D)

Section 102 of the Food and Agriculture Act of 1962, provided for assistance from U.S. Department of Agriculture agencies to resource conservation and development areas that are organized and sponsored by units of State and local government. Local program sponsors direct a continuing planning process and install planned conservation measures. The Soil Conservation Service, the Forest Service, and other USDA agencies provide technical, financial, or loan assistance to the sponsors under the leadership of the Soil Conservation Service.

Forestry work plans have been prepared for three California RC and D projects: North Cal Neva, Central Coast, and High Sierra, which are presently in the operational stage.

SMALL WATERSHED PLANNING AND OPERATIONS (P.L. 566)

The Watershed Protection and Flood Prevention Act of 1954, commonly referred to as P.L. 566, includes provisions for cooperation between the Federal Government and the States and local subdivisions in both planning and operations programs for protection and improvement of individual watersheds not exceeding 250,000 acres.

In carrying out these projects, the Soil Conservation Service has been assigned responsibility for leadership and the major part of the planning effort. The Forest Service has responsibility for planning and carrying out forestry measures within the National Forest system boundaries; and on other forest lands, in cooperation with the SCS and the Director of the Department of Forestry. State and local units of governments also participate in watershed planning and provide about a third of the total cost of this program.

Operations were completed on three projects in California during the past three years. This involved the installation of forest fire protection measures such as fuel breaks, fire access road betterment, and water developments on the Main Street Canyon watershed in Riverside County, the Upper Llagas watershed in Santa Clara County, and the Escondido watershed in San Diego County. A similar project, the Carpinteria Valley watershed in Santa Barbara County, is scheduled for completion in late 1981.

A draft watershed work plan has recently been completed for the Tehachapi watershed in Kern County. If it is approved for operations, implementation would begin in 1981.

RENEWABLE RESOURCES EVALUATION

The Forest and Rangeland Renewable Resources Research Act of 1978 (92 Stat. 353) authorizes the Secretary of Agriculture to cooperate with appropriate officials of each state to make and keep current a comprehensive survey and analysis of the present and prospective conditons of the requirements for renewable resources of the forest, and other facts necessary in determining ways and means to balance demands for, and supplies of, these resources. Forest Service assistance to the CDF in meeting its responsibilities under the California Forest Resources Assessment and Policy Act (FRAPA) is partially funded under this authority.

DUTCH ELM DISEASE

In response to congressional action, federal funding was provided to the State of California in Fiscal Year 1978 to initate a cooperative demonstration of methods for control of Dutch Elm disease, and for utilization of infected trees where feasible. The effort consists of an intensified five-year control program implemented by the California Department of Food and Agriculture and a public information outreach program conducted by University of California Extension.

The control activity, financed in part by the Forest Service General Forestry Assistance funds, is targeted to major infection areas, and involves intensive survey procedures, prompt diagnosis, and removal of affected trees.

STATE FORESTRY PROGRAMS

STATE FORESTS

The Department of Forestry manages and operates seven State forests totaling 68,664 acres. These forests are managed according to law (PRC 4531-4658) and Board of Forestry policy to investigate and demonstrate improved forest management practices, to achieve sustained production of high quality forest products while protecting environmental values, and to provide public recreation opportunities. Studies are conducted in silviculture, timber harvesting techniques, forest mensuration, watershed management, and insect and disease control. Annual timber harvest is 5 million cubic feet. Public recreation use was 84,000 visitor days in 1978.

FOREST PRACTICE ACT ADMINISTRATION

California timber operators harvest about five billion board feet annually, with about 2.8 billion board feet cut on non-federal lands. Because these lands are important for watershed, recreation, fish and wildlife, range and forage, and aesthetic enjoyment, in addition to timber production, proper timber harvesting practices are vital to the State's economy and welfare.

Under the Z'Berg-Nejedly Forest Practice Act of 1973 (see Appendix Item XII) a timber harvesting plan prepared by a Registered Professional Forester must be submitted to the Director of the Department of Forestry and found in conformance before timber operations may begin on any non-federal timberland in California.

The Secretary for Resources has directed that the Departments of Fish and Game, Parks and Recreation, the State Water Resources Control or Regional Water Quality Control Boards, and other agencies as appropriate be a part of the several Timber Harvesting Plan Review Teams to assist the Director of the Department of Forestry in reviewing timber harvesting plans as to environmental adequacy under the Forest Practice Act, District Rules, and related Board regulations. This review team approach has worked very well in achieving better plans utilizing the expertise of many disciplines.

The Department has 56 foresters headquartered in the major timber producing areas of the State whose main task is to make forest practice inspections. Each timber operation is inspected at least three times: at the commencement of operations; when operations are well underway; and following completion of operation; and at such other times as necessary to enforce the act.

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Assembly Bill No. 452

CHAPTER 1163

An act to add Chapter 12 (commencing with Section 4800) to Part 2 of Division 4 of, and to repeal Sections 741 and 744 of, the Public Resources Code, relating to forest resources, and making an appropriation therefor.

[Approved by Governor September 30, 1977. Filed with Secretary of State September 30, 1977.]

I am reducing the appropriation contained in Section 4 of Assembly Bill No. 452 from $450,000 to $400,500 by reducing subsection (a) from $150,000 to $133,500 and subsection (b) from $300,000 to $267,000.

These funds would be used for hiring a liaison officer. I do not believe this position is necessary at this time.

With this reduction, I approve Assembly Bill No. 452.

EDMUND G. BROWN JR., Governor

LEGISLATIVE COUNSEL'S DIGEST

AB 452, Keene. Forest resources.

The Z'berg-Nejedly Forest Practice Act of 1973 governs the conduct of forest practices on timberland. Under existing law there is no requirement for preparation of a formal assessment of the overall forest resources of the state or for preparation of a forest resource program.

This bill would require the Director of Forestry, under policy guidance from the State Board of Forestry, to prepare and submit to the board a forest resource assessment and analysis, which would include specified elements, by July 1, 1979, and to present an updated assessment by January 1, 1987, and January 1 of each fifth year thereafter. The bill would also require the board to prepare, based on a review of the assessment, a forest resource policy statement containing specified elements.

The bill would make legislative findings and declarations in such connection, would require the board to biennially determine state needs for forest management research and submit specified reports in such connection to the Governor and the Legislature, would authorize the director to prepare and implement a forest management information storage and retrieval program regarding forest land conditions in the state, would repeal certain related existing powers and duties of the board, and would enact other related provisions.

It would appropriate $450,000 to the Department of Forestry for expenditure, as specified, for purposes of the provisions of the bill.

Appropriation: yes.

The people of the State of California do enact as follows:

SECTION 1. Section 741 of the Public Resources Code is repealed.

SEC. 2. Section 744 of the Public Resources Code is repealed.

SEC. 3. Chapter 12 (commencing with Section 4800) is added to Part 2 of Division 4 of the Public Resources Code, to read:

CHAPTER 12. FOREST RESOURCES ASSESSMENT AND POLICY ACT OF 1977

4800. This chapter shall be known and may be cited as the Forest Resources Assessment and Policy Act of 1977.

4801. The Legislature finds and declares as follows:

(a) The forest resources of California provide vitally important economic and environmental benefits to the people of California.

(b) Demands on forest resources in California are expected to increase significantly in the next decades.

(c) Forest resources in California are limited.

(d) Better use of forest resources can result where there is good information as to anticipated needs and constraints and the potentials for meeting such needs consistent with Section 4513 of the Public Resources Code.

(e) The necessary information is not now available and should be developed.

(f) It is the intent of the Legislature to provide for the assessment of California's forest resources.

4802. As used in this chapter:

(a) "Board" means State Board of Forestry.

(b) "Resources Planning Act" means the Forest and Rangelands Renewable Resources Planning Act of 1974 (16 U.S.C. 1601–1610).

(c) "Assessment" means the forest resource assessment and analysis developed pursuant to Section 4803.

(d) "Director" means the Director of Forestry.

(e) "Forest resources" means those uses and values associated with, attainable from, or closely tied to, forest land, including fish, range, recreation, timber, watershed, wilderness, and wildlife.

(f) "Forest land" means timberland defined pursuant to subdivision (h), and other lands which have been withdrawn from timber production, such as state parks, national parks, and wilderness areas.

(g) "Timberland" means land on which is growing a significant stand of trees of commercial species, or potential commercial species, either in public or private ownership or which is generally capable of maintaining a stand of trees in perpetuity and not withdrawn or otherwise devoted to uses other than timber production.

(h) "Timber" means wood fiber of commercial or potential commercial species growing on timberland as defined in subdivision (g).

APPENDIX I

4803. (a) Under policy guidance from the board and in consultation with the Secretary for Resources, the director shall prepare and submit to the board and the Secretary for Resources, a forest resource assessment and analysis not later than July 1, 1979, and shall present an updated assessment by January 1, 1987, and by January 1 of each fifth year thereafter. The assessment and analysis shall recognize distinct differences in ownership and management of forest resources in California between the various public and the various private owners and shall include, but not be limited to, the following:

(1) An assessment and analysis of the supply and availability of the various present and potential forest resources of the state, including limits to such supplies imposed by natural site conditions, such as slope stability and erosion hazard, or by governmental restriction, such as special zoning. Among resource potentials to be evaluated are opportunities to:

(i) Improve and rehabilitate the understocked timberland in California and to more fully utilize the productive potential for growing and harvesting timber.

(ii) Improve wood fiber utilization and wood product recycling.

(iii) Salvage trees infested with insects and diseases on timberland.

(iv) Improve the management of forest wildlife and wildlife habitat within the state.

(v) Increase the quantity and quality of recreation available in the state.

(vi) Improve and rehabilitate forest range areas within the state.

(vii) Increase the potential to use wood fiber from timberland as an economically viable source of fuel for energy production.

(2) An analysis of present and anticipated demand for various forest resources in the state.

(3) A description and evaluation of current state programs and responsibilities in cooperative state-federal forestry programs, and management of state and local public forest and related lands.

(4) A discussion of important policy considerations, laws, regulations, management responsibilities, and other factors expected to influence and significantly affect the use, ownership, and management of forest and range resources.

(b) In preparing the assessment, the director, under policy guidance of the board, shall solicit the cooperation of, and information collected by, public and private organizations, federal forest resource agencies, state agencies concerned with forest resources, county planning and taxation agencies, and state-supported forest resource research agencies.

(c) For the purpose of assisting the director and the board in preparing the assessment and its revisions, the board may appoint such advisory committees as it deems necessary. Such committees shall consist of individuals with expertise in forest resource fields

with particular emphasis on survey and program analysis, and shall include representatives of state agencies concerned with the use of forest resources.

(d) In preparation of the assessment the director shall analyze the need to:

(1) Develop and maintain an effective system for the collection, analysis, and display of such data in forms that contribute to the achievement of the purposes of this chapter.

(2) Identify high priority needs for completing the data base and analytical framework essential to improving the quality of future assessments.

(3) Evaluate the accuracy and completeness of existing data and of steps needed to improve the accuracy and completeness of data for future assessments.

4804. (a) Based on a review of the assessment prepared pursuant to Section 4803, and consistent with Sections 740 and 4513, the board shall prepare a forest resource policy statement.

(b) Such policy statement shall recognize distinct differences between the various public and various private owners of forest resources in the state and should include, insofar as is possible, the following:

(1) A delineation of specific needs and opportunities for promoting both public and private forest resource management programs in California.

(2) A discussion of priorities for accomplishment of program opportunities, with specified costs, results, and possible constraints on implementation.

(3) An analysis of the relation of the alternative forest resource policies to employment opportunities in California.

4805. The board shall hold public hearings on the assessment and the proposed policy statement prepared pursuant to Sections 4803 and 4804.

4806. (a) The board, assisted by the director, shall biennially determine state needs for forest management research and recommend the conduct of needed projects to the Governor and the Legislature.

(b) To facilitate reporting and updating the assessment pursuant to Section 4803, the director, under guidance by the board, may prepare and implement a forest resource management information storage and retrieval program regarding forest land conditions in the state. Such program shall be coordinated and integrated to the maximum extent practicable with data storage and retrieval programs of other state and federal agencies and institutions. The director shall review existing forest resource management storage, retrieval, and analysis systems in the institutions of higher learning in this state, and insofar as the board deems desirable, may utilize such systems as a model for the state program established pursuant to this section.

4807. (a) The director shall convey the assessment and its updates to federal agencies charged with managing public land within the state.

(b) To assure the availability and compatibility of data and scientific information needed for development and implementation of the assessment, the board and the director shall cooperate with the United States Department of Agriculture in conducting surveys and analyses as provided for in the Resources Planning Act and with other federal agencies as provided by federal law.

SEC. 4. The sum of four hundred fifty thousand dollars ($450,000) is hereby appropriated from the General Fund to the Department of Forestry for expenditure for the purposes of Chapter 12 (commencing with Section 4800) of Part 2 of Division 4 of the Public Resources Code, in accordance with the following schedule:

(a) One hundred fifty thousand dollars ($150,000) for expenditure during the 1977–78 fiscal year.

(b) The three hundred thousand dollars ($300,000) for expenditure during the 1978–79 fiscal year.

It is the intent of the Legislature that the Department of Forestry and other departments affected by this act extend a high priority to their budget requests in subsequent fiscal years for the purpose of the Forest Resources Assessment and Policy Act of 1977.

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Assembly Bill No. 2685

CHAPTER 801

An act to amend Sections 4801 and 4803 of the Public Resources Code, relating to forest resources.

[Approved by Governor September 15, 1978. Filed with Secretary of State September 18, 1978.]

LEGISLATIVE COUNSEL'S DIGEST

AB 2685, Keene. Forest resources.

The Forest Resources Assessment and Policy Act of 1977 requires the Director of Forestry, under policy guidance from the State Board of Forestry, to prepare and submit a forest resource assessment and analysis to the board not later than July 1, 1979, and an updated assessment by January 1, 1987, and by January 1 of each fifth year thereafter.

This bill would specify that the forest resource assessment is to be provided in order to develop and implement forest resources policies for the state. The bill would provide that the initial assessment and analysis is "preliminary" and require the updated assessments to be "full" assessments. The bill would also require the director to include evaluations of probable direct and indirect economic and environmental benefits and costs, including opportunity costs, when assessing various resource potentials which could be obtained from forest lands.

The people of the State of California do enact as follows:

SECTION 1. Section 4801 of the Public Resources Code is amended to read:

4801. The Legislature finds and declares as follows:

(a) The forest resources of California provide vitally important economic and environmental benefits to the people of California.

(b) Demands on forest resources in California are expected to increase significantly in the next decades.

(c) Forest resources in California are limited.

(d) Better use of forest resources can result where there is good information as to anticipated needs and constraints and the potentials for meeting such needs consistent with Section 4513.

(e) The necessary information is not now available and should be developed.

(f) It is the intent of the Legislature to provide for the assessment of California's forest resources in order to develop and implement forest resources policies for the state.

SEC. 2. Section 4803 of the Public Resources Code is amended to read:

4803. (a) Under policy guidance from the board and in consultation with the Secretary of the Resources Agency, the director shall prepare and submit to the board and the Secretary of the Resources Agency, a preliminary forest resource assessment and analysis not later than July 1, 1979, and shall present a full and updated assessment by January 1, 1987, and by January 1 of each fifth year thereafter. The assessment and analysis shall recognize distinct differences in ownership and management of forest resources in California between the various public and the various private owners and shall include, but not be limited to, the following:

(1) An assessment and analysis of the supply and availability of the various present and potential forest resources of the state, including limits to such supplies imposed by natural site conditions, such as slope stability and erosion hazard, or by governmental restriction, such as special zoning. Among resource potentials to be evaluated are opportunities to:

(i) Improve and rehabilitate the understocked timberland in California and to more fully utilize the productive potential for growing and harvesting timber.

(ii) Improve wood fiber utilization and wood product recycling.

(iii) Salvage trees infested with insects and diseases on timberland.

(iv) Improve the management of forest wildlife and wildlife habitat within the state.

(v) Increase the quantity and quality of recreation available in the state.

(vi) Improve and rehabilitate forest range areas within the state.

(vii) Increase the potential to use wood fiber from timberland as an economically viable source of fuel for energy production.

(2) An analysis of present and anticipated demand for various forest resources in the state.

(3) A description and evaluation of current state programs and responsibilities in cooperative state-federal forestry programs, and management of state and local public forest and related lands.

(4) A discussion of important policy considerations, laws, regulations, management responsibilities, and other factors expected to influence and significantly affect the use, ownership, and management of forest and range resources.

(5) When assessing various resource potentials which could be obtained from forest lands, the director shall include an evaluation of probable direct and indirect economic and environmental benefits and costs, including opportunity costs, associated with realizing such potentials.

(b) In preparing the assessment, the director, under policy guidance of the board, shall solicit the cooperation of, and information collected by, public and private organizations, federal forest resource agencies, state agencies concerned with forest resources, county planning and taxation agencies, and

state-supported forest resource research agencies.

(c) For the purpose of assisting the director and the board in preparing the assessment and its revisions, the board may appoint such advisory committees as it deems necessary. Such committees shall consist of individuals with expertise in forest resource fields, with particular emphasis on survey and program analysis, and shall include representatives of state agencies concerned with the use of forest resources.

(d) In preparation of the assessment the director shall:

(1) Analyze the need to develop and maintain an effective system for the collection, analysis, and display of such data in forms that contribute to the achievement of the purposes of this chapter.

(2) Identify high-priority needs for completing the data base and analytical framework essential to improving the quality of future assessments.

(3) Evaluate the accuracy and completeness of existing data and of steps needed to improve the accuracy and completeness of data for future assessments.

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STATUS
OF
CALIFORNIA
STATE / FEDERAL / PRIVATE
RESOURCE INVENTORY PROJECTS

STATUS OF CALIFORNIA STATE/FEDERAL/PRIVATE RESOURCE INVENTORY PROJECTS

RESOURCE(S) INVENTORIED	AGENCY - INSTITUTION	INVENTORY PROGRAM/STUDY	AREA COVERED	COMPLE-TION DATE	DATA BY COUNTY	REMARKS
All	California Department of Forestry (CDF)	Resource Values Protected (Fire)	CDF area of direct protection	4/80	Timber yes - Others no	Working on valuation system of protected wildland resources
All	Soil Conservation Service (SCS)	Land Inventory Monitoring (LIM)	All private lands	1979	Yes	Remeasuring 1967 - 160 acre plots
All	SCS	Resource Conservation Act (RCA)	All private lands	10/20/78	Yes	
All	Dept. of Water Resources (DWR)	Two special studies in parts of	Alameda/Santa Clara & Plumas/Sierra Counties	1973-74	Yes	
All	Bureau of Land Management (BLM)	Resource Inventory	200 M Acres, BLM lands commercial timber	End of 1980	Yes	(M = 1,000)
All	Forest Service, R-5 (FS)	Contact RO or specific forests	By National Forest	Varied	Seldom	
Vegetation (Habitat)	BLM	IHICS Program		1988		
Vegetation	Pacific Southwest Forest and Range Experiment Station (PSWF & RES)	Vegetation Classification System	Southern California chaparral	Just started	No	Classification just started. System completed
Vegetation-Soils Vegetation (CALVEG & USGS)	PSWF & RES and CDF	Soil/Vegetation Survey	State forest lands, private forest lands Statewide. 9MM acres upland soils	7/1/79 PSW - CDF - on-going	Yes	BLM starting their's; CDF assuming PSW role. Question of program continuity (MM=1 Million)
Vegetation - soil	National Park Service (NPS)	Soil-Vegetation	Yosemite Valley	1963	Yes	
Vegetation	NPS	Vegetation Type Map	Yosemite National Park	1939	No	
Vegetation	USFS et al	CalVeg - Ecosystem mapping	State	Completed 1978	Yes	Most recent detailed vegetative mapping. Acreages by counties and ecotypes
Vegetation	CDF/NASA	Landsat imagery of land cover	State	6/79	Yes	Digital data files with political boundary mapping capabilities
Vegetation	USGS	Land cover mapping	State	End of 1979		Maps to scale 1:250,000

RESOURCE(S) INVENTORIED	AGENCY - INSTITUTION	INVENTORY PROGRAM/STUDY	AREA COVERED	COMPLE-TION DATE	DATA BY COUNTY	REMARKS
Vegetal, soils, ownership	SCS	MIAD (River Basin Studies)	Statewide	1970	Some	960 acre grid cells maps
Vegetal, soils, ownership	SCS	Sacramento Valley Cooperative Study	Valley into foothills	6/78	Yes	1:62,500 maps, digitized, 90 acre grid cells
Vegetal, soils, ownership	SCS	San Joaquin Valley Basin Study	Valley to mountain crest	1977	Yes	1:250,000 maps only
Vegetal, soils, fish & wildlife	DWR	Van Duzen River Basin Environment Atlas	Van Duzen watershed	12/75	Yes	
Timber	CDF	Continuous forest inventories	State forests	Every 5 years	Yes	
Timber	CDF	Timber production	Timber counties	12/78	Yes	Confidential individual data
Timber	Southern California Edison	Shaver Lake lands	Western Sierra Nevada slopes	1974	Yes	
Timber	Pacific Gas and Electric	Timber	All company forested lands	On-going	Yes	
Timber	Bureau of Indian Affairs (BIA)	Hoopa Forest Inventory	Reservation	1976	Yes	
Timber	State Lands Commission	Timber and Inventory	35,000 acres scattered	± 7/79	Yes	
Timber	PNWF & RES	Report on timber. Next inventory	State	1978 1984	Some	Review draft now. Next inventory '81, 82, 83
Timber	PNWF & RES	Sacramento and San Joaquin studies	Sacramento and San Joaquin areas	1978	Some	15 counties
Timber and range	Bureau of Indian Affairs	Tule, Round Valley, Fort Bidwell	Reservations	1977	Yes	
Timber insect kill	CDF	Aerial insect detection	Private lands, Sierras and coast	Yearly in fall	Yes	Very general
Wood biomass	CDF Forest Improvement Program	Wood Energy Study	Specific sites and State-wide	1/79	No	Intense study at specific sites and general information Statewide
Soils	SCS	National Cooperative Soil Survey	All private lands unless coop. with gov. agency	On going	Yes	50 percent completed
Soil	DWR	Landslide & erosion hazard maps	Trinity River Basin, Eel River Basin	10/78 1920-75	Yes No	
Soil, water quality	CDF	Soil Erosion Study on logged areas	Forested areas	1980	Yes	Detailed
Water	CDF	208 Water Quality Planning Project	Forested areas	1979	Yes	

RESOURCE(S) INVENTORIED	AGENCY - INSTITUTION	INVENTORY PROGRAM/STUDY	AREA COVERED	COMPLE-TION DATE	DATA BY COUNTY	REMARKS
Erosion, land-slide	DWR	Rehabilitation & Rec-reation specific watersheds	Humboldt and Mendocino Counties	1975	No	
Recreation (See * on page 3)	Department of Parks and Rec-reation (Parks and Rec)	Parks and Recreation Information System (PARIS)	State	1970, 1980, 1990	No	465 geopieces. Sub-county groupings. Supply by landscape provinces
Recreation	Water Resources Council	Comprehensive Framework Study XII	State	1971	No	
Recreation	Parks & Rec	* PARIS Inventory of Facilities	Public lands under juris-diction of BLM, NPS, FS, FWS, BIA, Army Corps, Bureau of Recl, CalTrans, Departments of F & G, Parks & Rec, Forestry, and 532 cities, and special districts; 2893 private respondents. Statewide.	data gathered in 1974-1976, pri-vate gath ered in 1973-1974. Computer runs avail-able (on-going basis) w/ private data not yet fully incorpo-rated.		
Recreation	Parks & Rec	* PARIS "demand" projections	Allocation of Statewide demand to geopieces, which can be aggregated to county. Statewide.	Projec-tion for 1970, 1980, and 1990 avail-able.	Yes	22 outdoor activities con-sidered. Unit = partici-pation day. Participation rates determined from a 1960-1961 BOR study, and projected population trends from Department of Finance. Demand alloca-tion based on "usability values" assigned to each geopiece and travel time factors

RESOURCE(S) INVENTORIED	AGENCY - INSTITUTION	INVENTORY PROGRAM/STUDY	AREA COVERED	COMPLE-TION DATE	DATA BY COUNTY	REMARKS
Recreation	Parks & Rec	"Needs Analysis" revision of PARIS methodology. a. per capita participation rates. b. expansion of outdoor recreation activities to 110. c. "demand" projections to year 2000.	Statewide.	Begun in summer 1978	Yes	a. Efforts to correlate socio-economic characteristics with participation rates for outdoor recreation. Also, determine amount of recreation occurring at private facilities b. Many more "urban" activities being considered although focus is still outdoor recreation
Recreation	Dept. of Parks and Recreation	Preparations to revise public inventory of facilities	Statewide	Begin federal FY 1979-1980	Yes	Not certain whether effort will be made to inventory private facilities
Recreation	Forest Service	RIM inventory of facilities (dispersed and developed)	California National Forests	On-going annual figures	Yes	No delineation to vegetative type (EG, forest)
Recreation	Forest Service	RIM outdoor recreation use by a. activity type b. developed sites c. dispersed recreation areas	California National Forests	On-going annual figures	Yes	Unit = visitor day
Recreation	Forest Service, Rocky Mountain Experiment Station, and Region 5 Hdqtrs.	User Preference Study	Sierra National Forest	1979	No	Survey to be conducted summer 1979
Wildlife	Department of Fish and Game (F & G)	Wildlife Element - Fish & Wildlife Plan	Statewide wildlife	6/79	Yes	
Wildlife	F & G	Oak Wildlife Relation Study	Statewide	--	Possibly	Oak use by wildlife and acorn production
Wildlife	U.S. Forest Service DFG	Status of riparian habitat	National Forests Valley & desert lands	1981 1980		

RESOURCE(S) INVENTORIED	AGENCY - INSTITUTION	INVENTORY PROGRAM/STUDY	AREA COVERED	COMPLE-TION DATE	DATA BY COUNTY	REMARKS
Fisheries	F & G	Fisheries Element - Fish & Wildlife Plan	Statewide	3/80	Yes	
Range	UCB - Forestry	Range Condition and Quality	Sacramento Valley foothills	1978	Yes	
Wilderness	Forest Service	RIM Wilderness use	California National Forests	On-going annual figures	Yes	
Wilderness	Forest Service	RIM acreage of wilderness areas	California National Forests	On-going annual figures	Yes	
Wilderness	Forest Service	RARE II Draft EIS	California National Forests	6/78	No	Resource data on roadless areas questionable
Wilderness	Forest Service	RARE II Final EIS	California National Forests	1/79	No	FS recommendation for wilderness, nonwilderness and further planning
Wilderness	Resources Agency	Status of California Wilderness Preservation System & Recommendations for Additions to the System	Lands under jurisdiction of Departments of Parks & Rec, F & G, Forestry, and Water Resources. Statewide	1/78	No	Status of California Wilderness System recommendations for wilderness nonwilderness, further study
Land Use	USGS	Land use mapping	State	End of 1979		Same

CHRONOLOGY OF CALIFORNIA AIR POLLUTION RELATED TO FOREST LAND

1945 to 1946 — Eye irritation annoys residents of Los Angeles. Cause unknown.

1947 — Los Angeles County Air Pollution Control District formed.

1949 — California Institute of Technology biochemistry Professor Arie J. Haagen-Smit discovers the nature and causes of photochemical smog. Experiments reveal that the reaction of sunlight on hydrocarbons and oxides of nitrogen produce irritants and ozone.

1948 to 1957 — Los Angeles County Air Pollution Control District (APCD) conducts intensive program to control emissions of pollutants from industrial and domestic sources.

1955 — Bureau of Air Sanitation established in the State Department of Public Health by the California Legislature.

1959 — Department of Public Health adopts first statewide ambient air quality standards and motor vehicle emission standards.

-- Assembly Bill 17 is signed into law, and the State Motor Vehicle Pollution Control Board is organized.

1961 — Test procedures and criteria adopted for crankcase devices and exhaust controls. Automobile industry announces it will voluntarily install crankcase devices nationwide on all 1963 model cars.

1963 — Clean Air Act passed by Congress.

1966 — Federal Government publishes U.S. Emission Standards to go into effect with the 1968 models.

1967 — Senate Bill 490, creating the California Air Resources Board (Mulford-Carrell Air Resources Act of 1967), is approved by the Senate and the Assembly, and signed by Governor Ronald Reagan. Effective date: November 8, 1967.

-- The Federal Air Quality Act of 1967 provides that control of motor vehicles be exclusively the province of the Federal Government; permits waiver to California to impose stricter emission standards on new vehicles.

1968 - Governor Reagan signs Assembly Bill 357, the Pure Air Act of 1968, establishing progressively stricter emission standards for 1970 through 1974 model vehicles on a five-year program. State requests new waiver from HEW to enforce these stricter standards, the strictest ever set anywhere.

-- ARB divides California into 11 air basins according to topography and climate.

1969 — HEW Secretary Robert Finch grants federal waiver requested by California, allowing the State to enforce stricter motor vehicle emission standards than those in the other 49 states.

-- New Statewide ambient air quality standards are adopted by the ARB for oxidant (including ozone), carbon monoxide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, visibility reducing particles and particulate matter. ARB Technical Advisory Committee proposes adoption of vehicle emission levels lower than those established by the Pure Air Act of 1968, the new standards to go into effect with the 1975 model cars.

1970 — Legislature passes into law ten proposals submitted by ARB. The legislation eliminates open burning, regulates motor fuel with regard to volatility and unsaturated hydrocarbons, extends smoke regulations statewide, establishes a statewide air monitoring network, coordinates air pollution control in each air basin, and insures proper adjustment of emissions control equipment on new automobiles. Also approved are bills authorizing ARB to establish agricultural burning guidelines and impose stiff fines for violations of cease-and-desist orders issued by APCD's or ARB.

-- Federal Clean Air Act amended establishing specific pollution control goals which states must attain.

1971 — ARB establishes guidelines to control agricultural burning.

1972 — Implementation Plan is sent to Environmental Protection Agency as required by the 1970 Clean Air Act. Revisions I and II, mandated by EPA, subsequently approved by ARB.

-- The number of open burning dumps is reduced statewide to 200 from 470 in 1971.

-- Sierra Club suit resulted in court order requiring EPA to disapprove all state air quality control plans not preventing significant deterioration of air quality where air quality is superior to National Standards.

1973 — Number of open burning dumps reduced to 77.

-- Mountain Counties Air Basin established.

1974 — Open dump burning extended for one year to 23 locations in 7 counties.

-- Identification of Air Quality Maintenance Areas, as Revision V to the State Implementation Plan, adopted.

-- Lake County Air Basin established.

1975 — Lake Tahoe Air Basin formed from portions of Mountain Counties Air Basin.

1976 — Unique air quality standards for carbon monoxide and visibility adopted for the Lake Tahoe Air Basin.

-- Lake Tahoe is the site of high altitude exhaust emission testing during summer months.

-- State study finds catalytic converter-equipped cars pose no special fire problem.

-- Statewide annual economic loss to agriculture caused by smog is estimated at $55 million by the California Department of Food and Agriculture.

1977 — Clean Air Act amended to provide, amongst other objectives, legislative guidance and clearer legislative intent to prevent significant deterioration of air quality over national parks, monuments, wilderness, etc.

1979 — Federal standard for ozone was revised from eight to 12 pphm.

STATUS OF NATIVE PLANTS ON NATIONAL FORESTS

Compiled by Ed Horton, Regional Botanist, Forest Service

(1) Classification established by the Smithsonian Institute (E - endangered; T - threatened)

(2) Status as established by the California Native Plant Society (CNPS) (Powell, R. W., CNPS Special Publication No. 1, 1974)

Rarity (R)

1. Rare, of limited distribution, but distributed widely enough that potential for extinction or extirpation is apparently low at present.

2. Occurrence confined to several populations or one extended population.

3. Occurs in such small numbers that it is seldom reported; or occurs in one or very few highly restricted populations.

P.E. Possibly extinct or extirpated.

Endangerment (E)

1. Not endangered.

2. Endangered in part.

3. Totally endangered.

Vigor (V)

1. Stable or increasing.

2. Declining.

3. Approaching extinction or extirpation.

General Distribution (D)

1. Not rare outside California.

2. Rare outside California.

3. Endemic to California.

STATUS OF NATIVE PLANTS ON NATIONAL FORESTS (1)

PLANT CODE	NAME	SMITHS. INSTIT.	CNPS REVD	OCCURRENCE: NATIONAL FOREST
ABAL	*Abronia alpina* Bdg.	E	3-2-1-3	Inyo, Sequoia
ALHO-2	*Allium hoffmanii* Ownbey	T	2-1-1-3	Shasta-Trinity, Six Rivers
ANCA-2	*Angelica callii* Math. & Const. ined.	E	3-2-2-3	Sequoia
ANSU-2	*Antennaria suffrutescens* Greene	T	1-2-2-2	Six Rivers
ANSU-1	*Antirrhinum subcordatum* Gray	T	2-2-1-3	Mendocino
ARBRP	*Arabis breweri* Wats, var. *pecuniaria* Roll.	E	3- - -3	San Bernardino
ARCO-7	*Arabis constancei* Roll. (Syn: *Arabis suffrutenscens* Wats. var. *perstylosa* Roll.)	T	3-1-1-3	Plumas
ARJO	*Arabis johnstonii* Munz	T	3- - -3	San Bernardino
ARMO-1	*Arabis modesta* Roll.	T	2-1-1-2	Klamath, Shasta-Trinity
ARPR-4	*Arabis parishii* Wats.	T	2- - -3	San Bernardino
ARPY-1	*Arabis pygmaea* Roll.	T		Inyo, Sequoia
ARSE-3	*Arabis serpentinicola* Roll.		3-1-1-3	Klamath
ARSH	*Arabis shockleyi* Munz		3-2-2-2	San Bernardino
ARCR-2	*Arctostaphylos cruzensis* Roof	T	2-2-2-3	Los Padres
AREDP	*Arctostaphylos edmundsii* J. T. Howell var. *parvifolia* Howell	E	2-1-1-3	Los Padres
ARLU-2	*Arctostaphylos luciana* Wells	T	2-1-1-3	Los Padres
AROT	*Arctostaphylos otayensis* Wies. & Schreib.	T	2-1-1-2	Cleveland
ARRE-3	*Arctostaphylos refugioensis* Gankin	E	3-2-2-3	Los Padres
ARHO-1	*Arenaria howellii* Wats.	T	2-1-1-3	Six Rivers
ARRO-1	*Arenaria rosei* Maguire & Barneby	T	2-2-2-3	Shasta-Trinity
ARUR	*Arenaria ursina* Rob.	E	2-2-1-3	San Bernardino
ARMUR-	*Argemone munita* Dur. & Hilg. ssp. *robusta* G. Ownby	T	- - -3	Cleveland
ARVE	*Arnica venosa* Hall	T	3-1-1-3	Shasta-Trinity
ARVI-1	*Arnica viscosa* Gray	T	2-1-1-2	Shasta-Trinity
ASVI	*Asplenium viride* Hudson		3-1-1-1	Tahoe
ASBRB	*Aster brickellioides* Greene var. *brickellioides*	T	- - -2	Klamath
ASPE	*Aster peirsonii* C. W. Sharsm.	T		Inyo, Sierra, Stanislaus
ASBR-3	*Astragalus brauntonii* Parish	T	- - -3	Angeles, Cleveland

PLANT CODE	NAME	SMITHS. INSTIT.	CNPS REVD	OCCURRENCE: NATIONAL FOREST
ASDE	*Astragalus deanei (Rydb.) Barneby*	T	3-2-1-3	Cleveland
ASJO	*Astragalus johannis-howellii Barneby*	E	3-2-2-3	Inyo
ASKEE	*Astragalus kentrophyta Gray var. elatus Barneby*		2-1-1-1	Inyo
ASMOH	*Astragalus mohavensis Wats. var. hemigyrus (Clokey) Barneby*	T	2- - -2	Inyo
ASMO-2	*Astragalus monoensis Barneby*	E	3-2-1-3	Inyo
ASRA-3	*Astragalus ravenii Barneby*	E	3-1-1-3	Inyo, Sierra
ASSU-1	*Astragalus subvestitus (Jeps.) Barneby*	T	2-1-1-3	Inyo, Sequoia
AYCO	*Ayenia compacta Rose*		1-2-1-1	San Bernardino
BEOR	*Bensoniella oregana (Abrams & Bacig.) Morton*	E	3-2-2-2	Six Rivers
BESO	*Berberis sonnei (Abrams) McMinn*	E	3-3-1-3	Tahoe
BOPU	*Botrychium pumicola Cov.*	T	3-3-3-1	Shasta-Trinity
BOTR-1	*Bouteloua trifida Thurb. & Watson*		3-1-1-1	San Bernardino
BRCOR	*Brodiaea coronaria (Salisb.) Engler ssp. rosea (Greene) Niehaus*	E	3-3-1-3	Mendocino
BRFI	*Brodiaea filifolia Wats.*	E	3-3-3-3	San Bernardino
BROR-2	*Brodiaea orcuttii (Greene) Hoover*	E	1-2-2-2	Cleveland
CADE-1	*Calamagrostis densa Vasey*		2-1-1-3	Cleveland
CAFO	*Calamagrostic foliosa Kearn.*	T	2-1-1-3	Six Rivers
CACOW	*Calochortus coeruleus (Kell.) Wats. var. westonii (Eastw.) Ownbey*	E	3-3-1-3	Sequoia
CADU-2	*Calochortus dunnii Purdy*	T	3-1-1-3	Cleveland
CAGR-2	*Calochortus greenei*	E	2-1-1-2	Shasta-Trinity
CALO-2	*Calochortus longebarbatus S. Wats.*	T	3-2- -2	Lassen, Modoc, Shasta-Trinity
CAOB-3	*Calochortus obispoensis Lemmon*	T	3-1-1-3	Los Padres
CAPE-2	*Calochortus persistens Ownbey*	E	3-1-1-3	Klamath
CAST-3	*Calochortus striatus Parish*	T	2-1-1-3	Angeles, San Bernardino
CAFR-2	*Calycadenia fremontii Gray*	P.E.	P.E. -3	Mendocino
CAPE-5	*Calystegia peirsonii (Abrams) Brimmitt*	T	2-1-1-3	Angeles
CASC-3	*Campanula scabrella Engelm.*		3-1-1-1	Shasta-Trinity
CASH-2	*Campanula shetleri Heck.*	T	3-1-1-3	Shasta-Trinity
CAWI	*Campanula wilkinsiana Greene*	T	2-1-1-3	Klamath, Shasta-Trinity

PLANT CODE	NAME	SMITHS. INSTIT.	CNPS REVD	OCCURRENCE: NATIONAL FOREST
CAOB-1	*Carex obisponensis* Stacey	T	2-1-1-3	Los Padres
CAPA-4	*Carex paucifructa* Mkze.	T	2-1-1-3	Tahoe, Lake Tahoe Basin
CATO	*Carex tomkinsii* J. T. Howell	E	3-1-1-3	Sierra
CAWH	*Carex whitneyi* Olney	T	1-2-1-3	Stanislaus, Sierra, Lake Tahoe Basin
CABR-9	*Castilleja brevilobata* Piper	T	2-1-1-2	Klamath, Six Rivers
CACI-2	*Castilleja cinerea* Gray	T	2-2-1-3	San Bernardino
CACU-2	*Castilleja culbertsonii* Greene	T		Inyo, Sequoia, Sierra
CAGL-3	*Castilleja gleasonii* Elmer	T	2-1-1-3	Angeles
CALA-7	*Castilleja lassenensis* Eastw.	T	2-1-1-3	Plumas, Sequoia, Sierra
CAMAE	*Castilleja martinii* Abrams var. *ewanii* (Eastw.) N. Holmgren			San Bernardino
CAMIE	*Castilleja miniata* Dougl. ex Hook. ssp. *elata* (Piper) Munz			Klamath
CAAMB	*Caulanthus amplexicaulis* Wats. var. *barbarae* (J. T. Howell) Munz	T	2-1-1-3	Los Padres
CEPRL	*Ceanothus prostratus* Benth. Var. *laxus* Jeps.	T	3-1-1-3	Klamath, Shasta-Trinity
CHPA-6	*Chaenactis parishii* Gray	T	3- - -2	Cleveland, San Bernardino
CHBR-2	*Chorizanthe breweri* Wats.	T	2-1-1-3	Los Padres
CHIN-3	*Chorizanthe insignis* Curran	T		Los-Padres
CHLE-3	*Chorizanthe leptoceras* (Gary) Wats.	E	1-2-2-3	Angeles, San Bernardino
CHRE	*Chorizanthe rectispina* Goodm.	T	2-2-1-3	Los Padres
CLLI-1	*Clarkia lingulata* Lewis & Lewis	E	3-1-1-3	Sierra
CLSP-3	*Clarkia springvillensis* Vasek		2- - -3	Sequoia
CLLAP	*Claytonia lanceolata* Pursh. var. *peirsonii* M. & J.	T	2-1-1-3	Angeles, San Bernardino

PLANT CODE	NAME	SMITHS. INSTIT.	CNPS REVD	OCCURRENCE: NATIONAL FOREST
COCA-12	*Cordylanthus capitatus* Nutt.		3-1-1-1	Modoc
COTEP	*Cordylanthus tenuis* Gray ssp. *pallescens* Perm.	E		Shasta-Trinity
CRCR-1	*Cryptantha crinita* Greene	T	2-2- -3	Shasta-Trinity
CRRO-1	*Cryptantha roosiorim* Munz	E	3-1-1-3	Inyo
CRSC	*Cryptantha scoparia* A. Nels.		3-1-1-1	Inyo
CRSU	*Cryptantha subretusa* Jtn.		2-1-1-2	Modoc, Shasta-Trinity
CUST	*Cupressus stephensonii* C. B. Wolf (Syn: *Cupressus arizonica* var. *stephensonii* (Wolf) Little)	T	2-1-1-2	Cleveland
CYCA-2	*Cypripedium californicum*	T		Klamath, Shasta-Trinity, Six Rivers
DEHU	*Delphinium hutchinsonae* Ewan	T	2-2-1-3	Los Padres
DEIN	*Delphinium inopinum* (Jepson) Lewis & Elp.		2-1-1-3	Sequoia
DIFOO	*Dicentra formosa* (Haw.) Walp. ssp. *oregana* (Eastw.)		2-2-2-2	Six Rivers
DINE-2	*Dicentra nevadensis* Eastw. (Syn: *Dicentra formosa* var. *nevadensis* (Eastw.) Munz)	T	3-1-1-3	Sequoia
DIOC-1	*Dicentra ochroleuca* Engelm.	E		Los Padres
DICA-1	*Dissanthelium californicum* (Nutt.) Benth.	P.E.	P.E.--2	Los Padres
DICA-4	*Ditaxis californica* (Bdg.) Pax & K. Hoffm.	T	2- - -3	San Bernardino
DRASA	*Draba asterophora* Pays. var. *asterophora*	T	3-1-1-2	El Dorado, Lake Tahoe Basin
DRASM	*Draba asterophora* Pays. var. *macrocarpa* C. L. Hitch	T	3-1-1-3	El Dorado, Lake Tahoe Basin
DRCRC-2	*Craba cruciata* Payson var. *cruciata*	T	2-1- -1	El Dorado, Sequoia, Lake Tahoe Basin
DRCRI	*Draba cruciata* Payson var. *integrifolia* Hitch. & Sharsm.	T	3-1-1-1	Inyo, Sierra
DRHOC	*Draba howellii* Wats. var. *carnosula* (O. E. Schulz) C. L. Hitchc.	T	- - -3	Shasta-Trinity
DRNIE	*Draba nivalis* Liljebl. var. *elongata* Wats.		2-1-1-1	Inyo
DRSTR	*Draba stenoloba* Ledeb. var. *ramosa* C. L. Hitchc.	T	- - -	Lake Tahoe Basin
DRAN	*Drosera anglica* Huds.		2-1-1-1	Klamath, Tahoe
DRFI	*Droypteris filix-mas* (L.) Schott		P.E.--1	San Bernardino
DUDE	*Dudleya densiflora* (Rose) Moran	T	2-2-2-3	Angeles
DUVI-2	*Dudleya viscida* (Wats.) Moran	T	2-1-1-3	Cleveland
ECENM	*Echinocereus engelmannii* (Parry) Lem. var. *munzii* (Parish) Pierce	T	2-1-1-2	San Bernardino
ELBR-2	*Elodea brandegeae* St. John	P.E.	P.E.--3	Tahoe

PLANT CODE	NAME	SMITHS INSTIT.	CNPS REVD	OCCURRENCE: NATIONAL FOREST
EPNI	*Epilobium nivium* Bdg.	T	3-1-1-3	Mendocino
ERBR-1	*Eriastrum brandegeae* Mason	T	2-1-1-3	Mendocino
ERTR-1	*Eriastrum tracyi* Mason	E	3-2-2-3	Mendocino, Shasta-Trinity
ERAE	*Erigeron aequifolius* Hall	T	3-1- -3	Inyo, Sequoia, Sierra
ERBLN	*Erigeron bloomeri* Gray var. *nudatus* (Gray) Cronq.	T	- - -2	Klamath, Six Rivers
ERDE-3	*Erigeron delicatus* Cronq.	E	P.E.--2	Six Rivers
ERFL	*Erigeron flexuosus* Cronq.	T	2-1-2-3	Klamath, Shasta-Trinity
ERMU-3	*Erigeron multiceps* Greene	T	3-1-1-3	Sequoia
ERPA-2	*Erigeron parishii* Gray	T	3-1-1-3	San Bernardino
ERAL-3	*Eriogonum alpinum* Engelm	E	3-1-1-3	Shasta-Trinity
ERAM-3	*Eriogonum ampullaceum* J. T. Howell	T	2-1-1-3	Inyo
ERBR-5	*Eriogonum breedlovei* (J. T. Howell) Reveal	E	3-2-1-3	Sequoia
ERBRS	*Eriogonum breedlovei* (J. T. Howell) Reveal var. *shevockii* J. T. Howell		3-2-1-3	Sequoia
ERBU	*Eriogonum butterworthianum* J. T. Howell	E	3-1-1-3	Los Padres
ERCO-8	*Eriogonum congdonii* (S. Stokes) Reveal	T	2-2-1-3	Klamath, Shasta-Trinity
ERDI-4	*Eriogonum diclinum* Reveal	E	3-3-1-3	Klamath
ERHI-2	*Eriogonum hirtellum* Howell & Bacig.	E	3-2-1-3	Klamath
ERKE-1	*Eriogonum kelloggii* Gray	T	3-1-1-3	Mendocino
ERKEA-2	*Eriogonum kennedyi* Porter ex Wats. var. *austromontanum* (Munz & Johnson) Stokes	T	2-2-1-3	San Bernardino
ERLA-4	*Eriogonum latens* Jeps.	T		Inyo
ERMIJ	*Eriogonum microthecum* Nutt. var. *johnstonii* Reveal	E	3-1-1-3	Angeles, San Bernardino
EROVV	*Eriogonum ovalifolium* Nutt. ssp. *vineum* (Small) S. Stokes	E	2-2- -3	San Bernardino
ERPR-4	*Eriogonum prociduum* Reveal		3-2-1-2	Modoc
ERRU	*Eriogonum rupinum* Reveal		3-1-1-1	Inyo
ERSI	*Eriogonum siskiyouense* Small	T	3-2-1-3	Klamath, Shasta-Trinity

PLANT CODE	NAME	SMITHS. INSTIT.	CNPS REVD	OCCURENCE: NATIONAL FOREST
ERTW	*Eriogonum twisselmannii* (J. T. Howell) Reveal	T	3-1-1-3	Sequoia
ERUMM-1	*Eriogonum imbellatum* Torr. var. *minus* I. M. Johnst.	E	2-2-1-3	Angeles, San Bernardino
ERUMT	*Eriogonum imbellatum* Torr. var. *torreyanum* (Gray) Jones	E	3-2-2-3	Tahoe
ERWRO	*Eriogonum wrightii* Torr. ex Benth. in DC. var. *olanchense* (J. T. Howell) Reveal	E	3-1-1-3	Inyo
ERLAH	*Eriophyllum lanatum* (Pursh) Forbes var. *hallii* Const.	E	3-2-2-3	Los Padres
ERNUC	*Eriophyllum nubigenum* Greene var. *congdonii* (Bdg.) Const.	T	3-1-1-3	Sierra, Stanislaus
ERGRP-3	*Erythronium grandiflorum* Pursh. ssp. *pusaterii* Munz & Howell	E	3- - -3	Sequoia
ERTU	*Erythronium tuolumnense* Applegate	T	1-2-1-3	Stanislaus
EUSH	*Eupatorium shastense* Taylor & Stebbins, ined.	T	2-1-1-3	Shasta-Trinity
FRUM	*Frasera umpquaensis* Peck & Appleg.	T	2-2-1-2	Shasta-Trinity, Six Rivers
FRBR	*Frittillaria brandegei* Eastw.	T	2-1-1-3	Sequoia
FRPH	*Frittillaria phaeanthera* Eastw.	E	2-2-2-3	Plumas
FRPL-2	*Frittillaria pluriflora* Torr. in Benth.	T	1-2-2-3	Mendocino, Plumas
FRST	*Frittillaria striata* Eastw.	T	2-2-1-3	Sequoia
GACAL	*Galium californicum* H. & A. ssp. *luciense* Demp. & Steb.	E	2-1-1-3	Los Padres
GACL	*Galium clementis* Eastw.	T	2-1-1-3	Los Padres
GAGLM	*Galium glabrescens* (Ehrend.) Demp. & Ehrend. ssp. *modocense* Demp. & Ehrend.	E	3-2- -3	Modoc
GAGR-2	*Galium grande* McClatchie	E	2-1-1-3	Angeles
GAHA-2	*Galium hardhamae* Dempster	E	2-1-1-3	Los Padres
GASES-1	*Galium serpenticum* Demp. ssp. *scotticum* Demp. & Ehrend.	E	3-3- -3	Klamath, Shasta-Trinity
GEFR	*Gentiana frémontii* Torr.	T	2-1-1-1	San Bernardino
GUCA	*Gutierrezia californica* (DC.) T. & G.	T	3-3- -3	Angeles
HAVI	*Halimolobus virgata* (Nutt.) Schulz		3-1-1-	Inyo
HAOP	*Haplopappus ophiditis* (J. T. Howell) Keck	T	2-1-1-3	Shasta-Trinity
HAUNG	*Haplopappus uniflorus* (Hook.) T. & G. ssp. *gossypinus* (Greene) Hall (Syn: *Pyrrocoma uniflorus* var. *gossypinus*)		- - -3	San Bernardino
HENUP	*Helianthus nuttalii* T. & G. ssp. *parishii* (Gray) Heiser	P.E.	P.E.--3	San Bernardino

PLANT CODE	NAME	SMITHS. INSTIT.	CNPS REVD	OCCURRENCE: NATIONAL FOREST
HEAD	*Hesperolinon adenophyllum (Gray) Small*	T	2-1-1-3	Mendocino
HEDR	*Hesperolinon drymariodes (Curran) Small*	T	2-1-1-3	Mendocino
HEBR	*Heuchera brevistaminea Wiggins*	T	2-1-1-3	Cleveland
HOTU	*Horkelia tularensis (Syn: Potentilla tularensis)*	T		Sequoia
HOWI	*Horkelia wilderae Parish*	E	2-2-1-3	San Bernardino
HOAQ	*Howellia aquatilis Gray*		3-1- -1	Mendocino
HUIN	*Hulsea inyoensis (Keck) Munz (Syn: Hulsea vestita ssp. inyoensis)*	T	2-1-1-3	Inyo
IRTEK	*Iris tenax Dougl. ssp. klamathensis Lenz*	E	3-2-2-3	Six Rivers
IVAR	*Ivesia argyrocoma (Rydb.) Rydb.*	T	2-1-1-3	San Bernardino
IVCA-1	*Ivesia callida (Hall) Rydb.*	E	P.E.--3	San Bernardino
IVPI	*Ivesia pickeringii Torr. ex Gray*	T	3-1-1-3	Shasta-Trinity
JUHI	*Juglans hindsii (Jeps.) Jeps.*	E	2-2-2-3	Sierra
LAZI	*Layia ziegleri Munz*	T	3-1-1-3	San Bernardino
LEBE	*Lesquerella bernardina Munz (Syn: Lesquerella kingii Wats. ssp. bernardina (Munz) Munz)*	T	2-2- -3	San Bernardino
LECO-1	*Lewisia congdonii (Rydb.) J. T. Howell*		2- - -3	Sierra, Stanislaus
LEDI-2	*Lewisia disepala Rydb.*	T	2-1-1-3	Sequoia
LEPYL	*Lewisia pygmaea (Gray) Rob. ssp. longipetala (Piper) Ferris*	T	2-1-1-3	El Dorado, Tahoe
LESE	*Lewisia serrata Heckard & Stebbins*	T	2-1-1-3	El Dorado, Tahoe
LEST-2	*Lewisia stebbinsii Gankin & Hildreth*	T	2-1-1-3	Mendocino
LIOC-2	*Lilium occidentale Purdy*	E	P.E.--2	Klamath, Shasta-Trinity, Six Rivers
LIVO	*Lilium vollmeri Eastw.*	T	1-2-2-3	Klamath, Six Rivers
LIWAM	*Lilium washingtonianum Kell. var. minus Purdy*	T	2-1-1-2	Klamath, Shasta-Trinity
LIWI	*Lilium wigginsii Beane & Vollmer*	T	2-1-1-3	Klamath, Six Rivers
LIGRP	*Limnanthes gracilis Howell var. parishii (Jeps.) C. Mason*	E	2-2-2-3	Cleveland
LIKI	*Linanthus killipii*			San Bernardino
LIORP	*Linanthus orcuttii (Parry & Gray) Jeps. ssp. pacificus (Mlkn.) Mason*	T	3-1-1-3	Cleveland
LOCO-1	*Lomatium congdonii*	T	2-2-2-3	Stanislaus
LOFOI	*Lomatium foeniculaceum (Nutt.) Coult. & Rose ssp. inyoense (Math. & Const.) Theobald*	T	2-1-1-3	Inyo

PLANT CODE	NAME	SMITHS. INSTIT.	CNPS REVD	OCCURRENCE: NATIONAL FOREST
LOHO	*Lomatium howellii (Wats.) Jepson*	T	2-1-1-2	Klamath, Six Rivers
LOPE-2	*Lomatium peckianum Math. & Const.*	T	2-2-2-2	Shasta-Trinity
LORA	*Lomatium ravenii Math. & Const.*	E	3-2-1-3	Lassen
LORI-1	*Lomatium rigidum (Jones) Jepson*	T	2-2-1-3	Inyo
LUCE	*Lupinus cervinus Kell.*	T	2-1-1-3	Los Padres
LUCIC	*Lupinus citrinus Kell. var. citrinus*	T	2-1-1-3	Sierra
LUCID	*Lupinus citrinus Kell. var. deflexus (Congd.) Jepson*	T	3-1-1-3	Sierra
LUDE-2	*Lupinus dedeckerae Munz & Dunn*	T	3-2-1-3	Inyo
LUDU	*Lupinus duranii Eastw.*	T		Inyo
LULU-2	*Lupinus ludovicianus Greene*	E	2-2-1-3	Los Padres
LUSP-3	*Lupinus spectabilis Hoover*	T	2-1-1-3	Sierra
LUTR-2	*Lupinus tracyi Eastw.*	E	3-2-2-3	Klamath, Shasta-Trinity, Six Rivers
MACAZ	*Machaeranthera canescens (Pursh) Gray var. ziegleri Munz*		2- - -3	San Bernardino
MALA	*Machaeranthera lagunensis Keck*	T	2-1-1-3	Cleveland, San Bernardino
MAPAL	*Malacothamnus palmeri (Wats.) Greene var. lucianus Kearney*	T	3-2-1-3	Los Padres
MAPAP	*Malacothamnus palmeri (Wats.) Greene var. palmeri*	T		Los Padres
MAPA-4	*Matelea parvifolia (Torr.) Woodson*		3-1-1-2	San Bernardino
MINUS	*Microseris nutans (Hook.) Sch. Big. ssp. siskiyouensis Chambers, ined.*		2-1-1-2	Klamath
MIEX	*Mimulus exiguus Gray*	T	2-1-1-3	San Bernardino
MIPU-3	*Mimulus purpureus Grant*	T	2-2-1-3	Angeles, San Bernardino
MIPY	*Mimulus pygmaeus Grant*	E	3-1-1-2	Lassen, Modoc
MIWH-1	*Mimulus whipplei Grant*	E	3-1-1-3	Stanislaus
MOHYL	*Monardella hypoleuca Gray ssp. lanata (Abrams) Munz*	T	2-1-1-3	Cleveland
MOLIO	*Monardella linoides Gray ssp. oblonga (Greene) Abrams*	T	2-1-1-3	Los Padres
MOMAH	*Monardella macrantha Gray var. hallii Abrams*	E	2-1-1-3	Cleveland, San Bernardino
MOST	*Monardella stebbinsii Hardham*		3-1-1-3	Plumas
MYHA	*Myrica hartwegii Wats.*	T	2-1-1-3	El Dorado, Sierra

PLANT CODE	NAME	SMITHS. INSTIT.	CNPS REVD	OCCURENCE: NATIONAL FOREST
NAPRL	*Navarretia prolifera* Greene ssp. *lutea* (Brand) Mason	T	2-1-1-3	El Dorado, Lake Tahoe Basin
NASE	*Navarretia setiloba* Cov.	E	2-2-1-3	Sequoia
NETW	*Nemacladus twisselmannii* J. T. Howell	T	3-1-1-3	Sequoia
OPCA	*Ophioglossum californicum* Prantl (Syn: *Ophioglossum lusitanicum* ssp. *californicum*)	T	2-2-1-2	Cleveland
OPVU	*Ophioglossum vulgatum* L.		P.E.--1	Shasta-Trinity
ORTE	*Orcuttia tenius* A. S. Hitchc.	E	3-3-2-3	Lassen
ORVA	*Orobanche valida* Jeps.	P.E.	P.E.--3	Angeles
ORLA-2	*Orthocarpus lasiorhynchus* Gray	T	1-2-2-3	Cleveland, San Bernardino
PASH	*Panicum shastense* Scribn. & Merr.		P.E.--3	Shasta-Trinity
PEDU	*Pedicularis dudleyi* Elmer	E	2-1-1-3	Los Padres
PEHO-1	*Pedicularis howellii* Gray	T	2-1-1-2	Klamath, Six Rivers
PECA-2	*Penstemon californicus* (M. & J.) Keck	T	2-1-1-2	Cleveland, San Bernardino
PECI-2	*Penstemon cinicola* Keck	T	2-1-1-2	Klamath, Lassen Modoc, Shasta-Trinity, Six Rivers
PEFI	*Penstemon filiformis* (Keck) Keck	T	2-1-1-3	Shasta-Trinity
PEPA-3	*Penstemon papillatus* J. T. Howell	T	2-1-1-3	Inyo
PEPE-4	*Penstemon personatus* Keck	E	3-1-1-3	Plumas
PETR	*Penstemon tracyi* Keck	T	3-1-1-3	Klamath, Shasta-Trinity
PEEXA	*Pentachaeta exilis* (Gray) Keck ssp. *aeolica* Van Horn & Ornduff	T	2-2- -3	Los Padres
PEBA	*Perideridia bacigalupii* Chuang & Const.	T	2-2-1-3	Sierra, Stanislaus
PELE-2	*Perideridia leptocarpa* Chuang & Const.	T	2-2-2-3	Klamath
PEPAP	*Perideridia parishii* (Coult. & Rose) Nels. & Macbr. ssp. *parishii*		2-2-2-2	San Bernardino

PLANT CODE	NAME	SMITHS. INSTIT.	CNPS REVD	OCCURRENCE: NATIONAL FOREST
PEPR	*Perideridia pringlei* (Coult. & Rose) Nels. & Macbr.	T		Los Padres, Sequoia
PHCO-5	*Phacelia cookei* Constance & Heckard	E	3-2-2-3	Klamath, Shasta-Trinity
PHDA	*Phacelia dalesiana* J. T. Howell	T	3-1-1-3	Klamath, Shasta-Trinity
PHGR-2	*Phacelia greenei* J. T. Howell	T	3-1-1-3	Klamath, Shasta-Trinity
PHNO	*Phacelia novemmillensis* Munz	T	3-1-1-3	Inyo, Sequoia
PHOR	*Phacelia orogenes* Brand	T	2-1-1-3	Sequoia
PHST-2	*Phacelia stebbinsii* Constance & Heckard		2-1-1-3	El Dorado, Tahoe
PHDO-2	*Phlox dolichantha* Gray		2-1-1-3	San Bernardino
PHHI	*Phlox hirsuta* E. Nels.	E	3- - -3	Klamath
PHAR-3	*Pholisma arenarium* Nuff. ex Hook.	T	2-2-2-2	Cleveland, San Bernardino
PICA	*Pityopus californicus* (Eastw.) Copel. f.	T	2-2-2-1	Klamath, Sequoia, Six Rivers
PLDI-2	*Plagiobothyrs distantiflorus* (Piper) Jtn.	T	2-1-1-3	Sierra
POAT	*Poa atropurpurea* Scribn.	E	3-1-1-3	Cleveland, San Bernardino
POFI	*Poa fibrata* Swall.	E	2-2-2-2	Klamath, Modoc, Shasta-Trinity
PODOP	*Pogogyne douglasii* Benth. ssp. *parviflora* (Benth.) J. T. Howell	E	2-2-2-3	Mendocino
POTU	*Potentilla tularensis* J. T. Howell (Syn: *Horkelia tularensis*)		3-1-1-3	Sequoia
RAMU-2	*Taillardella muirii* Gray	T	2-1-1-3	Los Padres, Sequoia, Sierra
RAPR	*Raillardella pringlei* Greene	T	3-2-1-3	Shasta-Trinity
RAHY	*Ranunculus hydrocharoides* Gray		3-2-1-1	Inyo
RHGLC	*Rhynchospora glomerata* (L.) Vahl var. *capitellata* (Michx.) Kukenthal		2-2-1-1	Tahoe
RICA-2	*Ribes cantharifome* Wiggins	T	2-1-1-3	Cleveland
ROSU-2	*Rorippa subumbellata* Roll.	T	2-2-2-3	Tahoe, Lake Tahoe Basin

PLANT CODE	NAME	SMITHS. INSTIT.	CNPS REVD	OCCURENCE: NATIONAL FOREST
SACOZ	*Salvia columbariae* Benth. var. *ziegleri* Munz	E	2-1-1-3	San Bernardino
SAHO-1	*Sanicula hoffmanii* (Munz) Shan & Const.	T	2-2-1-3	Los Padres
SAPE	*Sanicula peckiana* Macbr.	T	2-1-1-2	Six Rivers
SATR-1	*Sanicula tracyi* Shan & Const.	E	3-2-1-3	Six Rivers
SACH-1	*Satureja chandleri* (Bdg.) Druce	T	1-2-1-2	Cleveland
SAAM	*Saussurea americana* D. C. Eat.		3-2-2-2	Klamath
SCBR	*Schoenolirion bracteosum* (Wats.) Jeps.	T	2-1-1-2	Klamath, Six Rivers
SCPO	*Scleroccactus polyancistrus* (Engelm. & Bigelow) Britton & Rose	T	2-2-2-2	Inyo
SEBE	*Senecio bernardinus* Greene	T	2- - -3	San Bernardino
SEGA	*Senecio ganderi* Barkley & Beauchamp	T	2-1-1-3	Cleveland
SIHIA	*Sidalcea hickmanii* Greene ssp. *anomala* C. L. Hitchc.	T	3-1-1-3	Los Padres
SIHIH	*Sidalcea hickmanii* Greene ssp. *hickmanii*	T	2-1-1-3	Los Padres
SIHIP	*Sidalcea hickmanii* Greene ssp. *parishii* (Rob.) C. L. Hitchc.	T	2-2-1-3	Los Padres, San Bernardino
SIORH	*Sidalcea oregana* (Nutt.) Gray ssp. *hydrophila* (Heller) C. L. Hitchc.	T	2-1-1-3	Mendocino
SIPE	*Sidalcea pedata* Gray	T	3- - -3	San Bernardino
SIRO-2	*Sidalcea robusta* Heller ex Rousb	T	2-2-2-3	Lassen
SIIN	*Silene invisa* Hitchc. & Maguire	E	3-2-2-3	El Dorado, Plumas, Stanislaus, Tahoe, Lake Tahoe Basin
SIMA-4	*Silene marmorensis* Kruckeberg	E	2- - -3	Klamath, Six Rivers
SOTE-2	*Solanum tenuilobatum* Parish	T	2-1-1-3	Cleveland
SPOB	*Sphenopholis obtusata* (Michx.) Scribn.		2-1-1-1	Sierra
STLEP	*Stipa lemmonii* (Vasey) Scribn. var. *pubescens* Crampton	E	3-3-1-3	Mendocino
STCOP	*Streptanthus cordatus* Nutt. var. *piutensis* J. T. Howell	T	- - -3	Sequoia
STFA	*Streptanthus farnsworthianis* J. T. Howell	E	2-1- -3	Sequoia, Sierra
STFE	*Streptanthus fenestratus* (Greene) J. T. Howell	T	- - -3	Sierra
STGR-2	*Streptanthus gracilis* Eastw.	T	3-1-1-3	Inyo
TACA-3	*Taraxacum californicum* M. & J.	T	2-2-1-3	San Bernardino

PLANT CODE	NAME	SMITHS. INSTIT.	CNPS REVD	OCCURRENCE: NATIONAL FOREST
TAGL	*Tauschia glauca (Coult. & Rose) Math. & Const.*	T	2-1-1-2	Six Rivers
TAHO	*Tauschia howellii (Coult. & Rose) Macbr.*	T	2-2-2-2	Klamath, Six Rivers
THBR	*Thelypodium brachycarpum Torr.*		2-2-1-2	Klamath, Shasta-Trinity
THJA	*Thelypodium jaegeri Roll. (Syn: Caulostrámina jaegeri (Rollins) Comb. Nov.)*		3-1-1-3	Inyo
THST	*Thelypodium stenopetalum Wats.*	T	2-1-1-3	San Bernardino
THMAA	*Thermopsis macrophylla H. & A. var. agnina J. T. Howell*	T	3-2-1-3	Los Padres
TRBO	*Trifolium bolanderi Gray*	T	2-1-1-3	Sierra
TRDE-2	*Trifolium dedeckerae Gillett*	T	3-1-1-3	Inyo
TRLE	*Trifolium lemmonii Wats.*	E	3-2-1-3	Plumas, Tahoe
VACO	*Vaccinium coccinium Piper*	T	2-1-1-2	Klamath, Plumas
VECO-2	*Veronica copelandii Eastw.*	T	2-1-1-3	Klamath, Shasta-Trinity
VECU	*Veronica cusickii Gray*		2-1-1-2	El Dorado, Inyo, Sierra, Tahoe, Lake Tahoe Basin
VILAO	*Viola lanceolata L. ssp. occidentalis (Gray) Russell*	T	2- - -2	Six Rivers
VITO	*Viola tómentosa Baker & Clausen*	T	2-2-1-3	El Dorado, Plumas, Tahoe

STATE OF CALIFORNIA—RESOURCES AGENCY EDMUND G. BROWN JR., Governor

DEPARTMENT OF FORESTRY - FOREST RESOURCES ASSESSMENT PROGRAM
1416 NINTH STREET
SACRAMENTO, CALIFORNIA 95814
(916) 322-1945

P-1

October 23, 1978

(Sent to the Planning Departments of all California counties)

We are undertaking a resources assessment of all forested land in California under private and public ownership, as mandated by the Forest Resources Assessment and Policy Act of 1977. One objective of the program is to describe the management of local public forests. This would include forests managed by county, municipal, and regional entities, such as park systems and water districts. To this end, we would greatly appreciate your providing us, by November 27, 1978, with information (see Table below) for each local publicly owned unit of forested land within your county that has a minimum tree canopy cover of ten percent and encompasses 100 acres or more.

If we do not hear from you by November 27, we will assume your county does not have any local public forest land meeting the above criteria. To save your time, we have included an extra copy of this letter, the table of which could be completed and returned to us, attention FRAP (Forest Resources Assessment Program). If you have any questions, please contact Peter Wyckoff at the above number. Thank you.

Sincerely,

L. A. MORAN
Director

County _____

Area Name	Jurisdiction[1]	Acres[2]	Location[3]	Primary Mgmt Objective(s)[4]

[1] City, County, Multi-county, etc.

[2] Rough acreage of forested land not occupied by administrative facilities (buildings, parking, pasture, etc.).

[3] Township, range, section(s).

[4] Such as recreation, wood production, forage, watershed protection, nature study, wildlife protection, fishing, hunting, resource preservation.

CONSERVATION IS WISE USE—KEEP CALIFORNIA GREEN AND GOLDEN

FOREST SERVICE INVENTORY PROCEDURES AND DATA RELIABILITY

The statistics for national forests lands that are included in this Report were collected by national forest personnel. Data for all other lands were collected by Forest Survey personnel of the Pacific Northwest Forest and Range Experiment Station in Portland, Oregon. Detailed procedures for most of the inventories have been published in resource area reports (Oswald 1968, 1972, and 1978; Oswald and Walton 1966; Bolsinger 1976 and 1978; and Wall 1978).

Lands outside national forests except those in southern California and national forests north of Lake Tahoe were inventoried using a double sampling design. First, aerial photo sample plots one acre in size were distributed systematically across the area and classified into commerical forest, noncommercial forest, and nonforest. Commerical forest plots were further classified into several stand volume classes. In addition, plots outside national forests were classified by kind of owner, using county tax assessor records. A random sample of field plots was selected proportional to the number of aerial photo plots in each land and volume class on national forests and in each land, volume, and ownership class on lands outside national forests. The field sample was used to adjust the aerial photo sample for photo interpretation errors and changes since date of photography and also to provide detailed stand data such as stocking by species, volume by size, class, etc. Field plots consisted of 10 sample points distributed over an acre. The variable-radius plot sampling principle was used to select tally trees of 5.0 inches and larger. Trees smaller than five-inch diameter-at-breast-height (dbh) were tallied on a circular fixed radius plot. Where no trees were tallied a ground cover class was recorded.

For the national forests south of Tahoe National Forest, the present Forest Service Region 5 inventory systems were used. A type-map was made on which commercial, noncommercial, and nonforest land classes were delineated. Commercial forest areas were then further divided into stand condition classes and major types. Type-mapped areas of noncommercial and nonforest land were accepted without ground checking. The commercial forest area was sampled with field plots distributed proportional to area by condition class and major type. Field plots consisted of five sample points 132 feet apart in an L-shape. At each point, the variable-radius plot-sampling principle was used to select tally trees one-inch dbh and larger. Trees smaller than one-inch dbh were tallied on a circular fixed radius plot.

For lands outside national forests in southern California, the basic data collected for Forest Survey Release 25, 1954; and the State of California Fish and Wildlife Plan, 1966; were used along with records of timberland and brushland conversions to approximate forest areas and timber volumes in 1975.

Growth and mortality estimates for the national forests and lands outside national forests except those in southern California were developed from 10-year increment borings and five-year postdating of dead trees.

A total of 21,112 aerial photo plots were examined and 1,752 ground plots established on commercial forest land outside national forests. In addition, about 39,000 aerial photo plots and 1,500 field plots were examined by the Forest Survey on noncommercial forest lands. About 3,600 field plots were established on commerical forest land in the national forest.

Data for the Northern Interior, Sacramento, San Joaquin, and Central Coast resource areas were accepted as of time of inventory, except for adjustments made to account for major ownership changes. For the North Coast revisions were made by the Forest Survey to account for park expansion, cutting, growth on surviving trees 5.0 inches dbh and larger, and growth on trees estimated to have grown into the 5.0 inch or larger class since the inventories.

The regional reports in which most of the timber resource data were originally published contain details on their reliability (see Bolsinger, 1976 and 1978; Oswald 1968, 1972, and 1978; Oswald and Walton 1966; Wall 1978). The confidence intervals of the total area and volume estimates from these regional reports are shown in Table VI-1.

TABLE VI-1

RELIABILITY OF THE ESTIMATES OF COMMERCIAL FOREST, NONCOMMERCIAL FOREST, AND GROWING STOCK VOLUME, CALIFORNIA

RESOURCE AREA	TOTAL COMMERCIAL FOREST	TOTAL NONCOMMERCIAL FOREST (1)	TOTAL GROWING STOCK VOLUME
	CONFIDENCE INTERVAL IN PERCENT, 68-PERCENT PROBABILITY		
North Coast:			
Del Norte County	±2.9	N/A	±8.0
Humboldt County	±1.4	±17.0	±6.1
Mendocino and Sonoma Counties	±1.9	± 4.3	±4.4
Central Coast	±5.0	± 1.6	±9.1
Northern Interior	±1.1	± 2.8	±1.9
Sacramento	±1.5	± 4.0	±2.2
San Joaquin	±3.7	± 1.8	±5.8

N/A - Not Available

(1) Includes only the forest area outside parks and other reservations determined by sampling. Type-mapping procedures were used for most reservations.

Source: Data provided by Charles L. Blosinger, Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

APPENDIX VII

DEMAND FOR WOOD PRODUCTS IN CALIFORNIA

1976 - 2030

A REPORT TO THE CALIFORNIA DEPARTMENT OF FORESTRY

William McKillop
Department of Forestry and Resource Management
University of California
Berkeley, CA 94720

May 10, 1979

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SUMMARY AND HIGHLIGHTS

Anticipated sustained growth in California's population makes it evident that the State's consumption of pulp and paper products will increase steadily throughout the 1976-2030 projection period. It is estimated that 2030 levels of consumption of all types of paper and paperboard combined will be approximately four times the 1976 level. The growth in consumption of other wood products will be strong also, but in a number of cases, consumption will level off or even decline towards the end of the projection period. Softwood lumber consumption, for example, will increase markedly from its 1976 level of 6.6 billion board feet to 9.3 billion in 2010 and remain at that level until 2030. It is predicted that softwood plywood consumption will rise from its 1976 level of 2.1 million square feet to a plateau of approximately 2.7 million between 2010 and 2030. This pattern is due mainly to changes in the level of residential construction within the State as the composition of its population and rate of family formation change. It is anticipated, for example, that production of all forms of new residential units will rise from a 1976 level of 244 thousand units to a peak of 330 thousand in 1990, and then decline gradually to a level of 280 thousand in 2030. In some situations, such as residential construction, growing wood use per unit produced will tend to offset lower levels of industrial activity. In other cases, such as manufacturing, declining wood use per billion (constant 1967) dollars of shipments will not be offset by increasing levels of manufacturing activity, so that total use will remain stable or decline.

Analysis of demand/price relationships reveals increasing demand (outward shifting demand schedules) throughout the projection period. This, coupled with predicted decreases in timber availabilty results in forecasts of substantial "real" price increases for wood products (in addition to any general inflationary rises associated with the decline in the purchasing power of the dollar). It is anticipated that, in 2030, softwood lumber and plywood prices (in constant 1967 dollars) will be more than twice what they were in 1976. Stumpage prices will be more than five times their 1976 level. The increasing scarcity of wood products "supply" relative to "demand" is emphasized by comparison of forecasts of California consumption versus production for softwood lumber. Lumber production is expected to remain stable in the 1976-2030 period, whereas sharp increases in demand are expected. This means that there will be a distinct increase in the State's dependence on out-of-state suppliers. Net imports will rise from their 1976 level of 1.3 billion board feet (20 percent of consumption) to 3.2 billion (38 percent of consumption) in 1990. In 2030, net imports will constitute 44 percent of total softwood lumber consumption. Fortunately, an anticipated increase in California plywood production will result in only a slight increase in dependence on net plywood imports in the future. It should be noted, however, that currently the state supplies only some 29 percent of its softwood plywood needs, and will continue to be heavily dependent on out-of-state producers.

INTRODUCTION

In passing the Forest Resource Assessment and Policy Act the California Legislature recognized that "demands on forest resources in California are expected to increase significantly in the next decades" and that "better use of forest resources can result where there is good information as to anticipated needs and the potentials for meeting them." Knowledge of the physical attributes of the resource, and exploration of alternative strategies for its management are major components in the assessment of potential programs, but analysis of future demands and prospective markets for wood products is an essential, complementary element. Past studies by the U.S. Department of Agriculture Forest Service (1973) have made a thorough analysis of future demand and consumption at the national level. Forthcoming reports (Forest Service 1979a and 1979b) will provide information by broad regions within the country. To date, however, demand analyses relating specifically to California have not been available with the exception of an exploratory study by Barrette et al. (1978). This current report utilizes the most complete information available to analyze the present and future character of California's demand for wood products by decades to the year 2030. Emphasis is placed on major issues such as projecting aggregate consumption of softwood lumber, softwood plywood, building board, and pulp and paper products; but other aspects are covered to the extent feasible. These include estimation of wood products consumption in selected end- uses such as construction and manufacturing, estimation of demand/price relationships for softwood lumber, plywood and stumpage, and analysis of California's balance of trade in wood products.

AGGREGATE CONSUMPTION OF LUMBER, PLYWOOD AND BUILDING BOARD

Table 1 shows estimates of quantities of lumber, plywood and veneer, building board, and softwood plywood in all uses in California for 1976, and by decades from 1990 to 2030. Lumber estimates cover only softwood lumber; plywood and veneer estimates include hardwood and softwood categories. Estimates for plywood and veneer and building board were derived by aggregating estimates for individual categories of use shown in tables 4 through 10. These tables are discussed in a later section. The estimate of lumber consumption for 1976 was derived by analyzing data on shipments to California from various regions.

Table 1. Estimates of total use of lumber, plywood, and building board in California: 1976, 1990-2030. (in billions)

	1976	1990	2000	2010	2020	2030
1. Wood use						
Lumber(1) (billion b.f.)	6.600	8.539	8.518	9.264	9.383	9.372
Plywood and veneer(2) (billion sq. ft. 3/8")	2.334	3.087	3.458	3.409	3.543	3.917
Building board(2) (billion sq. ft. 1/2")	1.185	1.686	2.016	2.226	2.408	2.647
Softwood plywood(3) (billion sq. ft. 3/8")	2.075	2.583	2.651	2.704	2.723	2.712
2. Ratio relative to 1976						
Lumber	1.000	1.294	1.291	1.404	1.422	1.420
Plywood	1.000	1.323	1.482	1.461	1.518	1.678
Building board	1.000	1.423	1.701	1.878	2.032	2.234
Softwood plywood	1.000	1.245	1.278	1.303	1.312	1.307

(1) Softwood lumber only. 1976 figure based on data from California Redwood Association, Council of Forest Industries of British Columbia, National Forest Products Association, and Western Wood Products Association. Forecasts derived by analysis of preliminary U.S.D.A. Forest Service results.

(2) Estimates obtained by aggregation of consumption estimates for individual uses. Plywood and veneer includes hardwood and softwood. Building board includes hardboard, insulation board and particleboard.

(3) Estimates based on preliminary U.S.D.A. Forest Service results.

Table 2 shows estimates of aggregate shipments of softwood lumber and softwood plywood to California for the periods 1953-1977 and 1949-77, respectively. Plywood data represent shipments to California only from mills reporting to the American Plywood Association. Plywood estimates in Table 1 represent shipments from all sources. Lumber data were obtained by analyzing production and shipments data for British Columbia, the California Redwood Region, the Douglas Fir Region and the Western Pine Region. Lumber consumption in 1976 was estimated at 6.6 billion board feet, close to the level suggested by Barrette et al. (1978). Data in table 2 indicate a strong increase in lumber consumption from a level of 4 billion board feet in the 'fifties to 6 billion board feet in the nineteen-seventies. Forecasts in table 1 indicate that this strong upward movement will continue. A distinct upward movement is expected at the beginning of the forecast period, with the 1990 level of lumber consumption some 29 percent above the 1976 level. Consumption thereafter is expected to be between 8.5 and 9.4 billion board feet, although consumption in individual years may deviate significantly from these "trend line" estimates.

Table 2. Estimated shipments of softwood lumber and plywood to California from all sources, 1949-77.

Year	Softwood lumber(1) (million b.f.)	Softwood plywood(2) (million sq. ft. 3/8")
1949	(3)	267.505
1950	(3)	309.851
1951	(3)	341.961
1952	(3)	351.544
1953	4412.1	399.090
1954	4443.5	427.226
1955	3589.5	509.320
1956	4848.9	563.492
1957	4099.4	605.459
1958	4213.3	680.020
1959	4914.9	813.928
1960	4296.1	789.922
1961	4604.5	846.928
1962	4492.8	941.802
1963	4635.3	962.177
1964	4579.8	1081.135
1965	4311.2	1046.888
1966	4455.8	1086.549
1967	3923.7	1132.590
1968	4768.6	1413.253
1969	4868.4	1319.850
1970	4512.7	1395.419
1971	5618.6	1560.370
1972	6039.6	1649.073
1973	6404.4	1574.642
1974	6075.0	1383.906
1975	5486.1	1430.398
1976	6599.7	1667.398
1977	6448.7	1803.479

(1) Compiled from publications of the Council of Forest Industries of British Columbia, California Redwood Association, National Forest Products and Western Wood Products Association. Details given in Table 15.
(2) From American Plywood Association "Geographical analysis of shipments." Covers only shipments from mills reporting to APA.
(3) Not available.

Barrette et al. (1978) projected lumber consumption at 7.9 billion board feet for 1985, 8.9 billion for 2000 and 10.6 for 2020. Their 1985 estimate, and to a lesser extent their 2000 estimate conform to the results in table 1, but their estimate for 2020 is substantially higher. Their projection technique involved use of per capita consumption estimates under the assumption that anticipated price rises would not significantly dampen demand. The results in table 1, on the other hand, made use of analyses conducted by the U.S. Forest Service in connection with the forthcoming "1980 Timber Assessment," which allowed for the effect of price rises (U.S.D.A. Forest Service 1979b). Projected rates of increase in consumption for the Southwest Region (Arizona, California, Nevada and New Mexico) were applied to the 1976 base level estimate for California to yield the forecasts in table 1.

Forecasts of softwood plywood consumption were based on preliminary U.S. Forest Service estimates (U.S. Forest Service 1979b). The 1976 estimate in table 1 includes shipments from mills that do not report to the American Plywood Association and therefore differs from the estimate in table 2. Table 1 shows an increase until 1990 and a levelling out thereafter. Projections of plywood consumption by Barrette et al. (1978) are substantially higher than those in table 1. This again may be due to the fact that data were not available to Barrette et al. which made adequate allowance for substantial anticipated rises in price. Table 1 shows, also, data on plywood and veneer consumption, including both hardwood and softwood categories. These estimates were derived by aggregating levels of consumption in individual uses as described later. They are based partially on U.S. Forest Service analyses in which full allowance was not made for future price rises (U.S.D.A. Forest Service, 1979b). It is possible that they may therefore overestimate future levels of consumption.

Estimates of building board consumption, covering hardboard, insulation board and particleboard, were derived in the same general manner as plywood and veneer. Building board shows the strongest projected growth of all the wood products represented in table 1. It is estimated that its use in California will double by 2020 and continue to show strong growth in the following decade.

TABLE 3

PULP AND PAPER CONSUMPTION

Table 3 shows estimated levels of consumption in California of paper, paperboard and construction board (which includes hardboard and insulation board). The estimates were based on California Department of Finance projections of population and U.S. Forest Service forecasts of per capita consumption for the nation as a whole. As indicated in table 3, per capita consumption of all categories show strong increases over the forecast period. This together with a 1 percent per year average increase in population leads to estimates of substantial growth in total consumption. The estimates for 2030 are between three and four times greater than the 1976 levels.

Table 3. Estimated paper, paperboard and construction board consumption in California.

	1976	1990	2000	2010	2020	2030
1. California population(1) (Millions)	21.520	26.292	29.287	32.096	34.861	37.500
2. Per capita consumption of pulp and paper products(2) (pounds)						
All paper and board	596	824	949	1077	1189	1301
Paper	320	420	480	540	595	650
Paperboard	241	360	420	480	535	590
Construction board(3)	34	44	49	57	59	61
3. Total consumption (million tons)						
All paper and board	6.413	10.832	13.897	17.284	20.725	24.394
Paper	3.443	5.521	7.029	8.666	10.371	12.188
Paperboard	2.593	4.733	6.150	7.703	9.325	11.063
Construction board(3)	0.366	0.578	0.718	0.915	1.028	1.144
4. Ratio of consumption relative to 1976						
All paper and board	1.000	1.689	2.167	2.695	3.232	3.804
Paper	1.000	1.604	2.042	2.517	3.012	3.540
Paperboard	1.000	1.825	2.372	2.971	3.596	4.266
Construction board(3)	1.000	1.579	1.962	2.500	2.809	3.126

(1) 1976 estimate from State of Californian, Economic Report of the Governor. Forecasts based on California Department of Finance estimates.

(2) Based on U.S. Forest Service preliminary estimates. "Medium" projections.

(3) Includes hardboard and insulation board.

CONSUMPTION OF WOOD PRODUCTS IN SELECTED END USES

Tables 4 through 10 present estimates of consumption of lumber, plywood and building board in residential construction, residential upkeep and improvements, non-residential building construction, manufacturing, shipping and miscellaneous uses. Table 4, showing consumption in new residential construction is derived from tables 5, 6 and 7. It shows a slight increase in the use of lumber and plywood per housing unit over the forecast period. The use of building board (hardboard, insulation board and particleboard) per unit shows a more distinct rise. The number of housing units constructed in California is expected to increase significantly to 1990 and decline thereafter as the composition of the state's population changes and the rate of family formation decreases. The trend in total product use reflects these basic elements. Lumber and plywood use is expected to peak in 2010 and then decline slightly. Building board use, however, is expected to increase throughout the forecast period.

Table 4. Estimated wood use in all types of new residential construction in California: 1976, 1990-2030.

	1976	1990	2000	2010	2020	2030
1. Number of units constructed(1) (thousands)	244.0	330.5	313.5	315.0	296.7	280.3
2. Wood use per thousand units(2)						
Lumber(3) (Million b.f.)	9.980	9.449	9.780	10.168	10.526	10.928
Plywood(3) (million sq. ft., 3/8")	3.787	3.761	3.936	4.073	4.216	4.449
Building board (million sq. ft. 1/2")	1.225	1.489	1.716	1.879	2.096	2.273
3. Total wood use(4)						
Lumber (billion b.f.)	2.435	3.123	3.066	3.203	3.123	3.063
Plywood (billion sq. ft., 3/8")	0.924	1.243	1.234	1.283	1.251	1.247
Building board (billion sq. ft. 1/2")	0.299	0.492	0.538	0.592	0.622	0.637
4. Ratio of use relative to 1976						
Lumber	1.000	1.283	1.259	1.315	1.283	1.258
Plywood	1.000	1.345	1.335	1.389	1.354	1.350
Building board	1.000	1.645	1.799	1.980	2.080	2.130

(1) Forecasts based on preliminary nationwide estimates by U.S. Forest Service. Adjustment made for net migration to California. Includes mobile homes, single-family and multi-family residences.

(2) Derived from items 1. and 3.

(3) Hardwood and softwood.

(4) Aggregation of estimates in tables 5, 6 and 7.

Tables 5, 6 and 7 show estimates of use in the construction of conventional single-family homes, multi-family units and mobile homes respectively. The year 1976 was unusual in that the rates of multi-unit residences to single-family dwellings was abnormally low. In 1976, only 36.5 percent of all conventional housing starts were of the multi-family type. In contrast, the average over the 1968-77 period was 48.2 percent. Thus, estimates of increase relative to 1976 must be used with caution. Forecasts of home construction were obtained by first calculating the number of units produced in California relative to the nation as a whole over the 1970-77 period. This ratio was applied to nationwide forecasts prepared by the U.S.D.A. Forest Service (1979a). The resulting forecast was then adjusted by adding 50 thousand units per year to allow for net migration to California as estimated by the California Department of Finance (1977). Estimates of wood use per residential unit were derived from U.S. Forest Service nationwide estimates, with allowance for regional variation where feasible.

It is estimated that the trend in single-family home construction will peak in 1990 at 148 thousand units and decline slowly thereafter. It should of course be noted that actual housing starts in any specific year may deviate substantially from the projected trend line, depending on such factors as weather and the availability of mortgage funds. In 1977 for example, some 175 thousand single-family units were constructed in California, an unusually high level that was 65 percent above the 1968-77 average. The trend in construction of multi-family residences and mobile homes is expected, similarly to peak in 1990, but in all three cases increases in wood use per unit prevent a decline in total use until 2010 or later. In fact, wood use in mobile home construction is expected to increase throughout the projection period.

Comparison of estimates of total use in tables 5, 6 and 7 confirm the importance of single-unit residences as a consumer of lumber, plywood and building board relative to other residential structures. They also confirm that mobile home construction is (in absolute terms) the least important of the three types of residences as a consumer of wood products. Predicted growth in use of wood products by this sector is very substantial, however. By 2030, lumber consumption is expected to increase fourfold, plywood use is expected to more than double and building board use will almost triple. Part of the rapid growth is due to a substantial increase in the production of mobile homes; and part stems from a significant rise in the use of wood products per unit. On the other hand, wood use per single-family residence will increase only slightly and wood use per unit in multi-family dwelings is not expected to show any significant increase.

Table 5. Estimated wood use in single-unit conventional home construction in California: 1976, 1990-2030.

	1976	1990	2000	2010	2020	2030
1. Number of units constructed(1) (thousands)	140.0	148.0	140.4	141.1	132.9	125.5
2. Wood use per thousand units(2)						
Lumber(3) (Million b.f.)	13.264	14.160	14.725	15.267	15.785	16.280
Plywood(3) (million sq. ft., 3/8")	4.277	4.663	4.921	5.178	5.435	5.693
Building board (million sq. ft., 1/2")	1.167	1.400	1.611	1.838	2.079	2.333
3. Total wood use						
Lumber (billion b.f.)	1.857	2.096	2.067	2.154	2.098	2.043
Plywood (billion sq. ft., 3/8")	0.599	0.690	0.691	0.731	0.722	0.714
Building board (billion sq. ft., 1/2")	0.163	0.207	0.266	0.259	0.276	0.293
4. Ratio of use relative to 1976						
Lumber	1.000	1.129	1.113	1.160	1.129	1.100
Plywood	1.000	1.152	1.152	1.154	1.220	1.205
Building board	1.000	1.270	1.287	1.589	1.693	1.798

(1) 1976 estimate from Economic Report of Governor, 1978. Sacramento. Forecasts based on preliminary nationwide estimates by U.S. Forest Service. Adjustment made for net migration to California.

(2) U.S. Forest Service preliminary estimates (adjusted for California variation in use).

(3) Hardwood and softwood.

Table 6. Estimated wood use in multi-unit conventional home construction in California: 1976, 1990-2030.

	1976	1990	2000	2010	2020	2030
1. Number of units constructed(1) (thousands)	80.6	134.4	127.4	128.1	120.6	113.9
2. Wood use per thousand units(2)						
Lumber(3) (million b.f.)	6.3	6.3	6.2	6.2	6.1	6.1
Plywood(3) (million sq. ft., 3/8")	3.3	3.3	3.4	3.4	3.4	3.4
Building board (millin sq. ft., 1/2")	0.7	0.8	0.9	0.9	1.0	1.0
3. Total wood use						
Lumber (billion b.f.)	0.508	0.847	0.790	0.794	0.736	0.695
Plywood (billion b.f., 3/8")	0.266	0.444	0.433	0.436	0.410	0.387
Building board (billion b.f., 1/2")	0.506	0.108	0.115	0.115	0.121	0.114
4. Ratio of use relative to 1976						
Lumber	1.000	1.667	1.555	1.574	0.374	1.368
Plywood	1.000	1.669	1.628	1.639	1.541	1.455
Building board	1.000	1.929	2.054	2.054	2.161	2.036

(1) 1976 estimate from Economic Report of Governor 1978. Sacramento. Forecasts based on preliminary nationwide estimates by U.S. Forest Service. Adjustment made for net migration to California. Multi-unit construction in 1976 was at an unusually low level.

(2) U.S. Forest Service preliminary estimates.

(3) Hardwood and softwood.

Table 7. Estimated wood use in mobile home construction in California: 1976, 1990-2030.

	1976	1990	2000	2010	2020	2030
1. Number of units constructed(1) (thousands)	23.4	48.1	45.1	45.9	43.2	40.8
2. Wood use per thousand units(2)						
Lumber(3) (million b.f.)	2.998	3.736	4.577	5.557	6.687	7.957
Plywood(3) (million sq. ft., 3/8")	2.510	2.276	2.416	2.526	2.760	3.570
Building board (million sq. ft., 1/2")	3.439	3.686	4.319	4.750	5.198	5.630
3. Total wood use						
Lumber (billion b.f.)	0.070	0.180	0.209	0.255	0.289	0.325
Plywood (billion sq. ft., 3/8")	0.059	0.109	0.110	0.116	0.119	0.146
Building board (billion sq. ft., 1/2")	0.080	0.177	0.197	0.218	0.225	0.230
4. Ratio of use relative to 1976						
Lumber	1.000	2.571	2.986	3.643	4.129	4.643
Plywood	1.000	1.847	1.864	1.966	2.017	2.475
Building board	1.000	2.213	2.463	2.725	2.813	2.875

(1) 1976 estimate from the Manufactured Housing Institute. Forecasts based on preliminary nationwide estimates by U.S. Forest Service. Adjustment made for net migration to California.

(2) Preliminary U.S. Forest Service estimates, adjusted using Dickerhoff, H. E. (1978), Panel product usage in mobile home production in the top five producing states in the U.S. USDA Forest Products Laboratory. Resource Report FPL3, Madison, Wisconsin. 8p.

(3) Hardwood and softwood.

Data on wood use in residential upkeep and improvements, shown in table 8 reveal that this is an important (current and future) sector of consumption. Consumption of lumber will increase by 80 percent by 2030; consumption of plywood and building board will double and triple, respectively. It should be noted that data for estimated wood use in residential upkeep and improvements were not available for California. Estimates in table 8 were prepared by using nationwide ratios of use in upkeep and improvements to new residential construction. They should, therefore, be treated as "best available" at the present time.

Table 8. Estimated wood use in residential upkeep and improvements in California: 1976, 1990-2030.

	1976	1990	2000	2010	2020	2030
1. Wood use(1)						
Lumber (billion b.f.)	0.856	0.965	1.195	1.226	1.263	1.537
Plywood (billion sq. ft., 3/8")	0.376	0.487	0.635	0.658	0.686	0.862
Building board (billion sq. ft., 1/2")	0.176	0.274	0.364	0.390	0.433	0.548
2. Ratio relative to 1976						
Lumber	1.000	1.127	1.396	1.432	1.475	1.796
Plywood	1.000	1.295	1.689	1.750	1.824	2.293
Building board	1.000	1.557	2.068	2.216	2.460	3.114

(1) Estimated using ratios of nationwide use in residential upkeep and improvements to use in new housing (based on U.S. Forest Service preliminary estimates).

Data in table 9 reveals that non-residential building is not a major area of wood products consumption. It is estimated (on the basis of population forecasts) that value of non-residential building in California will increase substantially between 1976 and 2030. However, wood use per billion (constant 1967) dollars of construction is predicted to decline in the case of lumber, and to increase only slightly in the case of plywood and building board.

Table 9. Estimated wood use in non-residential building construction in California: 1976, 1990-2030.

	1976	1990	2000	2010	2020	2030
1. Value of construction(1) (billions of 1967 $)	1.890	2.868	3.194	3.502	3.804	4.091
2. Wood use per billion (1967) $ of construction(2)						
Lumber(3) (million b.f.)	132.9	114.2	108.9	104.6	102.5	100.3
Plywood(3) (million sq. ft., 3/8")	80.4	84.6	87.3	89.4	89.9	89.1
Building board (million sq. ft., 1/2")	16.2	20.0	22.5	24.5	25.7	26.1
3. Total wood use						
Lumber (billion b.f.)	0.251	0.328	0.348	0.366	0.390	0.410
Plywood (billion sq. ft., 3/8")	0.152	0.243	0.279	0.313	0.342	0.365
Building board (billion sq. ft., 1/2")	0.031	0.057	0.072	0.086	0.098	0.107
4. Ratio of total use relative to 1976						
Lumber	1.000	1.307	1.386	1.458	1.554	1.633
Plywood	1.000	1.599	1.836	2.059	2.250	2.401
Building board	1.000	1.839	2.323	2.774	3.161	3.452

(1) 1976 estimates from State of California, Economic Report of the Governor. Forecasts based on population forecasts of California Department of Finance.

(2) Based on preliminary estimates from U.S. Forest Service. "Medium" projections.

(3) Hardwood and softwood.

Estimates of future manufacturing activity in California were similarly based on projections of population. As may be seen from table 10, it is anticipated that the value of shipments from California manufacturers (in constant dollars) will increase some 70 percent between 1976 and 2030. Nationwide estimates of wood use per billion dollars of shipments were applied to these estimates to yield the forecasts of total wood consumption by California manufacturers shown in table 10. Use per billion dollars of shipments is expected to decline for all wood products, except for hardboard and particleboard. In these cases it is expected to remain virtually stable. As a result total wood use in manufacturing shows very slow or relatively modest growth.

Table 10. Estimated wood use in manufacturing in California: 1976, 1990-2030

	1976	1990	2000	2010	2020	2030
1. Value of shipments, all manufacturing(1)	55.76	66.17	73.71	80.78	87.74	94.54
2. Wood products consumed per billion (constant 1967) $ of shipments(2)						
Lumber(3) (million b.f.)	11.652	11.652	11.652	9.710	9.710	7.768
Veneer and plywood(3) (million sq. ft., 3/8")	5.826	5.826	5.826	3.884	3.884	3.884
Hardboard (million sq. ft., 1/8")	4.272	4.272	4.272	4.272	4.272	4.272
Particle board (million sq. ft., 3/4")	3.884	4.078	4.078	4.078	4.078	4.078
3. Total wood product use						
Lumber (billion b.f.)	0.650	0.771	0.859	0.784	0.852	0.734
Veneer and plywood (billion sq. ft. 3/8")	0.325	0.386	0.430	0.314	0.341	0.367
Hardboard (billion sq. ft., 3/8")	0.238	0.283	0.315	0.345	0.375	0.404
Particle board (billion sq. ft., 3/4")	0.217	0.270	0.301	0.329	0.358	0.386
4. Ratio of use relative to 1976						
Lumber	1.000	1.186	1.322	1.207	1.311	1.129
Veneer and plywood	1.000	1.188	1.322	.966	1.049	1.129
Hardboard	1.000	1.189	1.324	1.450	1.576	1.697
Particleboard	1.000	1.244	1.387	1.516	1.650	1.779

(1) 1976 data from U.S. Bureau of the Census Annual Survey of Manufactures. Forecasts based on forecasts of population (from California Department of Finance estimates).

(2) Preliminary estimates from U.S. Forest Service.

(3) Hardwood and softwood.

The same situation is expected in the case of lumber and plywood for the shipping of goods as shown in table 11.

Table 11. Estimated wood use in shipping in California: 1976, 1990-2030

	1976	1990	2000	2010	2020	2030
1. Wood use(1)						
Lumber (billion b.f.)	0.881	1.048	1.205	1.170	1.335	1.173
Plywood (billion sq. ft., 3/8")	0.094	0.129	0.152	0.118	0.139	0.161
2. Ratio relative to 1976						
Lumber	1.000	1.190	1.368	1.328	1.515	1.331
Plywood	1.000	1.372	1.617	1.255	1.479	1.713

(1) Estimated using nationwide ratios of use in shipping to use in manufacturing (based on U.S. Forest Service preliminary estimates). Estimates for building board not available (included in miscellaneous uses).

On the other hand, wood consumption in miscellaneous uses (such as the upkeep of non-residential buildings, made-at-home projects and made-on-the job items such as advertising and display items) may show stronger growth, as revealed in table 12.

Table 12. Estimated wood use in miscellaneous uses in California: 1976, 1990-2030.

	1976	1990	2000	2010	2020	2030
1. Wood use(1)						
Lumber (billion b.f.)	1.527	2.003	2.206	2.398	2.555	2.713
Plywood (billion sq. ft., 3/8")	0.463	0.599	0.728	0.723	0.784	0.915
Building board (billion sq. ft., 1/2")	0.224	0.310	0.426	0.484	0.522	0.565
2. Ratio relative to 1976						
Lumber	1.000	1.312	1.445	1.570	1.673	1.777
Plywood	1.000	1.294	1.572	1.562	1.693	1.976
Building board	1.000	1.384	1.902	2.161	2.330	2.522

(1) 1976 data for lumber estimated as the residual between total shipments and wood use calculated for all other uses. 1976 data for building board and plywood derived using nationwide ratio relative to all other uses (based on preliminary U.S. Forest Service estimates). Forecasts for 1990 to 2030 based on projected nationwide use levels. Lumber estimate excludes hardwood lumber. Plywood estimate includes hardwood plywood and veneer.

DEMAND AND PRICE RELATIONSHIP FOR SOFTWOOD

Lumber, Plywood and Stumpage

Analyses conducted by the U.S. Forest Service and its co-operators in connection with its "1980 Timber Assessment" are one important source of information on demand-price relationships (demand schedules) for softwood lumber, plywood and stumpage (U.S. Forest Service 1979b). Adams and Haynes (1979) describe the softwood timber market model which is basic to the "1980 Assessment." Estimates of demand elasticities were derived for softwood lumber and plywood for six regions within the United States. Estimates of elasticities for the Southwest region (consisting of Arizona, California, Nevada and New Mexico) were 0.34 and 0.55, respectively. The plywood estimate corresponds closely to an estimate of 0.58 derived for the nation as a whole by McKillop et al. (1979). Table 13 shows estimated demand schedules for softwood lumber, plywood and stumpage for California. The lumber and plywood equations are derived from preliminary estimates for the Southwest Region for 1977 through 2030. These schedules were obtained by calculating the percentage of Southwest region consumption accounted for by California in 1977 and applying it to the U.S. Forest Service estimated schedules. The stumpage schedules are "derived demand" equations based on relationships for processed wood.

Table 13. Estimated demand schedules for California for softwood lumber, plywood, and stumpage, 1977, 1990-2030(1)

Year	Lumber(2)		Plywood(2)		Stumpage(3)	
	Intercept (a)	Slope (b)	Intercept (a)	Slope (b)	Intercept (a)	Slope (b)
1977	471076	-57.95536	334440	-96.52619	980.6	-1.4450
1990	513644	-45.01952	334459	-71.31714	991.7	-1.3832
2000	548992	-46.39643	334462	-66.77119	978.1	-1.3366
2010	586815	-44.66238	334467	-58.70988	1033.7	-1.2907
2020	627213	-46.60417	334469	-55.78012	1063.3	-1.2457
2030	670370	-49.53917	334470	-54.09321	1108.3	-1.2015

(1) Based on preliminary U.S. Forest Service estimates.

(2) Equation form for lumber and plywood: Price = a + b (quantity demanded). Price in constant 1967 dollars per million board feet; quantity in million board feet for lumber; million square feet (3/8" basis) for plywood.

(3) Equation form for stumpage: Quantity = a + b (price). Price in dollars per thousand board feet. Quantity in million cubic feet.

Table 14 shows estimated prices (in constant 1967 dollars) for softwood lumber, plywood and stumpage. Lumber and plywood prices refer to the Southwest region as a whole but the stumpage prices refer specifically to California. The anticipated sharp rise in "real" (constant 1967 dollar) prices is clearly evident. Lumber and plywood prices will more than double in the 1976-2030 period, and stumpage prices are anticipated to increase fivefold. It should be noted that the major part of the growth in prices will take place in the first half of the period. Average annual compound growth rates over the 1976-2000 period are expected to be 2.0, 2.3 and 4.7 percent per year for lumber, plywood and stumpage, respectively. The corresponding rates for the 2000-2030 period are 0.9, 0.6 and 2.0 percent, respectively. The fact that these are rates of price increase over and above the rate of inflation means that there will be serious impacts on the welfare of consumers during the period of rising prices. This aspect is discussed in McKillop (1979).

Table 14. Estimates of softwood lumber, plywood and stumpage "demand" prices in California: 1976, 1990-2030(1)

	1976	1990	2000	2010	2020	2030
1. Price (constant 1967 $)						
Lumber ($ per M.b.f.)	126.50	179.84	205.80	227.51	247.45	266.80
Plywood ($ per M. sq. ft., 3/8")	94.20	155.94	162.93	180.61	187.28	192.29
Stumpage ($ per M.b.f. Scribner)	32.31	83.25	96.68	123.24	144.94	175.05
2. Ratio relative to 1976						
Lumber	1.000	1.422	1.627	1.798	1.956	2.109
Plywood	1.000	1.655	1.730	1.917	1.988	2.041
Stumpage	1.000	2.577	2.992	3.814	4.486	5.418

(1) Preliminary U.S. Forest Service estimates. Lumber and plywood estimates represent average prices paid in the Southwest Region (Arizona California, Nevada and New Mexico). Stumpage estimates are for standing timber sold from California National Forests.

CALIFORNIA'S BALANCE OF TRADE IN WOOD PRODUCTS

Sources of softwood lumber for California markets.

Table 15 shows the level of shipments of softwood lumber to California from major timber producing regions. The California Redwood Region (producing both redwoods, Douglas fir and other "whitewoods") is the leading source of shipments to California consumers, followed closely by the Western Pine Region (Western Wood Products Association "Inland" Region). The Douglas Fir Region (WWPA "Coast" Region) ranks third, with British Columbia a relatively minor source. Analyses of shipments data from mills reporting to the Western Wood Products Association (1978) reveal that in 1976, 46.3 percent of WWPA lumber shipments to California markets originated in California, 28.6 percent came from Oregon, 16.6 percent from Montana, and 7.1 percent from Washington. Shipments from other states (Arizona, Idaho, New Mexico, Utah, Wyoming and Colorado) were relatively insignificant. In 1968, on the other hand, 61.8 percent originated in California, 30.9 percent came from Oregon, 3.1 percent from Washington, 2.4 percent from Idaho and less than 1 percent from Montana.

Table 15. Estimated shipments of softwood lumber to California markets by source.(1) 1947-1977

	Volume of shipments (million b.f.) from					
	All Sources	Calif. Redwood Region	Western Pine Region	Douglas Fir Region	Douglas Fir & Western Pine Regions	British Columbia
1947	(2)	(2)	(2)	8.200	1088.200	(2)
1948	(2)	(2)	1588.100	1257.300	2845.400	(2)
1949	(2)	(2)	1379.900	945.420	2325.400	(2)
1950	(2)	(2)	1709.700	946.110	2655.800	53.545
1951	(2)	(2)	1583.300	937.468	2520.700	37.584
1952	(2)	(2)	1576.200	700.281	2276.500	39.559
1953	4412.100	2183.200	1491.400	692.916	2184.400	44.603
1954	4443.500	2387.300	1374.400	630.001	2004.400	51.812
1955	3589.500	2329.600	636.260	562.919	1199.200	60.672
1956	4848.900	2713.300	1501.900	576.378	2078.300	57.312
1957	4099.400	2265.900	1374.700	408.204	1782.900	50.599
1958	4213.300	2400.400	1350.200	403.680	1753.900	59.052
1959	4914.900	2605.500	1551.800	692.615	2244.500	65.019
1960	4296.100	1995.200	1545.600	690.666	2236.300	64.613
1961	4604.500	1916.500	1839.700	777.700	2617.400	70.650
1962	4492.800	1907.200	1787.700	718.408	2506.100	79.545
1963	4635.300	1929.600	1825.200	791.938	2617.100	88.664
1964	4579.800	1893.900	1744.800	853.450	2598.200	87.721
1965	4311.200	1784.500	1688.900	751.605	2440.600	86.128
1966	4455.800	1726.600	1652.300	995.304	2647.600	81.625
1967	3923.700	1697.00	1364.000	777.315	2141.300	85.449
1968	4768.600	2060.000	1636.500	975.705	2612.200	96.463
1969	4868.400	2171.200	1605.300	996.505	2601.800	95.445
1970	4512.700	2088.300	1515.900	815.038	2330.900	93.543
1971	5618.600	1989.500	(2)	(2)	3509.800	119.361
1972	6039.600	2092.600	(2)	(2)	3812.500	134.441
1973	6404.400	2276.000	(2)	(2)	3981.800	146.592
1974	6075.000	2338.900	(2)	(2)	3620.000	116.111
1975	5486.100	1840.000	(2)	(2)	3583.000	63.116
1976	6599.700	2040.800	(2)	(2)	4383.000	175.892
1977	6448.700	2410.200	2113.700	1812.300	3925.900	(2)

(1) Compiled from publications of Council of Forest Industries of British Columbia, California Redwood Association, National Forest Products Association, and Western Wood Products Association.

(2) Not available.

Distribution of lumber from California sawmills (1)

Table 16 shows the destinations of lumber shipped by California sawmills. California itself is the major destination, consuming approximately 60 percent of the state's production. The Midwest has historically taken 15 to 16 percent of California production, although this percentage appears to have declined slightly in recent years. Shipments to western states other than California have ranged between 5 and 8 persent over the 1964-77 period, as have shipments to the Southest region. The Northeast and South Central Regions are of lesser importance; foreign countries have taken only between 2 and 3 percent of the state' production.

Table 16. Destinations of softwood lumber from California mills (million board feet)

	Calif.	Other Western	Midwestern	Northeast	South Central	Southeast	Foreign Countries	Total California Production
1964	(2) (60.90%)	(2) (5.90%)	(2) (15.80%)	(2) (5.00%)	(2) (4.80%)	(2) (5.90%)	(2) (1.70%)	(2) (100.00%)
1965	(2) (60.90%)	(2) (5.90%)	(2) (15.80%)	(2) (5.00%)	(2) (4.80%)	(2) (5.90%)	(2) (1.70%)	(2) (100.00%)
1966	(2) (60.60%)	(2) (4.90%)	(2) (16.20%)	(2) (5.50%)	(2) (4.70%)	(2) (4.80%)	(2) (3.30%)	(2) (100.00%)
1967	2936.100 (60.60%)	237.405 (4.90%)	784.890 (16.20%)	266.475 (5.50%)	227.715 (4.70%)	232.560 (4.80%)	159.885 (3.30%)	4845.000 (100.00%)
1966	3276.000 (60.60%)	264.894 (4.90%)	875.772 (16.20%)	297.330 (5.50%)	254.082 (4.70%)	259.488 (4.80%)	178.398 (3.30%)	5406.000 (100.00%)
1969	3080.300 (60.60%)	249.067 (4.90%)	823.446 (16.20%)	279.565 (5.50%)	238.901 (4.70%)	243.984 (4.80%)	167.739 (3.30%)	5083.000 (100.00%)
1970	2892.800 (58.10%)	318.656 (6.40%)	721.955 (14.50%)	224.055 (4.50%)	298.740 (6.00%)	433.173 (8.70%)	89.622 (1.80%)	4979.000 (100.00%)
1971	3117.600 (58.10%)	343.424 (6.40%)	778.070 (14.50%)	241.470 (4.50%)	321.960 (6.00%)	466.842 (8.70%)	96.588 (1.80%)	5366.000 (100.00%)
1972	3356.400 (58.10%)	369.728 (6.40%)	837.665 (14.50%)	259.965 (4.50%)	346.620 (6.00%)	502.599 (8.70%)	103.986 (1.80%)	5777.000 (100.00%)
1973	3373.300 (58.10%)	371.584 (6.40%)	841.870 (14.50%)	261.270 (4.50%)	348.360 (6.00%)	505.122 (8.60%)	104.508 (1.80%)	5806.000 (100.00%)
1974	3224.500 (63.30%)	402.426 (7.90%)	646.938 (12.70%)	193.572 (3.80%)	244.512 (4.80%)	269.982 (5.30%)	112.068 (2.20%)	5094.000 (100.00%)
1975	2947.900 (63.30%)	367.903 (7.90%)	591.439 (12.70%)	176.966 (3.80%)	223.536 (4.80%)	246.821 (5.30%)	102.454 (2.20%)	4657.000 (100.00%)
1976	3375.800 (63.30%)	421.307 (7.90%)	677.291 (12.70%)	202.654 (3.80%)	255.984 (4.80%)	282.649 (5.30%)	117.326 (2.20%)	5333.000 (100.00%)
1977	3484.700 (63.30%)	434.895 (7.90%)	699.135 (12.70%)	209.190 (3.80%)	264.240 (4.80%)	291.765 (5.30%)	121.110 (2.20%)	5505.000 (100.00%)

(1) Source: Statistical Yearbook. Western Wood Products Association.

(2) Not available.

(February 18, 1979)

Exports of unprocessed wood to foreign countries

The level of exports of unprocessed wood to foreign countries has been a major forest policy issue in the Western U.S. for a number of years. Tables 17 through 20 show the level of exports of logs and wood chips from California. It can be seen from table 17 that softwood log exports from Northern California ports increased rapidly in the latter part of the nineteen-sixties to approximately 200 million board feet per year between 1968 and 1970. Starting in 1971, however, they dropped considerably and have ranged between 77 and 110 million board feet per year since then with the vast bulk of shipments going to Japan. Preliminary U.S. Forest Service forecasts suggest that the decline in softwood log exports will continue throughout the forecast period. This is to be expected in view of the strong growth in demand for raw materials by California wood processors. This influence is partially reflected in the rise in the price of softwood export logs which (in constant dollars) has doubled over the 1969-1976 period.

Table 17. Softwood log exports from Northern California ports (thousand board feet, Scribner)(1)

	To all countries				To Japan			
	All Species	Douglas Fir	Port Orford Cedar	Other Species	All Species	Douglas Fir	Port Orford Cedar	Other Species
Year	XSNWT(2)	XSNWD	XSNWC	XSNWO	XSMJT	XSNJD	XSNJC	XSNJO
1961	27951	1274	10600	16077	27463	982	10513	15968
1962	37469	412	5598	31459	37322	274	5589	31459
1963	38267	281	11873	26112	38049	110	11864	26075
1964	13367	40	7451	5876	13279	0	7451	5828
1965	14790	1124	6846	6820	13082	1095	6846	5141
1966	21888	1363	4999	15526	21771	1356	4999	15416
1967	43256	4936	4075	34247	43247	4936	4075	34236
1968	212163	26186	5275	180702	198834	24006	5275	169552
1969	206705	23754	3663	179288	200783	23384	3663	173736
1970	192083	32531	2894	156658	175217	29965	2894	142358
1971	102408	27032	2182	73194	93281	26712	2182	64387
1972	77459	18337	3418	55704	68830	15914	3418	49498
1973	104733	34454	4065	66214	94520	29261	4065	61194
1974	77735	35146	8823	33766	69271	32485	8823	27963
1975	86943	52547	2483	31913	78813	48188	2483	28142
1976	108912	73924	2508	33380	96485	69395	2853	24237

(1) Source: USDA Forest Service, Pacific Northwest Experiment Station. Production, prices, employment and trade in Northwest forest industries. Portland, Oregon.

(2) Code name of variable.

Table 18. Hardwood log exports from San Francisco Customs District(1)

Year	To all countries(2) Volume XHTFW(3)	To all countries(2) Value VHTFW	To Japan(2) Volume XHFTJ	To Japan(2) Value VHTFJ
1964	713	486.269	428	328.405
1965	1248	1311.801	1169	1228.778
1966	1640	2185.782	1622	2167.335
1967	2325	3157.742	2284	3125.00
1968	4973	3929.172	4924	3868.293
1969	8379	6414.511	8280	6299.531
1970	2353	2693.748	2296	2659.420
1971	1275	1443.328	1222	1394.205
1972	1320	1692.573	1126	1479.429
1973	1084	1730.335	1015	1670.379
1974	560	719.223	485	682.698
1975	3911	446.457	3803	364.208
1976	659	677.474	456	549.727

(1) Source: U.S.D.A. Forest Service (op. cit.)
(2) Volume in thousand board feet, Scribner. Value in thousand (constant 1967) dollars.
(3) Code name of variable.

Export of logs from Southern California ports are shown in table 19. Volumes exported have been relatively insignificant. In the peak year of 1976, for instance, total log exports amounted to only 2.4 million board feet, including 0.3 million board of hardwood logs. Hardwood log exports from Northern California (shown in table 18) have ranged from 0.6 million board feet (in 1974) to 8.4 million in 1969.

Table 19. Volume of log exports from Southern California ports.(1)
(Thousand board feet, Scribner)

Year	All Species XTST(2)	Douglas Fir XTSD	Other Softwoods XTSOS	Hardwoods XTSH
1965	160	65	9	86
1966	76	48	8	20
1967	85	0	27	58
1968	2111	(3)	1	50
1969	205	46	94	65
1970	561	276	60	225
1971	365	90	84	191
1972	631	203	92	336
1973	445	214	5	226
1974	378	32	130	216
1975	288	11	224	53
1976	2396	1411	670	315

(1) Source: U.S.D.A. Forest Service (op. cit.)
(2) Code name of variable.
(3) Not available.

Exports of wood chips from San Francisco Customs District are shown in table 20 for the 1967-76 period. Exports during this period reached a peak in 1971 and have remained relatively high during the seventies with a 1976 level of approximately 370 thousand tons. Price data in constant dollars show no evidence of increse; in fact the price per ton (in constant 1967 dollars) was slightly less in 1976 than in 1972. Preliminary U.S. Forest Service analyses of the availability of sawmill and plywood plant residues relative to pulp production within the State suggests that substantial volumes of residues will continue to be available either for export or as a source of fuel.

Table 20. Exports of wood chips from San Francisco Customs District(1)

Year	Volume XCF(2)	Average Value PXCF
1967	38291	(3)
1968	77381	15.512
1969	83520	14.235
1970	267347	(3)
1971	476400	(3)
1972	253401	20.789
1973	369403	18.122
1974	242017	19.169
1975	257735	16.558
1976	366678	18.995

(1) Source: U.D.S.A. Forest Service (op. cit). Volumes in short tons, oven-dried basis. Values in (contant 1967) dollars per short ton.

(2) Code name of variable.

(3) Not available.

Consumption/production balance for softwood lumber and plywood

Table 21 displays estimates of future consumption levels for softwood lumber and plywood, together with forecasts of production levels. As discussed earlier, a sharp increase in California lumber consumption of 1.9 billion board feet is anticipated between 1976 and 1990. This is a 29 percent increase over the 1976 level. No rise in lumber production within the State is expected, resulting in a marked increase in net imports (from 1.3 billion board feet in 1976 to 3.2 billion in 1990). This high degree of dependence on out-of-state producers is expected to continue throughout the projection period.

A lesser, 24 percent, increase in softwood plywood consumption is anticipated between 1976 and 1990. This increase is partially offset by a projected increase in California plywood production. Dependence on net imports is therefore expected to increase until around 2000 and stabilize thereafter. It should be noted, however, that the state is dependent on out-of-state supply to a much greater degree in the case of softwood plywood than softwood lumber. Net imports of softwood lumber made up some 20 percent of toal consumption in 1976, and it is anticipated that this will rise to 44 percent by 2030. In contrast, net imports of softwood plywood were estimated to be some 70 percent of total consumption in 1976, it is estimated that they will be 67 percent of consumption in the 2000-2030 period. Aggregation of lumber and plywood data on a "board foot lumber tally" basis gives an overall picture of the future trend in net imports to the state. Net imports are expected to increase by 105 percent from their 1976 level to 3.9 billion in 1990, continue to rise to a plateau of 4.8 billion feet in 2020. The degree of dependence of California on out-of-state suppliers of lumber and plywood in the aggregate (measured by net imports as a percentage of total consumption) is thus estimated to rise from 26 percent in 1976 to 46 percent in 2010 through 2030.

Table 21. Consumption/production balance for California for softwood lumber and plywood, 1976, 1990-2030.

	1976	1990	2000	2010	2020	2030
1. Softwood lumber (billion board feet)						
Consumption (1)	6.6	8.5	8.5	9.3	9.4	9.4
Production(2)	5.3	5.3	5.1	5.3	5.3	5.3
Net imports to state	1.3	3.2	3.4	4.0	4.1	4.1
2. Softwood plywood (billion square feet, 3/8")						
Consumption(1)	2.1	2.6	2.7	2.7	2.7	2.7
Production(3)	0.6	0.9	0.9	0.9	0.9	0.9
Net imports to state	1.5	1.7	1.8	1.8	1.8	1.8
3. Aggregate lumber and plywood (billion b.f., lumber tally)(4)						
Consumption	7.4	9.5	9.5	10.3	10.4	10.4
Production	5.5	5.6	5.4	5.6	5.6	5.6
Net imports	1.9	3.9	4.1	4.7	4.8	4.8

(1) From Table 1.

(2) 1976 estimate from Western Wood Products Association. Forecasts based on U.S.D.A. Forest Service preliminary estimates.

(3) 1976 estimate from U.S.D.A. Forest Service (op. cit.). Forecasts based on U.S.D.A. Forest Service preliminary estimates.

(4) Plywood converted to lumber tally using 2.66 sq. ft. per board foot (from Barrette et al).

29-79445

APPENDIX VIII

ECONOMIC IMPORTANCE OF TIMBER

IN CALIFORNIA

A report to the California Department of Forestry

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May 11, 1979

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SUMMARY AND HIGHLIGHTS

In terms of employment, payrolls, value added by manufacture and the value of shipments, the lumber and wood products sector and the paper and allied products sector each account for approximately three percent of manufacturing activity within California.[1] With respect to employment, in 1975 the lumber and wood products ranked ninth and paper and allied products ranked fourteenth among the nineteen "two-digit" industries surveyed by the U. S. Bureau of the Census. In terms of value of shipments, lumber and wood products ranked eighth and paper and allied products ranked tenth.

Employment in lumber and wood products has declined from its 1955 peak of 62.4 thousand employees to 54.2 thousand in 1976 but steady growth in paper and allied products has more than offset this. Thus 1976 employment in the two sectors combined was higher than in any other previous year in the 1950-76 period.

Sawmills and planing mills are the most important subsector within lumber and wood products accounting for 35 percent of sector employment in 1976. It is followed by millwork and plywood plants (23 percent of employment), "miscellaneous wood products" (13 percent), wood buildings and mobile homes (13 percent), wooden containers (8 percent) and logging firms (8 percent). Within the paper and allied products sector, the order of importance in terms of 1976 employment is paperboard containers (42 percent of sector employment), converted products (36 percent), papermills (9 percent) and paperboard mills (9 percent).

Analysis of the importance of timber in regional economies revealed that lumber and wood products employment in 1970 accounted for 50 to 66 percent of "basic" employment in Humboldt, Del Norte, Mendocino and Sierra Counties. In the case of Siskiyou, Tehama, Plumas, Shasta and Trinity Counties, the degree of dependence ranged between 39 and 50 percent. Estimates of income multipliers gave further indication of the substantial economic importance of timber in many counties. For the five counties most heavily dependent on the timber industry these multipliers revealed that for every one dollar change in lumber and wood products payrolls, total county income would change by an amount ranging from $1.30 in the case of Sierra County to $2.40 in the case of Humboldt County.

Employment data for individual counties for the period 1959-73 permitted further assessment of the role of timber in local economies. In 1973, seven counties had 1000 or more persons employed in the wood products sector. In order of magnitude they were Humboldt, Mendocino, Shasta, Siskiyou, Tehama, Butte and Del Norte. The ranking was different in terms of relative importance as measured by the percentage of the total work force in lumber and wood products. In 1973, the timber industry accounted for more than 30 percent of total employment in the case of eight counties. On this basis, Sierra County ranked first, followed by Trinity, Del Norte, Plumas, Mendocino, Tehama, Humboldt and Siskiyou.

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1) Sectors and subsectors refer to the U.S. Bureau of Census "Standard Industrial Classification".

INTRODUCTION

In adopting the Forest Resources Assessment and Program Act, the California Legislature found that the forest resources of the state "provide vitally important economic and environmental benefits to the people of California." This report seeks to underscore this finding, in part, by assessing the economic importance of timber both at the regional and statewide level.

Past studies such as those by Zivnuska et al (1965), Oswald (1970), Barrette et al (1970), Howard (1974), Hiserote and Howard (1978) and Bolsinger (1979) have addressed the issue in varying degrees. For example, Zivnuska et al conducted a comprehensive examination of the structure of the state's forest economy; Oswald and Bolsinger discussed employment and output of the timber industries; and Barrette et al, and Howard and Hiserote reported detailed findings of surveys of the wood processing industry. This report focuses on (1) industrial activity in the wood processing sector relative to the overall economy of the state; (2) trends and comparisons of employment and income in subsectors of the forest economy; and (3) the regional importance of timber within the state.

WOOD PROCESSING AND THE STATE'S ECONOMY

Wood processing activity is recorded by the U. S. Bureau of the Census in two Standard Industrial Classification (SIC) sectors: Lumber and Wood Products (SIC 24), and Paper and Allied Products (SIC 26). A comparison between these sectors and all manufacturing in California is provided in Table 1. It will be noted that the lumber and wood products sector is slightly larger than the paper and allied products sector in terms of the criteria shown. With respect to number of employees, payroll, value added and value of shipments it represents between 3.1 and 3.4 of all manufacturing in the state. The paper and allied products shows a somewhat lower contribution (2.3 percent) to the state's manufacturing economy in terms of employment and payroll; but its contributions in terms of value added (2) and value of shipments are 2.7 and 3.0 percent respectively. Lumber and wood products showed a substantially higher contribution (4.6 versus 3.0 percent) in terms of new capital expenditures but comparison based on a single year may be somewhat misleading because of year-to-year fluctuation in this type of expenditure.

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2) Value added is the difference between the cost of materials and the sale value of the product.

TABLE 1

The 1975 Annual Survey of Manufactures (U.S. Bureau of the Census, 1975) presents information on nineteen "two-digit" sectors in California including lumber and wood products (SIC 24) and paper and allied products (SIC 26). In terms of employment, lumber and wood products ranks ninth, and paper and allied products ranks fourteenth. With respect to value added by manufacture, lumber and wood products also ranks ninth, and paper and allied products ranks thirteenth. In terms of value of shipments, lumber and wood products ranks eighth and paper and allied products ranks tenth.

Table 1. Industry statistics for all manufacturing, lumber, and wood products, and paper and allied products in California 1976 (1)

	All manufacturing	Lumber and wood products (SIC 24)	%(2)	Paper and allied products (SIC 26)	%(2)
1. Number of employees (thousand)	1600.1	54.2	3.4	37.1	2.3
2. Payroll (million $)	21214.7	661.1	3.1	487.9	2.3
3. Value added by manufacture (million $)	46297.4	1523.8	3.3	1241.2	2.7
4. Value of shipments (million $)	102041.0	3469.6	3.4	3066.5	3.0
5. New capital expenditures (million $)	2867.1	132.7	4.6	84.7	3.0

(1) Source: U.S. Bureau of the Census, Annual Survey of Manufactures. 1975. Statistics for States. Washington D.C.

(2) Percentage of all manufacturing

Data in Table 2 shows the trend in forest industries employment for the 1950-76 period. Employment in lumber and wood products reached a peak of 62.4 thousand persons in 1955, declined to a low of 47 thousand in 1967, and then increased to the 1976 level of 54.2 thousand. Employment in paper and allied products, on the other hand, has shown a more or less steady increase from 13.5 thousand in 1950 to 36.7 thousand in 1976. This has resulted in a total overall increase in California forest industries employment between 1950 and 1976 of some 25 thousand persons (a 38 percent increase over the 1950 level).

Table 2. Employment in California forest industries 1950 to 1976 (thousands) (1)

YEAR	Forest Industries Total EFIC(2)	Lumber and Wood Products ELWC(2)	Paper and Allied Products EPPC(2)
1950	66.2	52.7	13.5
1951	73.8	58.0	15.8
1952	75.0	58.5	16.5
1953	76.7	58.4	18.3
1954	73.3	56.6	19.7
1955	83.8	62.4	21.4
1956	84.2	61.0	23.2
1957	80.0	55.3	24.7
1958	78.2	53.5	24.9
1959	85.5	58.6	26.9
1960	82.1	54.9	27.2
1961	78.9	51.1	27.8
1962	80.8	51.4	29.4
1963	81.4	51.3	30.1
1964	83.0	53.0	30.0
1965	81.7	51.0	30.7
1966	82.9	50.3	32.6
1967	80.7	47.0	33.7
1968	84.7	49.7	35.0
1969	87.2	50.8	36.4
1970	84.0	48.1	36.7
1971	86.0	50.5	35.5
1972	90.3	52.4	37.9
1973	90.2	54.1	36.1
1974	88.2	50.9	37.3
1975	87.3	52.8	34.5
1976	91.3	54.2(3)	37.1(3)

(1) Source: U.S.D.A. Forest Service; Pacific Northwest Forest and Range Experiment Station.

(a) Production, price, employment, and trade in Northwest Forest industry.

(b) B.R. Wall and D.D. Oswald. Research Paper PNW 159.

(2) Code name of variable.

(3) Adjusted to conform to U.S. Bureau of the Census.

Tables 3, 4 and 5 enable a detailed comparison to be made of changes over the 1963-76 period in California's forest industries relative to all manufacturing in the state. Total employment in paper and allied products increased some 29 percent between 1963 and 1976, in contrast to a 14 percent increase for manufacturing as a whole. Lumber and wood products employment, on the other hand showed only a 4 percent increase over that period. Value added (in constant 1967 dollars) increased 39 percent in the case of all manufacturing, 54 percent in lumber and wood products, and 73 percent in paper and allied products. Such increase in value added are partially due to "real" price increases (over and above the rate of general inflation) for forest industry products but, may also be indicative of growth relative to the economy as a whole. In terms of all manufacturing, the level of new capital expenditure went up 50 percent in the 1963-76 period, while the increase was 59 percent for lumber and wood products, and 26 percent for paper and allied products. As mentioned before, however, the level of new capital expenditures may be quite volatile, and comparisons such as these must be treated with care. In the case of paper or allied products, for example, the 1975 level was 73 percent greater than the 1976 level.

Table 3. Industry statistics for "all manufacturing" in California, 1963-1976 (1)

YEAR	Number of Firms FCALL(2)	Total Employees (thousands) ECALL(2)	Total Payroll (million 1967 $) PCALL(2)	Number of Production Workers (thousand) LCALL(2)	Total Man-hours (production workers) (million 1967 $) HCALL(2)	Total Wages (production workers) (million 1967 $) WCALL(2)	Value Added by Manufacture (million 1967 $) VCALL(2)	Value of Shipments (million 1967 $) SCALL(2)	New Capital Expenditures (million 1967 $) CCALL(2)
1963	32201.0	1398.611	9982.270	899.932	1791.421	5412.334	18161.443	(3)	1042.449
1964	(3)	1383.660	10459.016	879.732	1770.151	5527.422	19025.281	39613.539	1090.192
1965	(3)	1406.211	10668.061	909.541	1831.471	5765.745	19522.072	40776.101	1235.920
1966	(3)	1501.767	11404.176	984.000	1981.939	6279.113	21373.851	43793.105	1474.127
1967	26913.0	1583.500	12514.500	1044.900	2089.700	6877.800	23393.600	47106.100	1592.200
1968	(3)	1610.300	13052.585	1061.300	2112.900	7197.854	24730.049	49887.415	1498.829
1969	(3)	1631.800	13287.418	1075.200	2119.600	7231.080	25367.981	50645.070	1615.869
1970	(3)	1553.100	12732.609	1003.900	1981.300	6844.475	23875.272	47425.000	1419.746
1971	(3)	1447.300	12115.101	937.200	1843.500	6481.387	24203.863	47796.576	1243.986
1972	35713.0	1544.300	12970.613	1021.000	1974.900	7084.803	26249.034	52876.742	1382.452
1973	(3)	1641.200	12706.904	1097.200	2137.600	6988.790	27266.221	54848.181	1423.311
1974	(3)	1657.200	11788.132	1088.800	2115.100	6314.241	25333.729	53997.314	1613.741
1975	(3)	1558.100	11120.412	1004.400	1943.100	5881.589	23176.558	51569.182	1484.963
1976	(3)	1600.100	11592.732	1041.300	2021.800	6121.475	25299.126	55760.109	1566.721

(1) Source: U.S. Bureau of the Census. Annual Survey of Manufactures. Statistics for States. Dollar values converted to constant 1967 dollars.
(2) Code name of variable.
(3) Not available.

Table 4. Industry statistics for lumber and wood products sector (SIC24) in California: 1963-1976 (1)

YEAR	Number of Firms FC24(2)	Total Employees (thousands) EC24(2)	Total Payroll (million 1967 $) PC24(2)	Number of Production Workers (thousand) LC24(2)	Total Man-hours (production workers) (million 1967 $) HC24(2)	Total Wages (production workers) (million 1967 $) WC24(2)	Value Added by Manufacture (million 1967 $) VC24(2)	Value of Shipments (million 1967 $) SC24(2)	New Capital Expenditures (million 1967 $) CC24(2)
1963	2339.0	51.906	312.746	45.570	89.762	262.069	540.061	(3)	45.589
1964	(3)	50.250	317.644	43.422	87.792	262.353	585.363	1289.268	43.303
1965	(3)	71.676	452.358	64.895	128.626	401.217	787.800	1890.344	102.618
1966	(3)	44.087	285.469	38.917	77.518	239.053	518.311	1131.253	44.406
1967	1934.0	46.000	294.100	40.500	79.900	241.600	523.800	1222.700	34.400
1968	(3)	48.000	319.902	42.200	84.800	264.390	668.390	1460.293	36.683
1969	(3)	49.400	331.737	43.400	86.300	272.582	712.113	1564.883	58.122
1970	(3)	46.000	310.236	39.800	79.100	249.457	538.406	1289.402	34.058
1971	(3)	45.300	319.052	39.600	79.700	262.248	627.217	1460.228	46.795
1972	2236.0	62.300	453.652	54.100	106.600	367.170	948.447	2199.916	74.391
1973	(3)	66.400	448.849	57.600	114.800	362.955	1058.797	2344.766	51.299
1974	(3)	60.300	372.205	51.800	101.900	299.001	701.749	1769.894	65.022
1975	(3)	53.700	328.988	46.100	88.200	263.179	671.698	1563.007	53.402
1976	(3)	54.200	361.257	47.600	94.900	294.481	832.678	1895.956	72.514

(1) Source: U.S. Bureau of the Census. Annual Survey of Manufactures. Statistics for States. Dollar values converted to constant 1967 dollars.
(2) Code name of variable.
(3) Not available.

Table 5. Industry statistics for paper and allied products sector (SIC26) in California: 1963-1976 (1)

YEAR	Number of Firms FC26(2)	Total Employees (thousands) EC26(2)	Total Payroll (million 1967 $) PC26(2)	Number of Production Workers (thousand) LC26(2)	Total Man-hours (production workers) (million 1967 $) HC26(2)	Total Wages (production workers) (million 1967 $) WC26(2)	Value Added by Manufacture (million 1967 $) VC26(2)	Value of Shipments (million 1967 $) SC26(2)	New Capital Expenditures (million 1967 $) CC26(2)
1963	485.0	28.865	190.224	22.820	47.069	137.570	392.699	(3)	36.302
1964	(3)	29.929	203.910	23.164	48.044	148.027	379.437	1008.159	53.371
1965	(3)	30.303	209.687	23.931	48.900	150.264	419.189	1052.412	120.431
1966	(3)	31.800	224.843	25.003	52.062	161.752	470.749	1145.904	48.234
1967	499.0	32.000	232.100	25.600	52.400	169.800	497.900	1177.100	49.300
1968	(3)	32.300	241.854	25.700	52.900	177.561	533.756	1218.244	43.122
1969	(3)	34.700	258.216	27.600	56.300	188.826	570.516	1293.239	46.948
1970	(3)	34.200	268.659	26.900	54.500	190.308	572.011	1330.435	62.862
1971	(3)	33.000	269.535	25.700	52.100	189.025	568.218	1302.019	56.804
1972	506.0	34.300	284.887	26.700	53.100	205.793	602.855	1405.877	40.218
1973	(3)	35.100	268.448	27.200	54.300	195.843	623.979	1442.910	47.439
1974	(3)	38.100	265.522	29.600	59.100	188.257	757.464	1665.084	68.582
1975	(3)	35.400	248.199	27.500	54.100	176.215	653.631	1560.949	79.245
1976	(3)	37.100	266.612	28.800	57.600	192.951	678.251	1675.683	45.902

(1) Source: U.S. Bureau of the Census. Annual Survey of Manufactures. Statistics for States. Dollar values converted to constant 1967 dollars.
(2) Code name of variable.
(3) Not available.

TABLE 6

EMPLOYMENT AND INCOME WITHIN THE WOOD PROCESSING SECTOR

Tables 6 and 7 show employment and payrolls by forest industry subsectors in California for the 1965-76 period. The number of firms covered in each subsector is also shown. As might be expected, sawmills and planing mills (SIC 242) is the dominant component of the lumber and wood products sector in terms of employment and payrolls. In 1976 sawmills and planing mills accounted for only 12 percent of the number of firms, but for 35 percent of employment and 40 percent of total payrolls in the sector. Millwork and plywood plants ranked second with 23 percent of employment and total payrolls. The "miscellaneous wood products" subsector ranked third and the "wood buildings and mobile homes" subsector ranked fourth (each with 13 percent of total employment in 1976). "Wooden containers" ranked fifth, followed closely by logging firms. Each accounted for 8 percent of total lumber and wood products employment.

With regard to employment trends, it will be noted from Table 6, that while employment in millwork and plywood plants, sawmills and planing mills, and logging firms declined slightly between 1965 and 1976, other sectors showed significant growth. A similar situation occurred in the paper and allied products sector (SIC 26). Paperboard mill employment decreased and paper mill employment showed only a slight increase, but other subsectors experienced significant growth over the 1965-76 period. The second largest subsector (converted products), for example, had a 1976 level of employment that was 35 percent greater than the 1965 level. The largest subsector (paperboard containers) showed a 19 percent increase. These subsectors represented 36 percent and 42 percent of the total 1976 employment in paper and allied products. Paper mills and paperboard mills each accounted for 9 percent of total employment.

Table 6. Number of firms, employment and payrolls in lumber and(1) wood products subsectors in California. 1965-1976

	Total lumber and wood products			Logging camps and contractors			Sawmills and planing mills		
YEAR	Firms reporting RU24(2)	Number of employees RE24	Total payroll (million 1967 $) RW24	Firms reporting RU241	Number of employees RE241	Total payroll (million 1967 $) RW241	Firms reporting RU242	Number of employees RE242	Total payroll (million 1967 $) RW242
1965	1843	51022	349.403	542	4657	35.795	362	23553	160.118
1966	1747	50288	341.252	497	4154	32.393	329	22739	155.211
1967	1690	47042	330.446	485	3973	31.948	305	21350	153.192
1968	1678	49714	363.819	505	4509	36.221	282	22130	166.780
1969	1691	50773	371.850	513	4581	37.609	273	22134	168.172
1970	1614	48071	358.142	455	3730	30.704	262	20819	161.909
1971	1633	50474	394.189	460	4135	35.587	251	21170	175.082
1972	1589	51697	409.171	441	4578	39.656	242	21692	182.181
1973	1915	53753	401.198	605	4404	35.360	261	21957	177.157
1974	1800	50834	338.112	531	4192	31.648	241	20696	147.684
1975	1912	52879	338.919	497	3618	26.123	250	19301	136.329
1976	1958	59606	404.240	525	4593	34.519	239	20907	160.164

(1) Source: California Employment Development Department. Report 127. Payroll data converted to constant 1967 dollars
(2) Code name of variable (denoting SIC code)
(3) Not available

Table 6. (continued)

	Millwork and plywood			Wooden containers		
	Firms reporting	Number of employees	Total payroll (million 1967 $)	Firms reporting	Number of employees	Total payroll (million 1967 $)
YEAR	RU243(2)	RE243	RW243	RU244	RE244	RW244
1965	487	14194	102.751	132	3210	18.901
1966	463	13893	98.228	131	3594	21.167
1967	450	11885	86.289	133	3890	23.078
1968	440	12676	95.933	120	4038	24.766
1969	440	13139	99.147	122	3639	22.191
1970	429	12310	94.124	132	4145	26.322
1971	458	14135	109.739	123	4205	29.666
1972	451	14741	115.768	113	4095	30.439
1973	503	14907	108.990	129	4072	27.995
1974	491	12854	84.993	126	4030	24.752
1975	507	11661	76.224	172	4299	24.136
1976	519	13488	92.430	176	4748	27.416

	Wood buildings and mobile homes			Miscellaneous wood products		
	Firms reporting	Number of employees	Total payroll (million 1967 $)	Firms reporting	Number of employees	Total payroll (million 1967 $)
YEAR	RU245	RE245	RW245	RU249(2)	RE249	RW249
1965	(3)	(3)	(3)	311	5408	31.837
1966	(3)	(3)	(3)	327	5907	34.252
1967	(3)	(3)	(3)	317	5945	35.939
1968	(3)	(3)	(3)	331	6362	40.117
1969	(3)	(3)	(3)	343	7046	44.166
1970	(3)	(3)	(3)	346	7064	45.082
1971	(3)	(3)	(3)	341	6827	44.114
1972	(3)	(3)	(3)	342	6590	41.127
1973	(3)	(3)	(3)	417	8412	51.696
1974	(3)	(3)	(3)	411	9059	49.035
1975	128	7154	39.747	358	6842	36.359
1976	124	7895	46.009	375	7972	43.704

(1) Source: California Employment Development Department. Report 127. Payroll data converted to constant 1967 dollars
(2) Code name of variable (denoting SIC code)
(3) Not available

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TABLE 7

Table 7. Number of firms, employment and payrolls in paper and(1) allied products subsectors in California. 1965-1976

	Total paper and allied products			Paper mills			Paperboard mills		
YEAR	Firms reporting RU26(2)	Number of employees RE26	Total payroll (million 1967 $) RW26	Firms reporting RU262	Number of employees RE262	Total payroll (million 1967 $) RW262	Firms reporting RU263	Number of employees RE263	Total payroll (million 1967 $) RW263
1965	424	30673	221.490	13	2973	21.823	12	4398	33.106
1966	435	32638	239.843	14	3174	24.388	14	5087	40.891
1967	452	33654	252.934	15	3519	27.926	14	4743	38.897
1968	456	34972	272.118	14	3463	28.246	14	4706	39.914
1969	465	36447	289.496	12	3435	28.837	15	4617	40.041
1970	471	36781	299.037	10	3161	26.433	13	4302	37.725
1971	458	35584	299.953	13	3281	28.053	11	4148	38.652
1972	458	36242	312.047	13	3370	29.529	10	4176	40.264
1973	482	36100	293.768	13	3155	27.979	10	3927	36.325
1974	490	37298	274.142	13	3149	24.972	11	3905	32.831
1975	485	34697	257.115	16	3117	24.741	10	3473	28.505
1976	500	36715	288.232	19	3260	27.728	9	3245	29.728

(1) Source: California Employment Development Department. Report 127. Payroll data converted to constant 1967 dollars
(2) Code name of variable (denoting SIC code)

Table 7. (continued)

	Converted products			Paperboard containers			Other products		
YEAR	Firms reporting RU264(2)	Number of employees RE264	Total payroll (million 1967 $) RW264	Firms reporting RU265	Number of employees RE265	Total payroll (million 1967 $) RW265	Firms reporting RU26X	Number of employees RE26X	Total payroll (million 1967 $) RW26X
1965	204	9764	67.683	187	13107	95.235	8	432	3.642
1966	205	10381	73.632	191	13372	95.978	11	624	4.955
1967	211	10581	76.675	202	14050	104.073	10	761	6.364
1968	224	11421	85.116	195	14598	112.360	9	783	6.482
1969	224	12452	93.038	205	15155	120.883	9	788	6.699
1970	233	13261	102.622	205	15323	125.591	10	732	6.665
1971	218	12664	100.946	206	14720	125.085	10	768	7.216
1972	218	12404	99.597	209	15025	130.618	13	1264	12.040
1973	232	12599	94.547	211	15217	124.479	16	1239	10.437
1974	237	13618	92.439	211	15172	112.209	18	1452	11.691
1975	232	12514	84.871	209	14201	108.152	18	1389	10.846
1976	241	13165	92.505	214	15547	126.378	17	1497	11.892

(1) Source: California Employment Development Department. Report 127. Payroll data converted to constant 1967 dollars
(2) Code name of variable (denoting SIC code)

REGIONAL IMPORTANCE OF FOREST INDUSTRIES

Appendix A shows the trend in total employment, employment in all manufacturing, and employment in the lumber and wood products sector for the 15 most important timber producing counties in California. The economic importance of an industry to a county or other region is most appropriately measured by its "dependency indicator" or its employment or income multiplier.

The use of dependency indicators is supported by economic base (export base) theory which recognizes that the economy of a county or region may be divided into two parts: the "basic" sector (the economic or export base) which produces goods for export from the county; and the non-basic sector which exists to serve the needs of employees and firms in the basic sector. Expenditures by tourists and "transfer payments" (such as retirement income) coming from outside the county are included as part of the economic base.

The dependency indicators shown in Table 8 show, for the 15 most important timber producing counties in California, the percentage of basic employment provided by the lumber and wood products sector (SIC 24). It is apparent that the economies of Humboldt, Del Norte, Mendocino and Sierra counties are heavily dependent on the timber industry. The lumber and wood products sector accounted for 50 to 66 percent of basic employment in these counties in 1970. Siskiyou, Tehama, Plumas, Shasta and Trinity counties also show substantial reliance on the timber industry, with dependency indicators of between 39 and 50 percent.

Dependency indicators for 1960 are included in Table 8 for comparison. It will be noted that significant decreases in dependency on the timber industry occurred between 1960 and 1970 in most cases. There was, for example, an 80 percent drop in the indicators for Humboldt and Del Norte. For Lassen, Mendocino, Nevada, Sierra and Trinity the drop ranged between 9 and 18 percent. Only Siskiyou county showed an increase (some 4 percent) in the level of the dependency indicator between 1960 and 1970. The lessening dependence on the timber industry appears to be due mainly to growing diversity in local economies and increases in transfer payments (such as retirement income) coming from outside the county.

Table 8. Dependency indicators for 15 Northern California Counties based on the 1960 and 1970 censuses.(1)

County	1960 Percent	1970 Percent	County	1960 Percent	1970 Percent
Butte	14.7	8.4	Shasta	45.3	40.4
Del Norte	83.6	63.6	Sierra	60.2	50.2
El Dorado	20.1	5.4	Siskiyou	45.8	49.9
Humboldt	86.9	66.3	Trinity	55.0	39.0
Lassen	33.2	14.9	Tehama	51.3	43.7
Mendocino	69.9	55.9	Yuba	14.4	7.7
Modoc	19.9	13.2	Average	35.6	27.3
Nevada	23.7	14.3			
Plumas	48.2	42.5			

(1) Source: Connaughton, Kent and William McKillop (1979) Estimation of "Small-area" multipliers for the wood processing sector — an econometric approach. Forest Science (forthcoming)

The lumber and wood products income multipliers shown in Table 9 provide another important gauge of the role of the timber industry in regional economies in California. They measure the change in county income that would be created for each dollar change in payrolls in the lumber and wood product sector. Until recently, it was necessary to use input-output models to estimate multipliers for individual sectors such as lumber and wood products. Input-output models such as the one developed by Dean et al (1973) are expensive and time-consuming to construct for individual counties. Furthermore, it is difficult to assess the accuracy of input-output multipliers. The multipliers in Table 9 were derived by an inexpensive, econometric technique described by Connaughton and McKillop (1979). The degree of accuracy of the estimates is quite variable, but of acceptable accuracy for those counties where timber is highly important, such as Del Norte, Humboldt, and Mendocino, Sierra and Siskiyou. Results suggest that in the case of Del Norte, Humboldt and Siskiyou counties, each dollar change in lumber and wood products payrolls leads to a change of about $2.40 change in overall county income. For Mendocino and Sierra counties the estimated overall effects are $1.70 and $1.30, respectively, for each $1 change in timber industry payrolls. Magnitudes such as these give a clear indication of the high degree of importance of timber in the economies of these counties.

Table 9. Lumber and wood products income multipliers, standard errors, and confidence intervals for the fifteen most important wood processing counties in California

County	Multiplier	Standard Error	95% Confidence Interval
Butte	1.5936	1.0687	-1.514 to 4.3407
Del Norte	2.2610	.1191	1.9549 to 2.5671
El Dorado	4.2417	4.1206	-7.1987 to 15.6820
Humboldt	2.3685	.1345	1.9404 to 2.7965
Lassen	1.8646	.4834	.6221 to 3.1071
Mendocino	1.7364	.1408	1.3454 to 2.1274
Modoc	1.9378	.4766	.7124 to 3.1627
Nevada	.8480	.7707	-1.1311 to 2.8291
Plumas	1.3075	.6193	-.1569 to 2.7719
Shasta	3.2858	.7121	1.4553 to 5.1163
Sierra	1.3281	.1061	1.0684 to 1.5877
Siskiyou	2.4155	.2611	1.744 to 3.0866
Tehama	1.6083	1.5512	-2.6985 to 5.9152
Trinity	1.9175	.3488	1.064 to 2.7710
Yuba	1.2707	1.2932	-2.0535 to 4.5949

(1) Source: Connaughton and McKillop (op. cit.)

Appendix A shows data on employment for 1959, 1962, 1965-71 and 1973 for major wood processing counties. Appendix B displays the relationship between employment in lumber and wood products, all manufacturing and total county employment. In terms of total employment in lumber and wood products, Humboldt County ranks first, followed by Mendocino, Shasta, Siskiyou, Tehama, Butte, and Del Norte Counties. None of the remaining nine counties had lumber and wood products employment levels that exceeded 1000 persons. In fact, in several counties (Lassen, Modoc, Nevada, Sierra and Yuba), the lumber and wood products work force was less than 500.

Although absolute levels of employment are of interest, the percentages in Appendix B provides useful information of the relative importance of timber to the economies of individual counties. Thus, although Humboldt County ranked first in total timber industry employment, it ranked only seventh, percentagewise, with 30.6 percent of total employment being in the lumber and wood products sector. Sierra County, on the other hand, ranked first (with 60.5 percent) even though it had a relatively small timber industry work force. Trinity County ranked second (with 56.7 percent), Del Norte third (with 45.8 percent), Plumas fourth (with 39.6 percent) and Mendocino ranked fifth (with 32.8 percent of its total work force in the lumber and wood products sector).

Dependency indicators given in Table 8 are a useful measure of the degree of dependence on timber of individual counties. The data in Appendix B showing lumber and wood products employment as a percentage of total manufacturing employment is useful also, because manufacturing generally is an important component of the economic base of a county. It will be noted that in 1973 these percentages were over 90 percent in the case of Del Norte, Lassen, Plumas, Sierra, Siskiyou and Trinity Counties, indicating that there was almost no other manufacturing in these counties other than wood processing. In fact, lumber and wood products employment represented less than 50 percent of manufacturing employment only in the case of Butte, Nevada and Yuba Counties.

As was noted earlier, the relative degree of dependence on timber industries is lessening in many cases, as county economies become more diversified and as transfer payments such as retirement income become an important source of county income. This trend is underscored by the data in Appendix B. Over the 1959-73 period there was a general decline in lumber and wood products employment as a percentage of total employment, with the exception of Tehama, and Trinity Counties. Total timber industry employment given in Appendix A has shown a similar trend although the strong lumber markets of the early nineteen-seventies tended to mask the overall trend. Nevertheless, in spite of this decline, timber continues to be a mainstay of many local regional economies in Northern California.

APPENDIX A: Employment in lumber and wood products and manufacturing, and total employment in major wood processing counties 1959-73[1]

(1) Source: U. S. Department of Commerce. County Business Patterns.
Washington, D. C.

EMPLOYMENT IN MANUFACTURING, LUMBER & WOOD PRODUCTS: AND TOTAL EMPLOYMENT

A - MANUFACTURING B - LUMBER AND WOOD PRODUCTS C - TOTAL EMPLOYMENT

BUTTE COUNTY

YEAR	A	B	C
1959	2615	1419	11718
1962	2314	1082	13271
1965	2179	905	16060
1966	1895	823	15699
1967	1867	743	16491
1968	1932	839	14796
1969	2128	754	15109
1970	2192	777	15645
1971	2519	1063	16256
1973	3507	1644	18878

DEL NORTE COUNTY

YEAR	A	B	C
1959	2239	2153	3807
1962	1853	1787	3312
1965	1865	1760	3793
1966	1881	1797	3550
1967	1603	1502	3208
1968	1573	1485	3140
1969	1621	1540	3086
1970	1604	1564	3054
1971	1538	1405	2970
1973	1648	1567	3419

EL DORADO COUNTY

YEAR	A	B	C
1959	938	781	3485
1962	744	558	4342
1965	871	632	5560
1966	1490	609	6514
1967	753	603	5786
1968	747	566	5403
1969	679	515	5532
1970	672	487	6507
1971	781	608	6498
1973	884	649	8111

HUMBOLT COUNTY

YEAR	A	B	C
1959	11375	10142	22251
1962	10137	8890	21398
1965	10195	8565	22906
1966	9464	7791	22102
1967	8127	6594	20512
1968	8813	7128	20808
1969	9892	8123	22370
1970	8568	6765	21227
1971	9157	7124	21268
1973	9122	7282	23764

EMPLOYMENT IN MANUFACTURING, LUMBER & WOOD PRODUCTS; AND TOTAL EMPLOYMENT

A - MANUFACTURING B - LUMBER AND WOOD PRODUCTS C - TOTAL EMPLOYMENT

LASSEN COUNTY

YEAR	A	B	C
1959	534	489	1666
1962	554	517	1694
1965	363	296	1807
1966	341	273	1824
1967	353	289	1899
1968	379	330	1965
1969	395	364	1882
1970	361	337	1924
1971	364	344	1873
1973	485	458	2474

MENDOCINO COUNTY

YEAR	A	B	C
1959	5341	4592	8893
1962	3791	2996	7618
1965	4207	3839	9425
1966	3832	3515	8632
1967	3862	3462	8763
1968	3668	3352	8741
1969	3784	3486	9199
1970	3727	3333	9171
1971	4092	3522	9862
1973	4270	3689	11250

MODOC COUNTY

YEAR	A	B	C
1959	195	186	662
1962	154	127	702
1965	211	171	848
1966	144	128	714
1967	104	(1)	659
1968	172	142	795
1969	156	135	830
1970	125	117	800
1971	130	130	849
1973	145	109	906

(1) Not available

NEVADA COUNTY

YEAR	A	B	C
1959	528	384	2314
1962	345	205	2330
1965	601	427	3407
1966	534	329	3085
1967	515	313	3003
1968	649	430	3500
1969	665	428	3570
1970	663	407	3553
1971	592	403	3634
1973	760	375	4106

EMPLOYMENT IN MANUFACTURING, LUMBER & WOOD PRODUCTS; AND TOTAL EMPLOYMENT

A - MANUFACTURING B - LUMBER AND WOOD PRODUCTS C - TOTAL EMPLOYMENT

PLUMAS COUNTY

YEAR	A	B	C
1959	952	940	1772
1962	829	812	1792
1965	1194	1165	2555
1966	1180	1146	2313
1967	990	963	2347
1968	997	(1)	2343
1969	866	716	2155
1970	750	596	1881
1971	653	(1)	1817
1973	792	773	1954

(1)Not available

SHASTA COUNTY

YEAR	A	B	C
1959	3315	3090	9621
1962	3169	2673	10724
1965	3703	2870	15058
1966	3826	2895	14291
1967	3613	2708	14152
1968	3587	2652	14144
1969	3516	2498	14337
1970	3373	2287	14979
1971	3596	2348	14573
1973	4073	2583	16766

SIERRA COUNTY

YEAR	A	B	C
1959	327	327	457
1962	266	266	421
1965	(1)	(1)	497
1966	(1)	(1)	468
1967	(1)	(1)	424
1968	246	241	381
1969	287	287	401
1970	243	(1)	364
1971	(1)	(1)	312
1973	248	248	410

(1)Not available

SISKIYOU COUNTY

YEAR	A	B	C
1959	3091	2908	5925
1962	2632	2392	5325
1965	3058	2792	6422
1966	2924	2722	6335
1967	3166	2918	6497
1968	2507	2312	5882
1969	2441	2245	5950
1970	2222	2064	5746
1971	1862	1654	5498
1973	2187	2013	6628

EMPLOYMENT IN MANUFACTURING, LUMBER & WOOD PRODUCTS; AND TOTAL EMPLOYMENT

A - MANUFACTURING B - LUMBER AND WOOD PRODUCTS C - TOTAL EMPLOYMENT

TEHAMA COUNTY

YEAR	A	B	C
1959	1951	1588	4599
1962	1918	1412	4742
1965	1846	1437	4730
1966	1982	1436	4756
1967	2002	1467	5056
1968	2302	1785	5115
1969	2472	1821	5511
1970	2436	1729	5269
1971	3026	2414	5913
1973	2435	1854	5561

TRINITY COUNTY

YEAR	A	B	C
1959	791	711	1348
1962	460	391	814
1965	493	(1)	941
1966	431	377	874
1967	317	308	732
1968	384	291	911
1969	477	303	962
1970	425	239	847
1971	559	360	936
1973	697	697	1230

(1) Not available

YUBA COUNTY

YEAR	A	B	C
1959	562	378	5148
1962	612	376	8252
1965	765	452	5854
1966	616	363	5624
1967	594	309	6876
1968	548	270	7335
1969	699	209	7050
1970	603	235	6011
1971	610	256	5877
1973	811	355	6344

APPENDIX B: Percentage of work force employed in lumber and wood products and manufacturing for major wood processing counties 1959-73[1]

(1) Based on data in Appendix A.

PERCENTAGE EMPLOYED IN MANUFACTURING, LUMBER & WOOD PRODUCTS

A - MANUFACTURING % OF TOTAL B - LUMBER & WOOD PRODUCTS % OF TOTAL
C- LUMBER & WOOD PRODUCTS % OF MANUFACTURING

BUTTE COUNTY

YEAR	A	B	C
1959	22.3	12.1	54.3
1962	17.4	8.2	46.8
1965	13.6	5.6	41.5
1966	12.1	5.2	43.4
1967	11.3	4.5	39.8
1968	13.1	5.7	43.4
1969	14.1	5.0	35.4
1970	14.0	5.0	35.4
1971	15.5	6.5	42.2
1973	18.6	8.7	46.9

DEL NORTE COUNTY

YEAR	A	B	C
1959	58.8	56.6	96.2
1962	55.9	54.0	96.4
1965	49.2	46.4	94.4
1966	53.0	50.6	95.5
1967	50.0	46.8	93.7
1968	50.1	47.3	94.4
1969	52.5	49.9	95.0
1970	52.5	51.2	97.5
1971	51.8	47.3	91.4
1973	48.2	45.8	95.1

EL DORADO COUNTY

YEAR	A	B	C
1959	26.9	22.4	83.3
1962	17.1	12.9	75.0
1965	15.7	11.4	72.6
1966	22.9	9.3	40.9
1967	13.0	10.4	80.1
1968	13.8	10.5	75.8
1969	12.3	9.3	75.8
1970	10.3	7.5	72.5
1971	12.0	9.4	77.8
1973	10.9	8.0	73.4

HUMBOLDT COUNTY

YEAR	A	B	C
1959	51.1	45.6	89.2
1962	47.4	41.5	87.7
1965	44.5	37.4	84.0
1966	42.8	35.3	82.3
1967	39.6	32.1	81.1
1968	42.4	34.3	80.9
1969	44.2	36.3	82.1
1970	40.4	31.9	79.0
1971	43.1	33.5	77.8
1973	38.4	30.6	79.8

PERCENTAGE EMPLOYED IN MANUFACTURING, LUMBER & WOOD PRODUCTS

A - MANUFACTURING % OF TOTAL B - LUMBER & WOOD PRODUCTS % OF TOTAL
C- LUMBER & WOOD PRODUCTS % OF MANUFACTURING

LASSEN COUNTY

YEAR	A	B	C
1959	32.1	29.4	91.6
1962	32.7	30.5	93.3
1965	20.1	16.4	81.5
1966	18.7	15.0	80.1
1967	18.6	15.2	81.9
1968	19.3	16.8	87.1
1969	21.0	19.3	92.2
1970	18.8	17.5	93.4
1971	19.4	18.4	94.5
1973	19.6	18.5	94.4

MENDOCINO COUNTY

YEAR	A	B	C
1959	60.1	51.6	86.0
1962	49.8	39.3	79.0
1965	44.6	40.7	91.3
1966	44.4	40.7	91.7
1967	44.1	39.5	89.6
1968	42.0	38.3	91.4
1969	41.1	37.9	92.1
1970	40.6	36.3	89.4
1971	41.5	35.7	86.1
1973	38.0	32.8	86.4

MODOC COUNTY

YEAR	A	B	C
1959	29.5	28.1	95.4
1962	21.9	18.1	82.5
1965	24.9	20.2	81.0
1966	20.2	17.9	88.9
1967	15.8	(1)	(1)
1968	21.6	17.9	82.6
1969	18.8	16.3	86.5
1970	15.6	14.6	93.6
1971	15.3	15.3	100.0
1973	16.0	12.0	75.2

(1) Not available

NEVADA COUNTY

YEAR	A	B	C
1959	22.8	16.6	72.7
1962	14.8	8.8	59.4
1965	17.6	12.5	71.0
1966	17.3	10.7	61.6
1967	17.1	10.4	60.8
1968	18.5	12.3	66.3
1969	18.6	12.0	64.4
1970	18.7	11.5	61.4
1971	16.3	11.1	68.1
1973	18.5	9.1	49.3

PERCENTAGE EMPLOYED IN MANUFACTURING, LUMBER & WOOD PRODUCTS

A - MANUFACTURING % OF TOTAL B - LUMBER & WOOD PRODUCTS % OF TOTAL
C- LUMBER & WOOD PRODUCTS % OF MANUFACTURING

PLUMAS COUNTY

YEAR	A	B	C
1959	53.7	53.0	98.7
1962	46.3	45.3	97.9
1965	46.7	45.6	97.6
1966	51.0	49.5	97.1
1967	42.2	41.0	97.3
1968	42.6	(1)	(1)
1969	40.2	33.2	82.7
1970	39.9	31.7	79.5
1971	35.9	(1)	(1)
1973	40.5	39.6	97.6

(1)Not available

SHASTA COUNTY

YEAR	A	B	C
1959	34.5	32.1	93.2
1962	29.6	24.9	84.3
1965	24.6	19.1	77.5
1966	26.8	20.3	75.7
1967	25.5	19.1	75.0
1968	25.4	18.8	73.9
1969	24.5	17.4	71.0
1970	22.5	15.3	67.8
1971	24.7	16.1	65.3
1973	24.3	15.4	63.4

SIERRA COUNTY

YEAR	A	B	C
1959	71.6	71.6	100.0
1962	63.2	63.2	100.0
1965	(1)	(1)	(1)
1966	(1)	(1)	(1)
1967	(1)	(1)	(1)
1968	64.6	63.3	98.0
1969	71.6	71.6	100.0
1970	66.8	(1)	(1)
1971	(1)	(1)	(1)
1973	60.5	60.5	100.0

(1) Not available

SISKIYOU COUNTY

YEAR	A	B	C
1959	52.2	49.1	94.1
1962	49.4	44.9	90.9
1965	47.6	43.5	91.3
1966	46.2	43.0	93.1
1967	48.7	44.9	92.2
1968	42.6	39.3	92.2
1969	41.0	37.7	92.0
1970	38.7	35.9	92.9
1971	33.9	30.1	88.8
1973	33.0	30.4	92.0

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PERCENTAGE EMPLOYED IN MANUFACTURING, LUMBER & WOOD PRODUCTS

A - MANUFACTURING % OF TOTAL B - LUMBER & WOOD PRODUCTS % OF TOTAL
C- LUMBER & WOOD PRODUCTS % OF MANUFACTURING

TEHAMA COUNTY

YEAR	A	B	C
1959	42.4	34.5	81.4
1962	40.4	29.8	73.6
1965	39.0	30.4	77.8
1966	41.7	30.2	72.5
1967	39.6	29.0	73.3
1968	45.0	34.9	77.5
1969	44.9	33.0	73.7
1970	46.2	32.8	71.0
1971	51.2	40.8	79.8
1973	43.8	33.3	76.1

TRINITY COUNTY

YEAR	A	B	C
1959	58.7	52.7	89.9
1962	56.5	48.0	85.0
1965	52.4	(1)	(1)
1966	49.3	43.1	87.5
1967	43.3	42.1	97.2
1968	42.2	31.9	75.8
1969	49.6	31.5	63.5
1970	50.2	28.2	56.2
1971	59.7	38.5	64.4
1973	56.7	56.7	100.0

(1) Not available

YUBA COUNTY

YEAR	A	B	C
1959	10.9	7.3	67.3
1962	7.4	4.6	61.4
1965	13.1	7.7	59.1
1966	11.0	6.5	58.9
1967	8.6	4.5	52.0
1968	7.5	3.7	49.3
1969	9.9	3.0	29.9
1970	10.0	3.9	39.0
1971	10.4	4.4	42.0
1973	12.8	5.6	43.8

APPENDIX IX

AREA OF TIMBERLAND PRESERVE ZONES BY COUNTY, 1978
(STATE BOARD OF EQUILIZATION)

County	TPZ	County	TPZ
Alameda	Ø	Orange	Ø
Alpine	4,555	Placer	123,735
Amador	29,790	Plumas	267,090
Butte	132,010	Riverside	Ø
Calaveras	72,000	Sacramento	Ø
Colusa	Ø	San Benito	Ø
Contra Costa	Ø	San Bernardino	Ø
Del Norte	147,140	San Diego	Ø
El Dorado	143,490	San Francisco	Ø
Fresno	16,640	San Joaquin	Ø
Glenn	28,100	San Luis Obispo	Ø
Humboldt	1,066,910	San Mateo	23,710
Imperial	Ø	Santa Barbara	Ø
Inyo	Ø	Santa Clara	Ø
Kern	Ø	Santa Cruz	81,000
Kings	Ø	Shasta	633,620
Lake	Ø	Sierra	88,590
Lassen	330,330	Siskiyou	603,540
Los Angeles	Ø	Solano	Ø
Madera	4,060	Sonoma	76,920
Marin	Ø	Stanislaus	Ø
Mariposa	6,000	Sutter	Ø
Mendocino	892,255	Tehama	241,900
Merced	Ø	Trinity	281,560
Modoc	185,530	Tulare	10,050
Mono	Ø	Tuolumne	85,260
Monterey	Ø	Ventura	80
Napa	Ø	Yolo	Ø
Nevada	83,085	Yuba	30,970
		TOTAL	5,689,920

WOOD ENERGY

ASSUMPTIONS USED FOR TABLE 11-3

MILL RESIDUES

Total mill production (including lumber, plywood and veneer) in 1978 was estimated to be 5.3 billion board feet based upon data from the May 1979 issue of "Forest Industries" magazine, the California State Board of Equalization, the American Plywood Association and California Department of Forestry (CDF) estimates of plywood and veneer production in 1976 (State Forest Notes #71, 1978). To determine the gross amount of mill residue available in 1978, a conversion factor of 1.26 dry tons of residue per 1000 board feet produced was calculated from 1976 data (Hiserote and Howard, FS Resource Bulletin PNW-80, 1978) and assumed to be applicable to 1978.

Data on actual amounts of mill residue used as boiler fuel and currently installed electrical capacity came from a 1978 mill survey conducted by the Solid Waste Management Board, the California Energy Commission and CDF.

NOTE: Today, while some mills cogenerate electricity from wood-fired steam boilers a large number of mills burn wood for process steam only. Thus, the 2.6 million dry tons of mill residue used in 1978 as boiler fuel include the amounts used by not only the mills that produce process steam only, but also the mills that cogenerate electrical power.

Therefore, the 123.5 megawatts of installed capacity in 1978 reflect only those mills that currently produce electricity. If all of the 2.6 million dry tons is assumed to be used to cogenerate electricity, about 310 MW of installed capacity could potentially be realized.

To determine future mill production, CDF projections (State Forest Notes #71, 1978) were adjusted using the estimated 1978 data as base figures. The overall trend indicates that total mill production will decrease to 2000; and then increase slightly by 2030. This analysis assumes that improved recovery at the mill through reduced saw kerf and computerized processing will reduce residue generation by 10 percent by 2030. This is reflected in a uniform reduction of the 1978 conversion factor by 10 percent by 2030. Note that as old growth timber stands give way to younger second growth stands, logs will become smaller, with less defect, resulting in a further decrease in mill residue generation.

To determine the amounts of mill residues potentially available for energy as boiler fuel, the applicable competing uses were identified and an estimate of the percentage of the gross quantities going to that end use quantified. The percentage of the gross amount of mill residue available for energy was estimated to be 40 percent by 1985, 43 percent by 2000 and 47 percent by 2030 based on assumptions by CDF and the Forest Service PNW Experiment Station. Although approximately 90 percent of the mill residues are utilized today, a major assumption is that by 2030, 99 percent of the mill residues will be utilized (FS, PNW Experiment Station).

SOFTWOOD AND HARDWOOD SLASH

SOFTWOOD SLASH

Based upon preliminary timber tax data from the State Board of Equalization, softwood timber cut for 1978 was estimated to be 4.3 billion board feet harvested. The gross amount of softwood slash was determined using a conversion factor of 1.33 dry tons of slash per 1000 board feet harvested (FS and CDF).

To determine future softwood timber cut, FS projections for softwood harvests in California between 1980 and 2030 were adjusted using the estimated 1978 data as the base figures. This long-run forecasting model was used by the Forest Service for its 1980 RPA Assessment and also by CDF for its Forest Resource Assessment. The overall trend indicates that softwood timber cut will decrease to 2000; and then increase back up to the 1980 level by 2030. These projections were converted into gross amounts of slash using the factor of 1.33 dry tons per 1000 board feet harvested.

HARDWOOD SLASH

Based upon estimates by the Forest Service and the California State Polytechnic University - San Luis Obispo, the gross amount of hardwood slash generated in 1978 is assumed to be 1.9 million dry tons.

To determine future amounts of hardwood slash, harvest projections for California (Gedney, et al., FS Resource Bulletin PNW-60, 1975) were adjusted using the estimated 1978 data as base figures. The overall trend indicates that the hardwood cut will increase to 2010 and then level off.

To determine the amounts of both softwood and hardwood slash potentially available as boiler fuel, the applicable competing uses were identified and their estimated percentages of the gross quantities were quantified. Energy use was assumed to account for 10 percent of the gross quantities of slash by 1985, 28 percent by 2000 and 36 percent by 2030. Based on CDF data compiled from slash collection projects and fuel loading inventories, a major assumption is that 50 percent of all slash (material 8 inches and greater) will be economically available and utilized by 2030.

PRE-COMMERCIAL CONIFER THINNINGS

For this category, forest land acreages were broken down on an ownership basis: Forest Service-federal lands, and State and private lands.

Approximately 23,515 acres of federally owned timberland were thinned in 1978 under current management practices (FS Timber Management Plans). Acreages of federal land to be thinned in the future were based on actual plans by the Forest Service.

It is assumed that thinnings on State and private lands were minimal in 1978 (CDF). For future years, two phases of thinning were considered for State and private lands based on estimates from CDF's Forest Improvement Program.

Thinning Existing Stands. Thinning starts in 1980 at 32,760 acres per year and continues for 20 years until 2000. All of this thinning will likely be completed by 2030. Also reforestation of previously harvested areas will begin in 1980.

Thinning Future Stands Reforested in 1980. After 10 years of growth, replanted stands are suitable for thinning. Thus thinning will start in 1990 at 50,700 acres per year, continuing for 20 years until 2010, at which time thinning will stabilize and be maintained at a level of 10,000 acres per year (20 percent of the intial 1990 level).

The following table shows acres thinned for each ownership class and thinning phase, as well as total acreages thinned.

	1978	1985	2000	2030
Pre-Commercial Thinnings (in acres)				
Federal (USFS)	23,515	45,000	58,000	58,000
State & Private (CDF - FIP)				
a. Thinning existing stands	Min.	32,760	32,760	0
b. Thinning previously reforested	Min.	Planted 1980 (5 yrs.old)	50,700	10,000
TOTAL ACRES	23,515	77,760	141,460	68,000

Gross quantities of thinning residue were calculated assuming a conversion factor of 20 tons of residue per thinned acre (FS).

To determine the amounts of thinning residue potentially available for boiler fuel, estimated percentages of applicable competing uses were quantified. Energy use was assumed to be 12 percent of the gross quantity of thinning residue by 1985, 24 percent by 2000 and 30 percent by 2030. A major assumption was that the amounts of thinning residue utilized will increase to 50 percent of the gross quantity by 2030 (CDF). This assumption is based on the small size of the thinned material, i.e., pieces under a particular size will not be economical to use because collection, processing and transportation costs will be greater than the potential revenues.

DEAD AND DYING MATERIAL

During an average year in California, natural mortality approaches one billion board feet resulting in approximately 1.5 million dry tons of residue annually available (FS). But due to recent epidemic insect and disease outbreaks occurring in the forest, augmented by the drought of 1975-77, present amounts of dead and

dying material are greater than normal. For 1978, 2.4 million dry tons of dead and dying residue are estimated to be available (FS). From 1985 on, annual gross amounts of dead and dying material are assumed to be 1.5 million dry tons, or the quantity associated with a normal year of natural mortality (FS-CDF). Note that in the long term as old growth stands disappear and thinning programs increase the vigor of young stands, this "normal" amount may decrease (FS). However, this analysis does not reflect such a possibility.

To determine the amounts of dead and dying residue potentially available for energy as boiler fuel, the applicable competing uses and their estimated percentages of the gross quantities were quantified. The percentages associated with energy use were assumed to be 2 percent of the gross quantity of dead and dying residue by 1985, 7 percent by 2000 and 18 percent by 2030. A major assumption was that 50% of the gross amount of dead and dying material will be available and utilized by 2030 due to increased management of stands and development of complete road systems (FS). An additional assumption is that of this amount available for use by 2030, half will be utilized as sawlogs due to their higher value (FS, CDF). Note also that the dead and dying trees have fiber that may deteriorate over time, and this may be unusable for products other than fuel.

NONCOMMERCIAL FORESTS

SOFTWOODS

Based on Forest Service data, there are approximately 7.5 million acres of noncommercial softwoods in California. Assuming the average annual growth to be 10 cubic feet per acre per year and that any annual cut of noncommercial softwoods is accomplished on a sustained yield basis (i.e., cut equals growth), it is estimated that one million dry tons of residue could be generated annually (FS). This gross quantity is assumed to remain constant over time.

HARDWOODS

Based on data from the Forest Service and Cal Poly-San Luis Obispo, there are approximately 1.3 million acres of noncommercial hardwoods in California. Assuming a low average of 50 tons of residue per acre, a rotation of 40 years and that any annual cut of noncommercial hardwoods is accomplished on a sustained yield basis, it is estimated that 1.6 million dry tons of residue could be generated annually (FS). This gross quantity is assumed to remain constant over time.

To determine the amounts of both noncommercial softwood and hardwood slash potentially available for boiler fuel, the applicable competing uses and their estimated percentages of the gross quantities were quantified. The percentages associated with energy use were assumed to be one percent of the gross quantities of residues by 1985, two percent by 2000 and five percent by 2030. A major assumption is that amounts utilized by 2030 will only be 10 percent of the gross quantities due to sparseness of stands, accessibility problems, high collection costs, large distances from potential markets and ownership objectives that preclude any use (i.e., grazing lands, Indian reservations, protected areas, etc.), (CDF).

CHAPARRAL

Based on Forest Service data and U.C. Riverside Fire Laboratory measurements, approximately 7.6 million dry tons of residue are estimated to be annually available assuming:

(a) 7.6 million acres of chaparral in California

(b) an average fuel loading factor of 20 dry tons per acre

(c) a 20-year rotation period required to reach optimum fuel loading.

The gross quantity is assumed to remain over time.

To determine the amounts of chaparral residue potentially available for energy as boiler fuel, the applicable competing uses and their estimated percentages of the gross quantities were quantified.

In the future, some chaparral covered lands will likely be cleared for firebreaks and converted to agricultural and other uses. The percentages associated with energy use were assumed to be five percent of the gross quantity of residue by 1985, 15 percent by 2000 and 20 percent by 2030. A major assumption is that a maximum of only 20 percent of the gross quantity will be available for fuel by 2030 (CDF, U.C. Riverside Fire Lab). This high degree of non-utilization is due to such factors as steepness of slopes, fragility and erosiveness of the soil, high collection costs and remoteness of residue from potential fuel markets causing high transportation costs.

ORCHARD PRUNNINGS

According to the California Crop and Livestock Reporting Service (CC&LRS), approximately 1.745 million acres of bearing fruit and nut trees existed in California in 1978. This acreage includes such crops as almonds, apples, avocados, grapes, citrus fruits, olives, peaches, pears and walnuts. An orchard is classified as "bearing" when it reaches an age at which it can normally be expected to produce a commercially significant quantity of the crop as well as generate sizeable amounts of prunings. Young non-bearing trees also provide small amounts of prunings, but estimating the amount is difficult.

Assuming that the markets for these fruit and nut crops continue to be strong, and that annual rainfall remains normal over time, acreages can be expected to increase. Thus, bearing acreages are assumed to increase by one percent from 1978 to 1979, by one and one-half percent from 1979 to 1980, and by two percent from 1980 to 1985 at which time acreages are assumed to level off due to the limiting factor of water availability (CDF, CC&LRS).

These bearing acreages are pruned every year during their dormant period that extends from November 1 to March 1. These prunings are in the form of branches, limbs, stumps and sometimes whole trees. Since pruning practices have not changed significantly over the years, this analysis uses a conversion factor (calculated from 1973 data by the University of California, Agricultural Cooperative Extension) of .997 dry tons of residue per acre, adjusted for moisture content.

To determine the amounts of pruning residue potentially available for boiler fuel, the applicable competing uses and their estimated percentages of the gross quantities were quantified. The percentages associated with energy use were assumed to be three percent of the gross quantity of residue by 1985, eight percent by 2000 and 17 percent by 2030. A major assumption is that only 20 percent of the gross quantity will be used by 2030 (Solid Waste Management Board).

URBAN WOOD RESIDUES

The most available data on urban wood residues comes from the Association of Bay Area Governments (ABAG). The nine urban counties represented by this association generated a total of 592,600 dry tons of residue in 1978 (ABAG). This residue includes waste material from tree-trimming companies, demolition wastes, tree maintenance prunings, construction wastes and pallet stock. It is assumed that these urban wood wastes are readily available in concentrated amounts and have no attending separation costs (ABAG). Assuming that the ABAG data is generally representative of other typical urban areas in California, the ABAG per capita amount of urban residue (.121 tons per person) was applied to the State's estimated total urban population of 18.4 million (Department of Finance) to obtain an estimated 2.2 million dry tons of urban residues generated annually.

Future gross amounts of urban wood residues are assumed to increase at the same rate of population increase occurring within urban counties (CDF). Using population projections for California counties calculated by the Department of Finance (Series E-150), percentage increases were calculated for each of the years considered to escalate the gross amounts of urban residues over time. Included were the nine bay area counties and other counties that are estimated to have populations of at least 500,000 by 1980. Note that reduced landfills and centrally located urban residues that minimize transportation costs will further justify the increased amounts of urban residues available.

To determine the amounts of urban wood residues potentially available for energy as boiler fuel, the applicable competing uses were identified and an estimate of the percentage of the gross quantities going to that end use quantified. The percentages associated with energy use were assumed to be 10 percent of the gross quantity of residue by 1985, 35 percent by 2000 and 55 percent by 2030. A major assumption is that 80 percent of the gross quantities of urban residues will be utilized by 2030 (ABAG), with a major portion of the boiler fuel assumed to be used by electric utilities to produce electricity (Southern California Edison).

ENERGY POTENTIAL OF WOOD RESIDUES

To determine the energy potential of wood in California, the amounts of wood residues available for boiler fuel arrived at above were converted into units of energy. First, each potential quantity of dry tons or residue annually available for energy was converted into Btu's per year. Then these potential annual Btu's of wood energy were converted into megawatt-years (MW-yrs.) of potential congenerated electrical capacity.

To convert potential quantities of dry tons of wood residues into Btu's per year requires an assumption concerning the Btu content of dry wood. This analysis assumes an average heating value of 8500 Btu's per pound of dry wood -- or 17 x 10^6 Btu's per dry ton.

To convert each amount of potential Btu's per year of wood energy into megawatt-years, the following formula was used to calculate the amount of annual Btu's required to produce a MW-yr (California Energy Commission):

$$\frac{\text{Capacity Factor (percent)} \times 8760 \text{ hrs./yr.} \times 3413 \text{ Btu/kwh} \times 10^3 \text{ kwh/Mwh}}{\text{Plant Thermal Efficiency (percent)}}$$

The capacity factor is the percentage of electricity a power plant actually produces relative to what it would produce at full capacity at all times. This analysis assumes a capacity factor of 100 percent, i.e., the plant is assumed to operate at full capacity year round.

NOTE: This assumption is used so that the conversion factor reflects the notion of installed capacity. Installed capacity is the maximum rated power output produced at a given time from a given generating facility. Thus the assumption of a 100 percent capacity factor says that at any instant in time during the year the power plant is operating at its full installed capacity.

The plant thermal efficiency is a percentage determined by taking the figure of 3413 Btu's per kilowatt-hour (100 percent thermal efficiency) and dividing it by the assumed plant net heat rate, which is the Btu input used to produce one kilowatt-hour of output. This analysis uses the net heat rate associated with a cogeneration facility that produces both process steam and electricity. This gives a thermal efficiency of 21 percent.

Putting these assumptions into the above formula, the Btu's required to produce a megawatt-year can be calculated:

$$\frac{1.0 \times 8760 \times 3413 \times 10^3}{.21} = .1424 \times 10^{12} \text{ Btu's/MW-yr.}$$

Then by dividing this factor into the potential annual Btu's of wood residues, megawatt-years of potential congenerated installed capacity can be obtained.

This MW-year figure can be interpreted as the maximum installed MW capacity that could be realized at any given instant if all the indicated annual amount of wood fuel is burned in cogeneration plants operating at full capacity at all times.

TABLE X-1

USED MILL RESIDUES BY TYPE AND USE
(DRY TONS)

TYPE OF RESIDUE	PULP & BOARD	FUEL	OTHER	TOTAL
WOOD				
Coarse	2,738,747	332,065	261,213	3,332,025
Shavings	306,512	310,532	72,141	689,185
Sawdust	105,078	798,978	81,568	985,624
SUBTOTAL	3,150,337	1,441,575	414,922	5,006,834
Bark	-----	589,530	487,734	1,077,264
TOTAL	3,150,337	2,031,105	902,656	6,084,098
PERCENT OF TOTAL	(51.8)	(33.4)	(14.8)	(100.0)

Source: Hiserote, Bruce and Howard, James O., California Forest Industry, 1976, (U.S.D.A. Forest Service Resource Bulletin PNW - 80) 1978.

Taken From: Lucarelli, 1979

TABLE X-2

UNUSED MILL RESIDUES BY TYPE, 1976
(IN DRY TONS)

MILL TYPE	RESIDUE TYPE	WOOD		TOTAL WOOD RESIDUES	TOTAL BARK RESIDUES	TOTAL UNUSED MILL RESIDUE
	COARSE	SHAVINGS	SAWDUST			
Sawmills	197,499	38,622	384,858	620,979	511,779	1,132,758
Veneer & Plywood Mills	18,075	----	650	18,725	59,492	78,217
TOTAL	215,574	38,622	385,508	639,704	571,271	1,210,975

Source: Hiserote, Bruce and Howard, James O., California's Forest Industry, 1976. (USDA Forest Service Resource Bulletin PNW - 80) 1978.

Taken From: Lucarelli, 1979

TABLE X-3

UNUSED MILL RESIDUES BY COUNTY, 1976
(DRY TONS)

SUBREGION AND COUNTY	UNUSED RESIDUES		
	WOOD	BARK	TOTAL
1. NORTH COAST			
Del Norte	17,772	42,600	60,372
Humboldt	154,331	184,595	348,926
Mendocino	108,455	129,941	238,396
Siskiyou	6,013	3,093	9,106
Trinity	28,163	36,125	64,288
TOTAL	314,734	396,354	721,088
2. SACRAMENTO			
Butte	25,818	---	25,818
El Dorado	146	10,562	10,708
Glenn-Tehama	7,812	9,252	17,064
Placer-Nevada	35,579	9,257	44,836
Plumas-Sierra	22,320	18,423	40,743
Shasta	73,983	29,614	103,597
Sonoma	7,762	24,957	32,719
Yuba	22,302	24,168	46,470
TOTAL	195,722	126,233	321,955
3. NORTH LAHONTAN			
Lassen (Inc. Modoc)	31,562	12,584	44,146
TOTAL	31,562	12,584	44,146
4. SAN JOAQUIN DELTA			
CENTRAL SIERRA			
TULARE			
Calaveras - Amador	35,795	6,270	42,065
Fresno - Madera	30,523	18,040	48,565
Tulare - Kern	31,253	1,670	32,922
TOTAL	97,571	25,980	123,552
STATE TOTAL	639,589	561,151	1,210,741

Source: Hiserote, Bruce and Howard, James O., California Forest Industry, 1976. (USDA Forest Service Resources Bulletin PNW-80), 1978.

Taken From: Lucarelli, 1979

TABLE X-4

TIMBER PRODUCTION AND ESTIMATED SLASH YIELD
BY COUNTY AND ECONOMIC SUBREGION, 1976

SUBREGION AND COUNTY	TIMBER PRODUCTION (THOUSAND BOARD FEET)	SLASH YIELD (DRY TONS)
1. NORTH COAST		
Del Norte	242,548	322,589
Humboldt	959,154	1,275,675
Mendocino	573,106	762,231
Siskiyou	364,431	484,693
Trinity	255,032	339,193
SUBTOTAL	2,394,271	3,184,381
2. SACRAMENTO		
Butte	69,949	93,032
Colusa - Sutter	6,704	8,916
El Dorado	228,038	303,291
Glenn	47,690	63,428
Lake	8,218	10,930
Modoc	98,289	130,724
Nevada	54,783	72,861
Placer	117,617	156,431
Plumas	220,419	293,157
Shasta	451,547	600,558
Sierra	88,262	117,388
Tehama	158,273	210,503
Yolo	----	----
Yuba	34,878	46,388
SUBTOTAL	1,584,667	2,107,607
3. SAN FRANCISCO BAY		
Alameda	Included in San Benito County	
Contra Costa	Included in San Benito County	
Marin - Napa	523	696
San Francisco	----	----
San Mateo	5,843	7,771
Santa Clara	Included in San Benito County	
Solano	----	----
Sonoma	50,117	66,656
SUBTOTAL	56,483	75,123
4. DELTA-CENTRAL SIERRA		
Amador	39,503	52,539
Calaveras	60,738	80,782
San Joaquin	----	----
SUBTOTAL	100,241	133,321

TABLE X-4 (Continued)

TIMBER PRODUCTION AND ESTIMATED SLASH YIELD
BY COUNTY AND ECONOMIC SUBREGION, 1976

SUBREGION AND COUNTY	TIMBER PRODUCTION (THOUSAND BOARD FEET)	SLASH YEILD (DRY TONS)
5. SAN JOAQUIN		
Madera	52,413	69,709
Mariposa-Merced	20,516	27,286
Stanislaus	----	----
Tuolumne	184,520	245,412
SUBTOTAL	257,449	342,407
6. NORTH LAHONTAN		
Alpine	3,500	4,655
Lassen	123,320	164,016
Mono	3,274	4,354
SUBTOTAL	130,094	173,025
7. CENTRAL COASTAL		
Monterey	155	206
San Benito	903	1,201
San Luis Obispo	160	213
Santa Barbara	----	----
Santa Cruz	12,619	16,783
SUBTOTAL	13,837	18,403
8. TULARE		
Fresno	94,448	125,616
Kern	18,960	25,217
Kings	----	----
Tulare	67,275	89,476
SUBTOTAL	180,683	240,309
9. SOUTH LAHONTAN		
Inyo	1,650	2,195
TOTAL	1,650	2,195
STATE TOTAL	4,719,375	6,276,771

Source: Lucarelli, Bart, The Energy Potential of Wood Residues Generated by California's Wood Products Industry, 1979 Draft.

TABLE X-5

TYPICAL HEATING VALUES FOR SOFTWOODS

WOOD				BARK			
Species	Heating value (dry) (Btu/lb.)			Species	Heating value (dry) (Btu/lb.)		
	Average	Low	High		Average	Low	High
Cedar, White		7,780	8,400	All Varieties Balsam	9,100	8,900	9,210
Cedar, Western Red	9,700			Fir, Balsam	8,861		
Cypress		9,234	9,870	Fir, Douglas	9,800		
Fir, Douglas	9,050			Hemlock, Eastern	8,890		
Fir, Douglas		8,438	9,050	Hemlock, Eastern	8,802		
Fir, Douglas	8,900			Hemlock, Western	9,400		
Fir, White	8,200			Larch, Western	8,204		
Hemlock, Eastern	8,885			Pine, Jack	8,930	8,690	9,170
Hemlock, Western	8,620			Pine, Lodgepole	10,190		
Hemlock, Western		8,056	8,620	Pine, Ponderosa	9,100		
Pine Sawdust	9,130			Pine, Slash	9,002		
Pine, Jack, Wood Refuse	8,930			Pine, Western White	9,085		
Pine, Loblolly, Stemwood	8,600	8,310	9,352	Spruce, Black	8,610	8,150	8,710
Pine, Pitch		10,620	11,320	Spruce, Engelmann	8,359		
Pine, Ponderosa	9,100			Spruce, Pine (1 ft. above ground)	8,985	8,870	9,140
Pine, White		8,308	8,900				
Pine, Yellow		8,927	9,610	Spruce, Pine (mid height)	8,825	8,650	8,910
Redwood		8,498	9,040				
				Spruce, Pine (4 in. top)	8,700	8,550	8,825
				Spruce, Red	8,630		
				Spruce, White	8,530	8,340	8,630
				Tamarack	9,010		

Source: Arola, 1976.

Taken From: Bergvall, et al. Wood Waste For Energy Study, 1978.

TABLE X-6

TYPICAL HEATING VALUES FOR HARDWOODS

WOOD				BARK	
	Heating value (dry) (Btu/lb.)				
Species	Average	Low	High	Species	Heating value (dry) (Btu/lb.)
Ash, White		8,246	8,920	Alder, Red	7,947
Beech		8,151	8,760	Aspen, Quaking	8,433
Birch, Wood Refuse	8,870			Beech	7,640
Birch, White		8,019	8,650	Birch, Paper	9,434
Elm		8,171	8,810	Birch, Yellow	9,200
Hickory		8,039	8,670	Birch, White	10,310
Maple		7,995	8,580	Blackgum	7,936
Maple, Wood Refuse	8,190			Elm, American	6,921
Oak, Black		7,587	8,180	Elm, Soft	7,600
Oak, Red		8,037	8,690	Maple, Hard	8,230
Oak, White		8,169	8,810	Maple, Soft	8,100
Poplar		8,311	8,920	Maple, Sugar	7,301
				Oak, Northern Red	8,030
				Oak, White	6,995
				Poplar	8,810
				Sweetgum	7,450
				Sycamore	7,403
				Willow, Black	7,168

Source: Arola, 1976.

From: Bergvall, et al. Wood Waste for Energy Study, 1978.

TABLE X-7

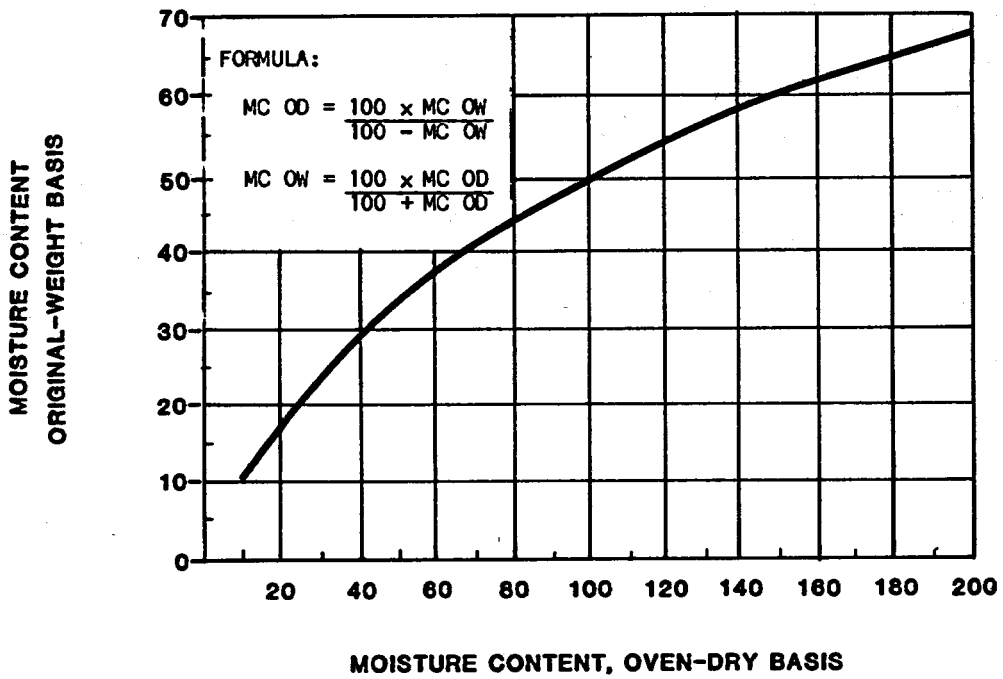
FOSSIL FUEL HEATING VALUES

FUEL		HEATING VALUE
COAL		
anthracite		13,900 Btu/lb.
bituminous		14,000 Btu/lb.
sub-bituminous		12,600 Btu/lb.
lignite		11,000 Btu/lb.
HEAVY FUEL OILS AND MIDDLE DISTILLATES		
kerosene	6.814 lb./gal.	134,000 Btu/gal.
No. 2 burner fuel oil	7.022 lb./gal.	140,000 Btu/gal.
No. 5 heavy fuel oil	7.612 lb./gal.	144,000 Btu/gal.
No. 5 heavy fuel oil	7.676 lb./gal.	150,000 Btu/gal.
No. 6 heavy fuel oil, 2.7% sulfer	8.082 lb./gal.	152,000 Btu/gal.
No. 6 heavy fuel oil, 0.3% sulfer	7.401 lb./gal.	143,800 Btu/gal.
GAS		
natural		1,000 Btu/cu.ft.
liquefied butane		103,300 Btu/gal.
liquefied propane		91,600 Btu/gal.

From: Energy Conservation Program, Guide for Industry and Commerce, U.S. Chamber of Commerce, National Bureau of Standards Handbook No.115, Washington, D.C., 1974.

FIGURE X-1

MOISTURE CONTENT COMPARISON



When considering wood fuel for combustion, the recommended practice is to compute moisture content on a wet basis using the following formula:

$$\text{M.C. wet} = \frac{(\text{wet weight} - \text{ovendry weight}) \times 100}{\text{wet weight}}$$

To convert moisture content on an ovendry basis to wet basis use the formula:

$$\text{M.C. wet} = \frac{100 \times \text{M.C. dry}}{100 + \text{M.C. dry}}$$

From: Energy and the Wood Products Industry, Forest Products Research Society, Wisconsin, 1977

AN ILLUSTRATION OF THE FRAP LINEAR PROGRAMMING MODEL

Linear programming selects the best mix of identified alternatives given an "objective function," or criterion, and a set of constraints which restrict the options available. "Linear" implies that these constraints and the objective function must be of a particular mathematical form. The technique was developed by George B. Danzig, of the Rand Corporation and the University of California at Berkeley, in 1947, and has been widely applied in the analysis of industrial and natural resources problems. Goal programming, which is a modification of linear programming, is the actual technique being used.

As an example of how the forest resources of California are being modeled, suppose there are two types of forest land and that they might be managed for timber, forage, or recreation, or some combination of these purposes as shown in Table XI-1. Further assume there are six possible land-type/management combinations--usually called "activities".

The question is, how many acres of each land type should be managed for each purpose? For each acre managed in these ways, some cost is incurred and various outputs are produced. Land managed for timber may produce some recreation, but presumably a different quantity than if recreation were the object of management. (All of the numerical entries in the table are hypothetical.)

One goal of management for the 300 acres shown in the table might be to produce at least 110,000 visitor-days of recreation. Another goal might be to have no more stream sedimentation than results from the loss of 500 tons of silt per year. We might also wish substantial volumes of timber and forage. The problem is constrained because there are only 100 acres of Type I land, 200 acres of Type II land, and $50,000 in the budget. The objective is to do as well as possible in meeting the goals.

The problem is mathematically represented by letting X_{ij} (a set of unknowns which is being solved for) be the area of land type i, being managed by method j--thus i = I or II and j = timber, forage, or recreation. The budget constraint, for example, then becomes:

$$80X_{I,T} + 15X_{I,F} + 12X_{I,R} + 80X_{II,T} +$$

$$14X_{II,F} + 13X_{II,R} \leq 50,000$$

Suppose d_R represents the amount by which the recreation goal of 110,000 visitor days is not achieved. We introduce into the model a constraint of the form:

$$25X_{I,T} + 60X_{I,F} + 500X_{I,R} + 10X_{II,T} +$$

$$50X_{II,F} + 900X_{II,R} + d_R \geq 110,000$$

TABLE XI-1

DATA FOR THE HYPOTHETICAL LAND USE MODEL DESCRIBED IN THE TEST OF THE APPENDIX

	TYPE I LAND 100 ACRES AVAILABLE			TYPE II LAND 200 ACRES AVAILABLE		
Managed For:	TIMBER	FORAGE	RECREA-TION	TIMBER	FORAGE	RECREA-TION
Annual dollar input per acre	80	15	12	80	14	13
Timber output cubic feet per acre per year	300	0	30	200	15	30
Forage output pounds per acre per year	0	3,000	20	100	2,000	10
Recreation output visitor days per acre per year	25	60	500	10	50	900
Annual soil loss (tons per acre)	8	6	2	5	10	3

The first six terms represent the amount of recreation produced. If the problem has a solution, either this amount will be at least 110,000, or the deficit term d_R will have a positive value. For each of the goals of the problem, such a deviation term is introduced.

The objective function of the problem is to minimize the deviation from the goals. If d_S represents the sedimentation deviation in this example, the objective might be:

$$\text{minimize } d_R + d_S.$$

Such a formulation implies indifference between the two deviations; being one visitor-day short is just as bad as producing one extra ton of sediment. If instead priorities are to be attached to the deviations, coefficients are associated with these variables in the objective function. For example, the objective:

$$\text{minimize } d_R + 200d_S$$

would imply that a deviation from the sedimentation goal of one ton would be as adverse as a deviation of 200 visitor-days in the recreation goal.

Adding timber and forage goals to the problem above might produce the linear programming or goal programming problem mathematically stated as shown in the following example (Table XI-2):

The solution to this problem will yield the X and d values which satisfy the constraints and produce the minimum weighted deviation from the goals. In this instance 44.6 acres of Type II forest should be managed for forage production, 3.7 for timber, and 17.5 acres of Type I forest should be managed for recreation

(i.e.: $X_{I,R} = 17.5$; $X_{II,T} = 3.7$; $X_{II,F} = 48.6$).

It is not possible to meet the timber goal; the deficit is 38 thousand cubic feet. Other goals are met and in fact 234 acres of land and $48,866 of budget funds would be available for other purposes. If the priority weights represent our actual priorities, the constraints levels are realistic, and the equations represent the technical exhanges inherent in the problem, the solution is the best one possible or the optimal.

By varying the priorities on the goals and/or the constraint levels, this model can be used to investigate the trade-offs of the various uses against each other. If, for example, the priority for timber is increased by using instead the objective:

TABLE XI-2

$$\text{MINIMIZE } d_R + 200d_S + 1000d_T + d_F$$

SUBJECT TO:

$$80X_{I,T} + 15X_{I,F} + 12X_{I,R} + 80X_{II,T} + 14X_{II,F} + 13X_{II,R} \leq 50000$$

$$25X_{I,T} + 60X_{I,F} + 500X_{I,R} + 10X_{II,T} + 50X_{II,F} + 900X_{II,R} + d_R \geq 11000$$

$$8X_{I,T} + 6X_{I,F} + 2X_{I,R} + 5X_{II,T} + 10X_{II,F} + 3X_{II,R} - d_S \leq 500$$

$$300X_{I,T} + 30X_{I,R} + 200X_{II,T} + 15X_{II,F} + 30X_{II,R} + d_T \geq 2000$$

$$300X_{I,F} + 20X_{I,R} + 100X_{II,T} + 2000X_{II,F} + 10X_{II,R} + d_F \geq 90000$$

$$X_{I,T} + X_{I,F} + X_{I,R} \leq 100$$

$$X_{II,T} + X_{II,F} + X_{II,R} \leq 200$$

minimize $d_R + 200d_S + 100d_T + d_F$,

the optimal solution is to increase $X_{11,T}$ to 197.1.

The sedimentation goal and the forage goals would no longer be met. But the desired timber production would be achieved. Thus, these results indicate that an increase in timber output from 2 to 40 thousand cubic feet can be achieved by reducing forage production from 90 to 64 thousand pounds and accepting twice as much sediment as was much sediment as was originally considered acceptable. LP is used to model the forest resources because it identifies these sorts of trade-offs. (This example was selected to illustrate the use of LP, not to produce realistic results.)

Only in very simple situations, such as the small problem here, will these interactions be obvious to an analyst or decision maker. Assuming the equations correctly model forest conditions, LP can be used to produce the optimal solution if the objective function can be appropriately specified. No one individual would be so presumptuous as to attempt to determine California's actual priorities for a variety of outputs from its forest land, so such an objective cannot be specified. The model is, however, still useful. By reviewing a variety of solutions in which various priorities have been assigned, the interaction of the goals with each other and with the resource constraints can be identified. Knowing what must be given up to produce substantial increases in timber output, for instance, enables legislators and administrators to better weigh alterna tive policies and programs. Such weighing must consider factors not included in the model, as well as the desirability of the output levels it identifies.

I. LAWS RELATING TO THE PROTECTION AND MANAGEMENT OF FOREST AND RELATED LANDS

A. STATE LAWS:

1. Organization and General Powers of the Department of Forestry and State Board of Forestry
2. Professional Foresters Law
3. Prevention and Control of Forest Fires
4. Hazardous Fire Areas, Hazard Reduction and Closures, Restricted Areas, Rubbish Dumps, Burning Regulations, and Prohibited Activities
5. Burning of Lands
6. State Forests
7. Protection of Forest and Lands
8. Range Revegetation and Improvement
9. California Wild and Scenic Rivers Act of 1972
10. California Wilderness Act of 1974
11. Resource Conservation Act of 1975
12. Surface Mining and Reclamation Act of 1975
13. California Coastal Act of 1976
14. Forest Resources Assessment and Policy Act of 1977
15. Wildland Fire Protection and Resources Management Act of 1978
16. Vegetation Management Study Bill (1978)

B. FEDERAL LAWS:

1. Organic Administration Act of 1897
2. Park Service Organic Act of 1916
3. Taylor Grazing Act (1934)
4. Multiple Use - Sustained Yield Act (1960)
5. Wilderness Act (1964)
6. Federal Water Project Recreation Act (1965)
7. Land and Water Conservation Fund Act of 1965
8. Wild and Scenic Rivers Act (1968)
9. Coastal Zone Management Act of 1972
10. Forest and Rangeland Renewable Resources Planning Act of 1974
11. National Forest Management Act (1976)
12. Federal Land Policy and Management Act of 1976
13. Resource Conservation Act of 1977

I. LAWS RELATING TO THE PROTECTION AND MANAGEMENT OF FOREST AND RELATED LANDS

A. STATE LAWS:

1. Organization and General Powers of the Department of Forestry and State Board of Forestry (Div. 1, Chap. 2.5, Sec. 700-745, P.R.C.)

   Establishes the organization and general powers of the Department of Forestry and State Board of Forestry. The department is in the Resources Agency and controlled by a Director of Forestry, appointed by the Governor, with the confirmation of the Senate. The State Board of Forestry, organized within the Department, consists of nine members appointed by the Governor.

2. Professional Foresters Law (Div. 1, Chap. 2.5, Sec. 750-783, P.R.C.)

   Provides for the registration of professional foresters by the Board of Forestry. The purpose of regulation of persons who practice the profession of forestry is to assure sound management and treatment of the forest resources and timberlands in the State.

3. Prevention and Control of Forest Fires (Div. 4, Chap. 1, Sec. 4101-4187, P.R.C.)

   Authorizes the Board of Forestry and the Department of Forestry to prevent and control forest fires. Provides definitions and general provisions for administration of the Department. Establishes the authority of the Board and Department of Forestry to provide fire protection and defines those lands of state responsibility. Also authorizes counties to provide fire protection of state responsibility lands under contract, and authorizes the Department to enter into agreements with landowners and counties to provide fire protection. Authorizes the Department to appoint voluntary fire wardens, summon aid to suppress fires, and designate peace officers. Designates misconduct at a forest fire as a misdemeanor. Defines uncontrolled fire a public nuisance and authorizes the Director to abate public nuisances and hazardous fire conditions. Authorizes the Department to cooperate with the Federal Government in providing protection of forest and watershed lands under the Federal Clarke-McNary Act. (Note: The Clarke-McNary Act of 1924 was repealed and superseded by the Cooperative Forestry Assistance Act of 1978).

4. Hazardous Fire Areas, Hazard Reduction and Closures, Restricted Areas, Rubbish Dumps, Burning Regulation, and Prohibited Activities (Div. 4, Chap. 2-6, Sec. 4251-4446, P.R.C.)

   Defines hazardous fires areas and authorizes the Director of Forestry to restrict entry. Authorizes the Director to enforce fire hazard reduction standards and clearance around improvements of forest, brush, and grass covered lands. Provides for proclamation by the Governor to restrict access to designated areas. Authorizes the Director to order closed to camping, hunting, etc., State Parks or State Forests -- order to be published and posted. Authorizes the Department to issue rubbish

dump permits and enforce minimum requirements for fire safety. Authorizes the Department to regulate burning on private lands and establishes standards and enforcement criteria. Establishes minimum standards, fire safety standards and fire tool requirements for equipment operation. Authorizes the Department to conscript persons to fight fire. Establishes sawmill waste disposal standards and minimum fire protection standards and tool requirements associated with the operation of mobile equipment. Authorizes the Department to establish minimum fire safety standards for incinerators.

5. Burning of Lands (Div. 4, Chap. 7, Sec. 4475-4494 P.R.C.)

Authorizes the Department of Forestry to contract with landowners for burning of vegetation and authorizes the Department to issue permits and cooperate in the burning of brush covered lands for purposes of fire prevention, watershed protection and range improvement.

6. State Forest (Div. 4, Chap. 9, Sec. 4631-4658)

Provides for the acquisition of State forests and authorizes the Department of Forestry, in accordance with plans approved by the Board of Forestry, to administer State forests with the objective of demonstrating effective forest management and resource protection methods.

7. Protection of Forest and Lands (Div. 4, Chap. 10, Sec. 4671-4727).

Authorizes the Department of Forestry, in accordance with the policy of the Board of Forestry, to engage in actions to demonstrate and provide advice on effective forest and wildland protection, conduct soil and forest surveys, participate with the Federal Government in related research, and enter into agreements with counties for fire and watershed protection, and provides for the revegetation of denuded watersheds. Authorizes the Department to operate State forest nurseries, provide for the reforestation of public and private lands, and conduct cooperative studies to encourage reforestation. Authorizes the State to accept gifts of land for forestry purposes. Authorizes the Department to engage in insect control projects in cooperation with Federal, State, and local Government and private landowners.

Provides for the protection of *Sequoia gigantea* and authorizes the Department to enforce this mandate.

8. Range Revegetation and Improvement (Div. 4, Chap. 11, Sec. 4771-4788)

Authorizes the Department of Forestry to conduct range improvement research and experiments and cooperate with landowners in the conduct of brush clearing operations.

9. California Wild and Scenic Rivers Act of 1972 (Stats. 1972. C1259, p. 2510)

Creates a California Wild and Scenic Rivers System. The Act stated ".....that certain rivers which possess extraordinary scenic, recrea-

tional, fishery or wildlife values, shall be preserved in their free-flowing state, together with their immediate environments, for the benefit and enjoyment of the people of the State." The rivers, or segments of rivers, to be included under the Act were to be classified in one of three categories: (a) Wild rivers, are those that are free of impoundments and generally inaccessible except by trail with watersheds or shorelines essentially primitive and waters unpolluted; (b) scenic rivers, are those that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads; and (c) recreational rivers, are those that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past. The Secretary of Resources is empowered by the Act to determine which of the three classes best fit the segment of included rivers. Furthermore, the Secretary is responsible for preparation of a management plan to administer the rivers and their adjacent land areas in accordance with the Act, and to submit such plans to the legislature for its approval. The Act also states that each component of the system shall be administered so as to protect and enchance the values for which it was included in the system, without unreasonably limiting lumbering, grazing, and other resources uses, where the extent and nature of such uses do not conflict with public use and enjoyment of these values. The Act designated components of the system, and provides that other rivers which qualify for inclusion may be recommended to the legislature by the Secretary of Resources.

10. California Wilderness Act of 1974 (Stats. 1974, C1196, p. 2581)

This Act established a California wilderness preservation system to be composed of State-owned areas designated by the legislature as "wilderness areas," and administered for the use and enjoyment of the people in such a manner as will leave them unimpaired for future use and enjoyment as wilderness. The Act provides for the protection of such areas to preserve their wilderness character, and for the gathering and determination of information regarding their use and enjoyment as wilderness.

In addition to designating specific areas as components of the system, the Act required the Resources Secretary, in cooperation with each department within the Resources Agency, to review State-owned roadless areas and to report to the legislature before January 1, 1978, his recommendations as to the suitability or nonsuitability of each such area for preservation as State wilderness.

Wilderness areas will continue to be subject to the jurisdiction of the State agency having jurisdiction prior to its inclusion in the system, and that Agency shall adopt regulations for management consistent with the Act.

11. Resource Conservation Act of 1975 (A.B. 850, Chap. 513, 1975)

This Act provides the means by which the State may cooperate with the

United States and with resource conservation districts in adopting conservation practices, including but not limited to, farm, range, open space, urban development, wildlife, recreation, watershed, water quality, and woodland, best adapted to save the basic resources, soil, water, and air from unreasonable and economically preventable waste and destruction. It further provides for the organization and operation of resource conservation districts for the purpose of soil and water conservation.

Most of the provisions of the former law relating to resource conservation, the State Resource Conservation Commission, the Department of Conservation, the Division of Resource Conservation, and the resource conservation districts have been retained. A few substantive changes were made, including an increase in the number of the State Resource Conservation Commission and qualifications of members.

12. Surface Mining and Reclamation Act of 1975 (Chap. 9, Div. 2, Sec. 2710, P.R.C.)

This Act requires the State Mining and Geology Board to adopt State policy for the reclamation of mined lands. That policy is for the guidance of local governments who are required by the Act to obtain reclamation plans for surface mining operations as a condition of granting the permits (also specified by the Act) required before surface mining may proceed. The Act also requires the Board to adopt policies relative to mineral resource conservation through appropriate land use planning by local governing agencies.

13. California Coastal Act of 1976 (Div. 20, Sec. 30000, P.R.C.)

This Act acknowledges the California Coastal Zone Conservation Plan prepared and adopted by the California Coastal Zone Conservation Commission and submitted to the Governor and the legislature on December 1, 1975, pursuant to the California Coastal Zone Conservation Act of 1972. The Plan provides for the orderly, long-range conservation, use, and management of the natural, scenic, cultural, recreational, and man-made resources of the coastal zone.

The Act also defines planning and management policies, the creation and powers of commission and six regional coastal commissions, and roles of State agencies. To achieve maximum responsiveness to local conditions, accountability, and public accessibility, implementation of the program relies heavily on local government and local land use planning procedures and enforcement.

This legislation constitutes California's Coastal Zone Management Program within the coastal zone for purposes of the Federal Coastal Zone Management Act of 1972.

14. Forest Resources Assessment and Policy Act of 1977 (A.B. 452, 1977)

This Act requires the Director of Forestry, under policy guidance from the State Board of Forestry, to prepare and submit to the Board, a

forest resource assessment and analysis, which would include specified elements, by July 1, 1979, and to present an updated assessment by January 1, 1987 and January 1 of each fifth year thereafter. The Act also requires the Board to prepare, based on a review of the assessment, a forest resource policy statement containing specified elements.

15. Wildland Fire Protection and Resources Management Act of 1978 (A.B. 1006, 1977)

This Act directs the Department of Forestry to prepare two model plans for the initial development and implementation of programs, one in northern and one in southern California, for the management and reduction of timber, brush, grass, or other flammable vegetation through prescribed burning and other methods of managing or reducing such wildland fuels.

The Act also authorizes the Department to provide and maintain prescribed burning crews for backup duty in the event of an emergency during prescribed burning operations. When the holder of a prescribed burning permit has fully complied with the provisions relating to prescribed burning and the fire escapes, the Act specifies that suppression costs incurred by public agencies would not be a debt to the holder of the permit.

16. Vegetation Management Reports (1978) (S.B. 2019, Chap. 881, 1978)

This Act requires appropriate State agencies to each submit a report to the legislature on vegetation management by March 1, 1979. These reports shall include a description of the agencies' present policy, activities, and the programs, and regulatory activities affecting vegetation management. The report will describe agency activities that influence the ability of private landowners to undertake vegetative management programs, and which of the agencies' existing programs would be affected by an active vegetation management program in its agency or by another agency.

Although this Act will remain in effect only until January 1, 1980, it is expected to provide information necessary for the development of a comprehensive program of vegetation management which can further conservation policies by reducing the fire hazard, increasing wildlife habitat areas and forage for livestock, and protecting viable plant communities, while at the same time providing jobs which aid the economy of the state.

B. FEDERAL LAWS:

1. Organic Administration Act of 1897 (30 Stat. 34, as supplemented and amended; 16 U.S.C. 473-478, 479-482, 551)

Established authority for Secretary of Agriculture to manage the National Forests. The Creative Act of 1891, authorizing the establish-

ment of forest reserves, had made no provision for their administration. The Organic Act authorized the hiring of employees to protect and administer the reserves and made policy the opening of the reserves for use. This basic Act, with later amendments, is the one under which the National Forests are administered.

2. Act to Establish National Park Service (1916)

Eatablishes a National Park Service within the Department of the Interior to promote and regulate the use of the Federal areas known as national parks, monuments, and reservations to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

3. Taylor Grazing Act (1934) (48 Stat. 1269, 43 U.S.C. 315, 315a, 315h, 315m)

Establish authority for the Secretary of the Interior to establish grazing districts of vacant, unappropriate, and unreserved lands from any part of the public domain of the United States (exclusive of Alaska) which are not in national forests, national parks and monuments, and Indian reservations, and which, in his opinion, are chiefly valuable for grazing and raising forage crops.

4. Multiple Use - Sustained Yield Act (1960) (74 Stat. 215, as amended; 16 U.S.C. 528-531)

Authorizes and directs the Secretary of Agriculture to develop and administer the renewable surface resources of the national forests for multiple use and sustained yield of the several products and services obtained therefrom. In the administration of the national forests due consideration shall be given to the relative values of the various resources in particular areas. The establishment and maintenance of areas of wilderness are consistent with the purposes and provisions of this Act.

5. Wilderness Act (1964) (78 Stat. 890, 16 U.S.C. 1131-1136)

Establishes a National Wilderness Preservation System to be composed of Federally owned areas designated by Congress as "wilderness areas" to be administered for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness, and so as to provide for the protection of these areas, and the preservation of their wilderness charter.

The Act also directed that the Secretary of Agriculture, within 10 years, review each area in the national forests then classified as "primitive" as to its suitability or nonsuitability as wilderness, and to report his findings to the President.

The Secretary of the Interior was directed to report his recommendations as to the suitability or nonsuitability for wilderness, every

roadless areas within national parks and monuments, and national wildlife and game ranges. A recommendation of the President for designation as wilderness would become effective only by an Act of Congress.

6. Federal Water Project Recreation Act (1965) (79 Stat. 213, 16 U.S.C. 460)

Establishes policy that in investigation and planning any Federal navigation, flood control, reclamation, hydroelectric, or multiple-purpose water resources project, full consideration shall be given to the opportunities, if any, which the project affords for outdoor recreation and fish and wildlife enhancement. Such plans shall be based on the coordination of recreational use of the project area with the use of existing and planned Federal, State, or local public recreation developments. Directs project construction agencies to encourage non-Federal public bodies to administer project land and water areas for these purposes unless appropriate for administration by a Federal agency.

7. Land and Water Conservation Fund Act of 1965 (78 Stat. 897, as amended; 16 U.S.C. 4601-4 to 4601-11, 23 U.S.C. 120 (note))

Provides funds for and authorizes Federal assistance to the States in planning, acquisition, and development of needed land and water areas and facilities, and for Federal acquisition and development of certain lands and other areas for such purposes. The purpose of the Act is to assist in preserving, developing, and assuring accessibility to all citizens, present and future, such qualify and quantity of outdoor recreation resources as may be available or are necessary and desirable for their health and vitality.

Establishes a Land and Water Conservation Fund for the above purposes from revenues received from admission fees at designated units of the National Park Service and National Recreation Areas, recreation use fees from Federal special outdoor recreation sites, and other sources.

8. Wild and Scenic Rivers Act (1968) (82 Stat. 906, as amended; 16 U.S.C. 1271-1287)

Establishes policy that certain selected rivers of the Nation which possess outstandingly remarkable scenic, recreation, geologic, fish and wildlife, historic, cultural, or similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations.

The Act implements this policy by instituting a national wild and scenic rivers system, by designating the initital components of that system, and by prescribing the methods and standards for additions to the system. The system shall comprise rivers (1) that are authorizes for inclusion by Act of Congress, and (2) that are designated as wild, scenic, or recreational rivers by an act of the legislature of the

state or states through which they flow, that are found by the Secretary of the Interior, upon application of the Governor of the states concerned, to meet the criteria established in this Act. These later would be permanently administered as wild, scenic, or recreational rivers by agencies or political subdivisions of the states concerned without expenses to the United States.

9. Coastal Zone Management Act of 1972 (86 Stat. 1280, 16 U.S.C. 1451-1464)

Establishes national policy (a) to preserve, protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations, (b) to encourage and assist the states to exercise effectively their responsibilities in the coastal zone to achieve wise use of land and water resources, and (c) for all Federal agencies engaged in programs affecting the coastal zone to cooperate and participate with state and local governments and regional agencies in the development of coastal zone management programs.

10. Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) (88 Stat. 476, as amended; 16 U.S.C. 1600-1614)

This Act, as amended by the National Forest Management Act of 1976, seeks to insure that Americans recognize the importance of the Nation's renewable resources and the necessity for long-term planning for management and use of these resources. To achieve this, RPA requires the Secretary of Agriculture to prepare:

(1) An Assessment of long-term demands and supplies of renewable resources on Nation's 1.6 billion acres of forest and rangeland, under all ownerships, and the opportunities to better use these resources. The first Assessment was submitted to Congress in early 1976 and will be updated in 1980 and every 10 years after that.

(2) A Long-range Program--based on the Assessment--of Forest Service activities, including management of the National Forest System, State and Private Forestry Programs, and Research. The initial Program was submitted to Congress in early 1976 and will be updated in 1980 and every 5 years after that.

One of the prime purposes of the law is to insure that annual decisions on funding for Forest Service programs are related to the long-range Program. First, the Act requires a Presidential Statement of Policy, along with the Assessment and Program, to express how the President intends to shape the Forest Service budget request for the next 5- to 10-year period. Secondly, the President must include in his annual budget a report that explains that progress that has been made in implementing the Program.

11. National Forest Management Act of 1976 (90 Stat. 2949, 16 U.S.C. 472a, 476, 476 (note) 500, 513-516, 521b, 528 (note) 576b 594-2 (note) 1600 (note) 1600-1602, 1604, 1606, 1608-1614)

This Act amends the Forest and Rangeland Renewable Resources Planning Act of 1974 by adding new subsections on fiber potential, wood utilization and recycling, reforestation, National Forest System resource planning, limitations on timber removal from the National Forests, public involvement, and advisory boards. In addition, the Act repeals a paragraph in the Organic Act of 1897 relating to timber sales, and adds new authority for sale of timber on National Forest System lands in accordance with policies set forth in the Multiple Use - Sustained Yield Act of 1960.

12. Federal Land Policy and Management Act of 1976 (90 Stat. 2743; 43 U.S.C. 1701 (note), 1701, 1702, 1712, 1714-1717, 1732, 1740, 1744, 1745, 1751-1753, 1761, 1763-1771, 1781; 7 U.S.C. 1012a: 16 U.S.C. 478a, 1338a)

This Act establishes uniform procedures for any disposal of public land, acquisition of non-Federal land for public purposes, and the exchange of such lands be established by statute, requiring each disposal, acquisition and exchange to be consistent with the prescribed mission of the department or agency involved, and reserving to the Congress review of disposals in excess of a specified acreage. The Act delineates the extent to which the Executive may withdraw lands without legislative action; and provides for payments to compensate states and local governments for burdens created as a result of the immunity of Federal lands from state and local taxation.

It also contains sections on range management, rights-of-way, and designated management areas.

13. Soil and Water Resource Conservation Act of 1977 (RCA) (91 Stat. 1407, 16 U.S.C. 2001 note, 2001-2009)

The purpose of RCA is to ensure that programs administered by the Secretary of Agriculture for the conservation of soil, water, and related resources shall respond to the Nation's long-term needs. (The term "soil, water and related resources," as used in this Act, means those resources which come within the scope of the programs administered in by the Secretary through the Soil Conservation Service.)

The law requires five reports to Congress:

(1) An appraisal of the soil, water, and related resources of the Nation, to be completed by December 31, 1979. A second appraisal is due 5 years later.

(2) A national soil and water conservation program that guides SCS activities to further soil and water conservation on the private and non-Federal lands of the Nation, to be completed by December 31, 1979. A second appraisal is due 5 years later.

(3) A detailed statement of policy is to accompany the appraisal and program reports.

(4) Beginning with the FY 1982 budget and annually thereafter, a budget comparative report that compares the annual budget to the statement of policy.

(5) Beginning with the FY 1982 budget and annually thereafter, a program evaluation report that evaluates the program's effectiveness in attaining the purposes of the Act.

II. LAWS WHICH REGULATE USE OF FOREST AND RELATED LANDS

A. STATE LAWS:

1. California Land Conservation Act of 1965 (Williamson Act)
2. Porter-Cologne Water Quality Control Act (1969)
3. California Environmental Quality Act of 1970
4. California Species Preservation Act of 1970
5. California Endangered Species Act of 1970
6. Z'berg-Nejedly Forest Practices Act of 1973
7. Native Species-Conservation and Enhancement Act (1974)
8. Z'berg-Warren-Keene-Collier Forest Taxation Reform Act of 1976

B. FEDERAL LAWS:

1. Fish and Wildlife Coordination Act (1934)
2. National Environmental Policy Act of 1969
3. Endangered Species Conservation Act of 1969
4. Anadromous Fish Conservation Act (1970)
5. Wild Horses and Burros Protection Act (1971)
6. Bald and Golden Eagle Act (1972)
7. Federal Water Pollution Control Act (1976) (as amended)
8. Clean Water Act of 1977
9. Clean Air Act (1963) (as amended)

II. LAWS WHICH REGULATE USE OF FOREST AND RELATED LANDS

A. STATE LAWS:

1. California Land Conservation Act of 1965 (Williamson Act) and related open space legislation (Sec. 51200, G.C.)

This Act was adopted primarily as a means of keeping prime agricultural land in agriculture by the utilization of tax incentives to landowners. Initially, the Act included only prime agricultural land and there was no guarantee that the owner of the land under contract or agreement would receive a reduction in property taxes because of a constitutional requirement that all lands be assessed at market value.

In 1967, Sections 423 and 423.5 were added to the Revenue and Taxation Code to prohibit the State Board of Equalization and local assessors from using comparable sales data in valuing open space lands subject to enforceable restrictions and assess these lands on the basis of capitalized income. In the case of timberland, the value would be determined to be the present worth of the income which the future harvest of timber crops from the land can reasonable be expected to yield[1/]. Where the land being valued is not capable of producing income or is not used to produce income, or where sufficient information is not available by which income can be determined, the law directs the assessor to impute to the land a reasonable amount to be considered as income.

This change is assessment practices led to a rapid increase in participation in the Act. Participation in the Act is voluntary on the part of both local government and the landowner. The Act enables an owner of agricultural land to enter into a contract with local government to permit his land to be taxed as agricultural land in return for foregoing development of that land for a minimum of 10 years, with automatic annual renewal after that period.

In 1971, the State Legislature approved the Open Space Subvention Program. The stated purpose of the Program is to provide replacement revenues to local government by reason of the reduction of the property tax on open space lands assessed under Sections 423 and 423.5 of the Revenue and Taxation Code. Open space lands include agricultural lands, forest lands, and other lands such as grazing lands, wildlife habitats, wetlands, saltponds, scenic highway corridors, submerged lands, and recreational areas.

1/ Pursuant to the Z'berg-Warren-Keene-Collier Forest Taxation Reform Act of 1976, the counties must provide for the zoning of land used for growing and harvesting timber as timberland preserve zones (TPZ's). A TPZ is a 10-year restriction on the use of land, and will replace the use of agricultural preserves (Williamson Act contracts) on timberland.

A particularly important aspect of the Williamson Act and related open space legislation, from the standpoint of land use planning, is a requirement that cities and counties prepare open space plans and submit them for review to the Secretary of Resources.

Local governments are required to adopt an open space action program and zoning ordinances consistent with their open space plan.

2. Porter-Cologne Water Quality Act (Stats. 1969, Ch. 482)

This Act establishes policy that the quality of all the waters in the State to be protected to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible.

The Act provides a Statewide program for water quality control to be administered regionally, within a framework of Statewide coordination and policy. Organization, membership, powers, duties, and enforcement powers are established for both State and regional boards.

Regional boards are required to formulate and adopt water quality control plans for all areas within the regions in conformance with the above state policy. These plans will include objectives for protection of water quality resulting from forest management activity.

Although provisions of the California Forest Practices Act should be adequate to assure compliance with regional water quality objectives during most logging operations, the regional boards may, for any particular operations, require timber operators to comply with Section 13260 of the Act. This Section requires any person discharging waste or proposing to discharge waste (includes debris or eroded earth from logging operations) that could affect the quality of the waters of the State to file with the regional board a report of the discharge. The board, after any necessary hearing, shall prescribe requirements as to the nature of any proposed discharge, or may request the Attorney General to petition the court for the issuance of a restraining order or injunction, as appropriate, to prohibit the discharge of waste.

The regional board, in reviewing any water control plan or waste discharge requirements, may investigate the quality of any waters within the region. In such an investigation, the board may require that any person discharging waste to furnish such technical or monitoring program reports as the board may specify.

3. California Environmental Quality Act of 1970 (Chap. 1433, Div. 13, Sec. 21000, P.R.C.)

This Act requires that all agencies of the State Government which regulate activities of private individuals, corporations, and public agencies which are found to affect the quality of the environment, shall regulate such activities so that major consideration is given to preventing environmental damage.

State EIR guidelines have been developed by the Office of Planning and Research for adoption by the Secretary of Resources, in accordance with Public Resources Code Section 21083, for the purpose in implementing this Act. These guidelines are binding on all public agencies and provide them with principles, objectives, criteria, and definitions of Statewide application to be used in dealing with environmental quality, the evaluation of projects, and the preparation and evaluation of environmental impact reports.

4. California Species Preservation Act of 1970 (Stats. 1970, Chap. 1036, P. 1847)

This Act directs the California Department of Fish and Game to inventory all threatened fish and wildlife, develop criteria for rare and endangered species, and report to the Governor and the legislature every 2 years on the status of these animals. The Department's report entitled "At the Crossroads," published biennially since 1972 in response to this Act, recommended actions for the protection and preservation of rare and endangered species.

These recommendations impact land use policies since the protection of habitat is key to the survivial of these species. On public lands necesary protection of habitat can usually be arranged through the cooperative efforts of government agencies. Where the habitat of threatened fish and wildlife is in private ownership, the State and Federal endangered species acts are virtually ineffective in preventing its modification or destruction.

5. California Endangered Species Act of 1970 (Stats. 1970, Chap. 1510, P. 2998)

This Act expresses legislative concern over California's threatened wildlife, defines rare and endangered wildlife, and gives authority to the Fish and Game Commission to deem what animals in California are rare and endangered. Prohibits importation into the State, or taking, possessing, or selling within the State any endangered or rare animal. Authorizes the Commission to permit the importation of endangered or rare animals subject to such terms and conditions as it may prescribe.

6. Z'berg-Nejedly Forest Practice Act of 1973 (Div. 4, Chap. 8, Sec. 4511, P.R.C.)

The intent of this Act is to create and maintain an effective and comprehensive system to regulate the use of all timberlands so as to assure that, where feasible, the productivity of timberlands is restored, enhanced, and maintained. The goal of maximum sustained production of high quality timber products is achieved while giving consideration to values relating to recreation, watershed, wildlife, range and forage, fisheries, and aesthetic enjoyment.

The Act provides direction to the Board of Forestry in the establishment of forest districts, the appointment and duties of district technical advisory committee members, and procedures adoption of district

forest practice rules that are in accordance with the intent of the Act.

The Act establishes application requirements and procedures for the issuance of revocation of timber operations' licenses; and requires a timber harvesting plan be prepared by a registered professional forester before the start of each timber operation. Timber harvest plan procedures include requirements for completion reports and harvesting inspections when all work except stocking has been completed, and stocking reports and stocking inspections within 5 years after completion of the timber operation.

The Act also requires any person who owns timberland to be devoted to uses other than the growing of timber to file an application for conversion with the Board of Forestry. The Board is directed to, by regulation, prescribe procedures for form and content of such applications in accordance with certain criteria.

7. Native Species Conservation and Enhancement Act (1974) (Stats. 1974, Chap. 898, p. 1900)

This Act declares the policy of the State to maintain sufficient populations of all species of wildlife and habitat necessary to insure their continued existence at the highest levels possible to (1) provide for the beneficial use and enjoyment of wildlife by all citizens of the State; (2) perpetuate all species of wildlife for their intrinsic and ecological values, as well as for their direct benefits to man; and (3) provide for aesthetic, educational, and nonappropriative uses of the various wildlife species.

The Act creates a Native Species Conservation and Enhancement Account to be maintained by the Department of Fish and Game within the Fish and Game Preservation Fund, to permit separate accountablility for the receipt and expenditure of monies derived through donations from persons or organizations for the support of nongame species conservation and enhancement programs. Appropriations from this account for nongame species conservation and enhancement programs would be in addition to other appropriations from the Fish and Game Preservation Fund for the same purpose.

8. Z'berg-Warren-Keene-Collier Forest Taxation Reform Act of 1976 (A.B. 1258, Chap. 176, 1976 as amended by A.B. 100 Chap. 853, 1977)

This Act replaces the present annual ad valorum tax on timber with a yield tax system to be paid at the time of harvest. It provides for the establishment of "Timberland Preserve Zones" (TPZ) to be composed of lands assessed for growing and harvesting of timber as the highest and best land use. A TPZ is a 10-year restriction on the use of land and will replace the use of agricultural preserves (Williamson Act contracts) on timberland. Land use under a TPZ will be restricted to growing and harvesting timber and to compatible uses approved by the county. In return, effective July 1, 1977, timber owners with TPZ's

will no longer pay an ad valorum tax on standing timber and taxation of their timberland will be based only on such restrictions of use.

A timber yield tax is imposed on every timber owner who harvests his timber on or after April 1, 1977, and on every timber owner of felled or downed timber who acquires little to such felled or downed timber from an exempt person or agency after that date.

The Act also imposes a Timber Reserve Fund tax to be paid by the timber owner who harvests his timber on or after April 1, 1977 through December 31, 1982. The fund will be used to compensate counties for any loss in revenues through the change from the former annual ad valorum tax on timber to the timber yield tax system.

Parcels not included in TPZ's will be taxed on the basis of comparable value of similar property similarly situated for purposes other than timber growing and compatible uses. Any trees growing on such parcels may be taxed for aesthetic and amenity values. Any trees harvested from lands outside TPZ's are also subject to the timber yield tax and the Timber Reserve Fund Tax.

B. FEDERAL LAWS:

1. Fish and Wildlife Coordination Act (1934), as amended (48 Stat. 401, 16 U.S.C. 661-667e)

   The purpose of this Act is to provide that wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs through the effectual and harmonious planning, development, maintenance, and coordination of wildlife conservation and rehabilitation. The Act authorizes the Secretary of the Interior (1) to provide assistance to, and cooperate with, Federal, State, and public or private agencies and organizations in various fish and wildlife management measures; (2) to make surveys and investigations of the wildlife of the public domain, including lands and waters controlled by any Federal agency; and (3) to accept donations of land and contributions of funds for these purposes.

2. National Environmental Policy Act of 1969 (83 Sta. 852 as amended; 42 U.S.C. 4321, 4331-4335, 4341-4347)

   The purposes of this Act are: to declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality (CEQ).

   It directs that all Federal agencies shall identify and develop methods and procedures which will insure that presently unqualified environmental amenities and values may be given appropriate consideration in

decision-making along with economic and technical considerations. For each proposal for legislation or other major Federal action, the Act requires a detailed environmental impact statement by the responsible official. Copies of such statements and the comments and views of the appropriate Federal, State, and local agencies, which are authorized to develop and enforce environmental standards, shall be made available to the President, the CEQ, and to the public, and shall accompany the proposal through the existing agency review processes.

3. Endangered Species Conservation Act of 1969 (80 Stat. 926, 16 U.S.C. 668aa-666cc-6)

This Act provides a program for the conservation, protection, restoration, and propagation of selected species of native fish and wildlife, including migratory birds, that are threatened with extinction. It directs that the Secretaries of the Interior, Agriculture, and Defense, together with the agency heads within those Departments, shall seek to protect species of native fish and wildlife that are threatened with extinction, and insofar as is practicable and consistent with the agencies' primary purpose, shall preserve the habitats of such species on lands under their jurisdiction. The Act sets the procedure by which species shall be regarded as threatened, and cites statutory authorities to be utilized by the Secretary of the Interior for carrying out endangered species programs.

4. Anadromous Fish Conservation Act (1970) (84 Stat. 214, 16 U.S. C. 757a)

Authorizes the Secretary of the Interior to enter into cooperative agreements with States, or wherever he deems it appropriate, with other non-Federal interests, for the purpose of conserving, developing, and enhancing the anadromous fishery resources that are subject to depletion from water resources development and other causes. Such agreements describe actions to be taken by the Secretary and the cooperating parties, benefits expected, estimated cost, and the share of the cost to be borne by the Federal Government and other parties. The Federal share shall not exceed 50 percent of the total cost exclusive of the value of any Federal land involved. Authorized activities under the Act include investigations, surveys, research, stream clearance, conservation devices and structures, fish hatcheries, and land acquisition.

5. Wild Horses and Burros Protection Act (1971) (85 Stat. 649, as amended; 16 U.S.C. 1331-1338, 1338a, 1339, 1340)

This Act establishes policy that wild, free roaming horses and burros will be protected from capture, branding, harassment, or death; and to accomplish this, they are to be considered in the area where presently found, as an integral part of the natural system of the public lands. Such animals shall be under the jurisdiction of the Secretary of the Interior when on public lands administered by the Bureau of Land Management, and the Secretary of Agriculture on lands administered by the Forest Service.

All management activities shall be at the minimal feasible level and shall be carried out in consultation with the wildlife agency of the State wherein such lands are located in order to protect the natural ecological balance of all wildlife species which inhabit such lands, particularly endangered wildlife species. The Act establishes procedures for disposal of excess animals, removal from private lands, and arrest and prosecution for violations under the Act.

6. Bald and Golden Eagle Act (1972) (86 Stat. 1064, 16 U.S.C. 668-668d)

Prohibits the taking, possession, selling, transporting, export, or import of any bald eagle, commonly known as the American eagle, or any golden eagle, alive or dead, or any part, nest, or egg thereof. In addition to criminal penalties for violations, the Act also provides for the cancellation of agreements authorizing the grazing of domestic livestock on Federal lands to any person convicted of a violation of the Act. The Act also prescribes procedures by which the Secretary of the Interior may, when determined to be compatible with the preservation of these species, permit the taking, possession, or transportation of specimens for scientific or exhibition purposes of public museums, zoos, or for religious purposes of Indian tribes, or when necessary for protection of wildlife or of agricultural or other interests in a particular locality, under regulations he is authorized to prescribe.

7. Federal Water Pollution Control Act of 1972 (33 U.S.C. 1251 et seq.)

Section 208 of this Act requires that an areawide waste treatment management plan be prepared, certified by the Governor, and submitted to the Administrator of the Environmental Protection Agency. Such plans are to be prepared by regional agencies for areas designated by the Governor as having substantial water quality problems, and by the State for all portions of the State not so designated. The Administrator is authorized to make grants to such agencies for the reasonable costs of developing and administering the planning process. The initial plans are to be submitted to the Administrator within 3 years after the receipt of the initial grant. The agricultural portion of such a Section 208 plan would (1) identify agriculturally and silviculturally related nonpoint sources of pollution including runoff from land used for livestock and crop production, and (2) set forth procedures and methods (including land use requirements) to control to the extent feasible such sources.

8. Clean Water Act of 1977 (PL 95-217)

This Act authorized the Secretary of Agriculture, with the concurrence of the Administrator of the Environmental Protection Agency, to establish and administer a program of long-term contracts with rural landowners and operators for the purpose of installing and maintaining measures incorporating "best management" practices for agriculture in order to control nonpoint source pollution for improved water quality. States or areas having an approved agricultural portion of a Section 208 plan under the Federal Water Pollution Control Act of 1972 may qualify for cost-sharing assistance. Responsibility for this program

has been delegated to the Soil Conservation Service. National and State Rural Clean Water Coordinating Committees, chaired by the SCS and including the Forest Service along with other involved agencies, and have been established to aid in carrying out programs with States and other cooperators. This cost-sharing program applies to "rural lands," which are defined as privately-owned agricultural lands, including cropland, pasture land, forest land, range land, and associated lands.

9. Clean Air Act of 1963, as amended (42 U.S.C. 7401 et seq.)

This Act and its amendments through 1974, were designed to achieve four major objectives: (1) protect and enhance the quality of the Nation's air resources in order to promote the public health and welfare, (2) initiate and accelerate a national research and development program in order to achieve the prevention and control of air pollution, (3) provide technical and financial assistance to State and local governments for air pollution control programs, and (4) encourage and assist the development and operation of regional programs.

The 1977 amendments were intended to achieve several additional objectives. One is to provide a greater role for State and local governments in the administration of the Act. Another objective is to provide legislative guidance and clearer legislative intent to the prevention of significant deterioration of air quality in areas where air pollution levels are currently below the National Standards. Air quality classes have been specified and certain Federal areas designated for protection under them. In addition, the protection of visibility over National Parks and Wildernesses has been declared a national goal.

III. LAWS WHICH AUTHORIZE PUBLIC ASSISTANCE (INCENTIVES) TO THE PRIVATE FOREST LANDOWNER

A. STATE LAWS:

1. California Forest Improvement Act of 1978 and California Urban Forestry Act of 1978 (both Acts were created by AB 3304).

B.FEDERAL LAWS:

1. Cooperative Forestry Assistance Act of 1978 (P.L. 95-313)
2. Soil Conservation and Domestic Allotment Act of 1936 (ACP)
3. Watershed Protection and Flood Prevention Act of 1954 (P.L. 566)

III. LAWS WHICH AUTHORIZE PUBLIC ASSISTANCE (INCENTIVES) TO THE PRIVE FOREST LANDOWNER

A. STATE LAWS:

1. California Forest Improvement Act of 1978 and the California Urban Forestry Act of 1978 (AB 3304, Chap. 1181, 1978).

   This legislation sets in motion a far-reaching plan to restore California forest lands to full productivity and increase employment in the forest products industry, establishes a new "urban forestry" plan, and encourages the utilization of wood for energy production. It also creates the Forest Resources Improvement Fund which would become operative to the extent funding is available from the Federal Government, private institutions or organization, or any source other than the State General Fund.

   This Bill grants authorization to the Director of Forestry for a variety of means to bring about improvement and reforestation of understocked forest land. Among them: entering into cost-sharing agreements for forest improvement works; making grants to qualified landowners for payment of inheritance taxes; making loans for forest resource improvement work; providing technical assistance, seed and seedlings, and contracting for seed and seedling production.

   The Director is required to submit a report to the State Board of Forestry and the legislature by December 31, 1980 and annually thereafter concerning the progress of the program.

   The Bill also requires the Department of Forestry to provide technical assistance to urban areas for urban reforestation. A grant and loan program is authorized for making grants to cities, counties, districts, and nonprofit organizations. The Board of Forestry is to establish guidelines for these purposes by December 31, 1979.

B. FEDERAL LAWS:

1. Cooperative Forestry Assistance Act of 1978 (P.L. 95-313) [92 Stat. 365; 16 U.S.C. 2101-2111, 2101 (note)]

   This Act repeals the following laws, and portions of laws: Sec. 1,2,3, and 4 of the Clark-McNary Act of 1924; White Pine Blister Rust Protection Act; Forest Pest Control Act; Cooperative Forest Management Act; Sec. 401 of the Agricultural Act of 1956; Title IV of the Rural Development Act of 1972; and Sec. 1009 and the proviso to Sec. 1010 of the Agricultural Act of 1970, as added by the Agriculture and Consumer Protection Act of 1973.

   The purpose of the Act is to consolidate and update authorities of the Secretary of Agriculture with respect to non-Federal forest lands, and to complement the policies and direction set forth in the Forest and Range Land Renewable Resource Planning Act of 1974. The Act reaffirms existing policy that it is in the national interest for the Secretary

to work through and in cooperation with State Foresters or equivalent State officials in implementing Federal programs affecting non-Federal forest lands.

Major sections of the Act deal with the following issues: Advancement of forest resources management; the encouragement of the production of timber; the prevention and control of insects and diseases affecting trees and forests; the planning and conduct of urban forestry programs; the prevention and control of rural fires; and management and planning assistance to State Foresters, and technology implementations.

A summary of these sections follows:

Section 3 - Rural Forestry Assistance. The Secretary is authorized to provide financial, technical, and related assistance to State foresters to (1) develop genetically improved tree seeds; (2) procure, produce, and distribute tree seeds and trees; (3) plant tree seeds and trees for the reforestation of non-Federal forest lands; (4) plan, organize, and implement measures on non-Federal forest lands for improving the quality and quantity of timber, fish and wildlife habitat, and water yield; (5) protect or improve soil fertility and the quality, quantity, and timing of water yields; and (6) provide technical information, advice, and related assistance to private forest landowners and managers, vendors, forest operators, wood processors, public agencies, and individuals regarding -

(A) harvesting, processing, and marketing of timber and other forest resources and the marketing and utilization of wood and wood products;

(B) conversion of wood to energy;

(C) management planning and treatment of forest land to increase the quantity and improve the quality of timber and other forest resources;

(D) protection and improvement of forest soil fertility and the quality, quantity, and timing of water yields; and

(E) the effects of forestry practices on fish and wildlife and their habitats.

Section 4 - Forestry Incentives. The Secretary is authorized to develop and implement a forestry incentives program to encourage the development, management, and protection of nonindustrial private forest lands so as to provide for the production of timber and other forest resources associated therewith.

Provide cost sharing of up to 75 percent of the actual costs incurred by the landowners if they own 1,000 acres or less of private forest land (up to 5,000 acres if approved by Secretary, where significant public benefits will accrue). The Act requires that individual forest management plans developed by the landowner, in cooperation with and

approved by the State Forester, will be basis for such cost-sharing agreements. Regulations for administration of this section are developed by the Secretary in consultation with a committee of not less than five State Foresters selected by the majority of State Foresters participating in this Act.

Section 5 - Insect and Disease Control - authorizes the Secretary to protect from insects and diseased forests and wood products, stored wood, and wood in use directly on the National Forest System and in cooperation with others on other lands.

Section 6 - Urban Forestry Assistance - authorizes the Secretary to provide financial, technical, and related assistance to State Foresters to provide information and technical assistance to units of local government and others that will encourage cooperative efforts to plan urban forestry programs and to plant, protect, maintain, and utilize wood from trees in open spaces, greenbelts, roadside screens, parks, etc., in urban areas.

Section 7 - Rural Fire Prevention and Control - provides authority to the Secretary to (1) cooperate with State Foresters in developing systems and methods for the prevention, control, suppression, and prescribed use of fires on rural lands and in rural communities; (2) provide financial, technical, and related assistance to State Foresters, and through them to other agencies for the above activities on non-Federal forest lands and other non-Federal lands; and (3) provide financial, technical, and related assistance to State Foresters in cooperative efforts to organize, train, and equip local fire fighting forces, including those of Indian tribes and other native groups, to prevent, control, and suppress fires threatening human lives, crops, livestock, farmsteads, pastures, orchards, wildlife, range land, woodland, and other resources in rural areas. The Act also established in the Treasury a special rural fire disaster fund that shall be immediately available and used to supplement any other money to carry out this section with respect to rural fire emergencies.

Section 8 - Management Assistance, Planning Assistance, and Technology Implementation.

(a) To aid in achieving maximum effectiveness in the programs and activities conducted under this Act, the Secretary is authorized to provide financial, technical, and related assistance to State Foresters for the development of stronger and more efficient organizations that will enable them to fulfill better their responsibilities for the protection and management of non-Federal forest lands.

(b) To ensure that data regarding forest lands are available for and are effectively presented in State and Federal natural resources planning, the Secretary is authorized to provide financial, technical, and related assistance to State Foresters in the assembly, analysis, display, and reporting of State forest resources data, in the training of State forest resources planners,

and in participating in natural resources planning at the State and Federal levels.

(c) To ensure that new technology is introduced, new information is integrated into existing technology, and forest resources research findings are promptly made available to State forestry personnel, private forest landowners and managers, vendors, forest operators, wood processors, public agencies, and individuals, the Secretary is authorized to carry out a program of technology implementation.

Section 9 - Consolidated Payments. To provide flexibility in funding activities authorized under this Act, the Secretary may, upon request of any state, consolidate the anual financial assistance payments to that state under the Act (except Section 4) in lieu of functional cost sharing mechanisms, formulas, or agreements. Such consolidated payments would be based upon State forest resource programs developed by the State Forester and reviewed by the Secretary.

2. Soil Conservation and Domestic Allotment Act of 1936 (ACP) -

Establishes the Agricultural Conservation Program which provides cost-sharing funds to private forest landowners for tree planting and forest improvement measures. Administered by the Agricultural Stabilization and Conservation Service with technical assistance for landowners receiving cost-sharing provided by Forest Service through State forestry agencies.

3. Watershed Protection and Flood Prevention Act of 1954 (P.L. - 566.) 68 Stat. 666, as amended; U.S.C. 1001-1008, 33 U.S.C. 701b (note)

This Act authorizes and directs the Secretary of Agriculture to cooperate with qualified State and local agencies in planning and carrying out watershed protection and flood prevention measures on approved watersheds. Overall program responsibility rests with the Soil Conservation Service. In carrying out its responsibility for the forestry phase of the program, the Forest Service works through State forestry agencies whenever possible. River basin program planning is carried out under Section 6 of the Act. Certain provisions of the Act have been extended to apply to the 11 flood prevention projects authorized by the Flood Control Act of 1944, including the Los Angeles and Santa Ynez Rivers in California.

BIBLIOGRAPHY

Adams, Darius M. and Haynes, Richard W., A REGIONALLY DISAGGREGATED ECONOMIC SIMULATION MODEL FOR ESTIMATING LONG-RUN TIMBER DEMAND-SUPPLY EQUILIBRIUM, Forest Service, Pacific Northwest Forest and Range Experiment Station, in process, Portland, Oregon, 1978.

Adams, Darius M. and Haynes, Richard W., THE 1980 SOFTWOOD TIMBER ASSESSMENT MARKET MODEL: STRUCTURE, PROJECTIONS AND POLICY SIMULATIONS, Oregon State University/U.S. Department of Agriculture, Forest Service (forthcoming), 1979.

Adams, Theodore E., "CALIFORNIA'S BRUSHLANDS," California Agriculture, October 1978, p. 9.

Agriculture, U.S. Department of, CALIFORNIA LIVESTOCK STATISTICS, 1977.

Agriculture, U.S. Department of, FOREST STATISTICS OF THE U.S., 1977 Review Draft, Washington, D.C., 1978.

Agriculture, U.S. Department of, PRIME RANGE LANDS, draft version, September 1978, p. 7.

Agriculture, U.S. Department of, STATEMENT OF PRIME FARMLAND, RANGE, AND FOREST LAND, Secretary's Memorandum No. 1827, Supplement, June 1976.

Air Pollution Research Center, University of California, Photochemical Oxidant Air Pollution Effects on a Mixed Conifer Forest Ecosystem, Riverside, California, 1977.

Air Resources Board, State of California, Intergovernmental Relations, Chapter 25, Revision to the State of California Implementation Plan, September and October 1978.

Air Resources Board, State of California, Statewide Perspective, Chapter 2, Revision to the State of California Implementation Plan, October 1978.

Allison, B. J., SOME ASPECTS OF FOREST PLANNING, New Zealand Forest Products Limited, Private Bag, Tokoroa, New Zealand, January 1978.

Anderson, H. W., MANAGING CALIFORNIA'S SNOW ZONE LANDS FOR WATER, U.S. Forest Service Research Paper PSW-6, 1963.

Anderson, Henry; Hoover, Marvin and Reinhard, Kennth, FORESTS AND WATER: EFFECTS ON FOREST MANAGEMENT ON FLOODS, SEDIMENTATION AND WATER SUPPLY, PSW, U.S. Department of Agriculture General Technical Report, PSLO-18, 1976.

Anderson, James R.; Hardy, E. E.; Roach, J. T.; Witmer, R. E., "A LAND USE AND LAND COVER CLASSIFICATION SYSTEM FOR USE WITH REMOTE SENSOR DATA," Geological Survey Professional Paper 964 III, U.S. Government Printing Office, Washington, D.C., 1976, 28 pp.

Arvola, T. F., CALIFORNIA FORESTRY HANDBOOK, California Department of Forestry, Sacramento, California, 1978.

Barbour, Michael A.; Major, Jack - (editors), TERRESTRIAL VEGETATION OF CALIFORNIA, John Wiley & Sons, New York, 1977, ix + 1002 pp. + map.

Barrette, B. R., Gedney, D. R., and Oswald, D. D., CALIFORNIA TIMBER INDUSTRIES, Mill Characteristics and Wood Supply, California Division of Forestry, Sacramento, California, 1970, 115 pp.

Barrette, Brian R.; Stanley, Mark R.; and Cox, Paul, TIMBER PROJECTIONS FOR CALIFORNIA, PRODUCTION VS. CONSUMPTION, State Forest Notes No. 71, Sacramento, California, 1978, 7 pp.

Bergvall, J. A.; Bullington, D. C.; Gee, L.; and Koss, W., WOOD WASTE FOR ENERGY STUDY: INVENTORY ASSESSMENT AND ECONOMIC ANALYSIS, Department of Natural Resources, State of Washington, September 1978.

Berstein, Arthur, "Using a Chainsaw to Control Brush," Journal of Forestry, August 1978.

Board of Forestry, DRAFT 208 REPORT, California Department of Forestry, March 1979.

Bohrer, Zene, "The Definition of Productive Agricultural Land at Four Coal-Fired Powerplant Sites in North Central California," California Energy Commission, 1978.

Boisinger, Charles L., CALIFORNIA'S FORESTS -- TRENDS, PROBLEMS AND OPPORTUNITIES, U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, 1979 (draft).

Boisinger, Charles L., Timber Resources of Northern Interior California, 1970 U.S. Department of Agriculture, Forest Service, Resource Bulletin, PNW-65, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, 1976, 75 pp.

Briggs, Darwyn, Prime Agricultural Land and Rangelands, unpublished data, 1975.

Brown, O.D., "Energy Generation from Wood Waste," paper given at the University of Michigan's conference on Wood Energy, Eugene Water and Electric Board, Eugene, Oregon, November 1977.

Burcham, L. T., CALIFORNIA RANGE LAND, California Division of Forestry, Sacramento, California, 1957, 261 pp.

Burcham, L. T., "Inventorying California's Wildland Resources," California Department of Forestry, 1973.

California Forest Pest Control Action Council, FOREST PEST CONDITIONS IN CALIFORNIA (ANNUAL REPORT), Sacramento, California, 1967-78.

California Region Framework Study Committee, COMPREHENSIVE FRAMEWORK STUDY, California Region, Appendix II, The Region, June 1971.

California Region Framework Study Committee, COMPREHENSIVE FRAMEWORK STUDY, California Region, Appendix V, Water Resources, 1971.

California Region Framework Study Committee, COMPREHENSIVE FRAMEWORK STUDY, California Region, Appendix VII, Mineral Resources, June 1971.

California Region Framework Study Committee, COMPREHENSIVE FRAMEWORK STUDY, California Region, Appendix VIII, Watershed Management, 1971.

California Region Framework Study Committee, COMPREHENSIVE FRAMEWORK STUDY, California Region, Appendix XIII, Fish and Wildlife, June 1971.

California Almanac Company, CALIFORNIA YEARBOOK, Bicentennial Edition, LaVerne, 1975, pp. 86, 92-93.

CALVEG, CLASSIFICATION AND ASSESSMENT WITH LANDSAT OF VISIBLE ECOLOGICAL GROUPINGS (CALVEG), U.S. Forest Service Draft, 1978.

Census, U.S. Bureau of the, ANNUAL SURVEY OF MANUFACTURES, STATISTICS FOR STATES, STANDARD METROPOLITAN STATISTICAL AREAS, LARGE INDUSTRIAL COUNTIES AND SELECTED CITIES, Publication M75 (AS)-6, Washington, D.C., 1975.

Central Valley Regional Water Quality Control Board, Inventory and Assessment of Water Quality Problems Related to Abandoned and Inactive Mines in the Central Valley Region of California, June 1978.

Clark, William B., "California Mining Review," California Geology, September 1978.

Clark, William B., "Gold Rush of the 1970's," California Geology, September 1978.

Clawson, J. W., "The Use of California Rangelands," California Livestock News, April 1976, pp. 34-36.

Clawson, Marion, "Forests in the Long Sweep of American History," Science, Volume 204, June 1979.

Coats, Robert N., "The Road to Erosion," Environment, Volume 20, No. 1, January/February 1978.

Cochran, William G., SAMPLING TECHNIQUES, Second Edition, John Wiley and Sons, Inc., New York, 1963, 413 pp.

Colwell, W. L., "Forest Soils of California," chapter in CALIFORNIA FOREST SOILS, Division of Agricultural Sciences, #4094, University of California, 1979.

Connaughton, Kent P. and McKillop, William, "Estimation of Small-Area Multipliers for the Wood Processing Sector -- An Econometric Approach," Forest Science (forthcoming), 1979.

Conservation, California Department of, California Soils: An Assessment, April 1979 (draft report).

Cothern, James H., PRINCIPAL FACTORS AFFECTING THE DEMAND FOR RED MEAT IN CALIFORNIA, Agricultural Extension Service, University of California, Davis, 1973.

Coules, Dennis, California Wilderness Coalition, Personal Correspondence to Peter Wyckoff, June 14, 1979.

Dantzig, George B., LINEAR PROGRAMMING AND EXTENSIONS, The Rand Corporation and University of California, Berkeley, 1963.

Dasmann, William, IF DEER ARE TO SURVIVE, Wildlife Management Institute, 1971.

Day, Robert D., Jr., "Threat of Wood Smoke," Journal of Forestry, August 1978.

Dean, Gerald W., Carter, Harold O., Nickerson, Eric A. and Adams, Richard M., STRUCTURE AND PROJECTIONS OF THE HUMBOLDT COUNTY ECONOMY: ECONOMIC GROWTH VERSUS ENVIRONMENTAL QUALITY, Giannini Foundation Research Report No. 318, University of California, Davis, 1973, 98 pp.

Dodge, Marvin, California Department of Forestry, Personal Communication, September 1979.

Dodge, Marvin; Burchan, L. T.; Goldhaber, Susan; McCulley, Bryan and Springer, Charles, An Investigation Of Soil Characteristics And Erosion Rates On California Forest Lands, California Department of Forestry, October 1976.

Durrenberger, Robert, Patterns on the Land, 1967.

Energy Commission, State of California, Energy Choices for California...Looking Ahead, Introduction to the 1979 Biennial Report, March 1979.

Energy, U.S. Department of, Distributed Energy Systems in California's Future, Volume 1, March 1978.

Environmental Protection Agency, IMPACT OF FORESTRY BURNING UPON AIR QUALITY, Final Report by Geomet, Environmental Protection Agency contract, October 1978.

Environmental Protection Agency, Office of Planning Standards, Nonpoint Source Control Guidance - Silviculture, Washington, D.C., March 1977a.

Environmental Protection Agency, SILVICULTURAL CHEMICALS AND PROTECTION OF WATER QUALITY, 1977b.

Finance, California Department of, POPULATION PROJECTIONS FOR CALIFORNIA COUNTIES, 1975-2020, Report 77, Sacramento, California, 1977, p. 3.

Fish and Game, California Department of, 1974 STATE ANGLING SURVEY, Sacramento, California.

Fish and Game, California Department of, 1976-77 LICENSED FUR TRAPPER REPORTS, unpublished data, Sacramento, California.

Fish and Game, California Department of, PRESENT AND FUTURE HUMAN DEMAND FOR FISH AND WILDLIFE, unpublished data, Sacramento, California.

Fish and Game, California Department of, Report of the 1970 Game Take Hunter Survey, unpublished report, Sacramento, California, 1970.

Fish and Game, California Department of, REPORT OF THE 1977 GAME TAKE HUNTER SURVEY, unpublished data, Sacramento, California.

Fish and Game, California Department of, WATER QUALITY PLANNING PROJECT, Present and Future Human Demands for Fish and Wildlife, Sacramento, California, 1972.

Forest Industries Council, CALIFORNIA FOREST PRODUCTIVITY REPORT, Forest Productivity Committee, Washington, D.C., draft, 1979.

Forest Service, U.S. Department of Agriculture, AN ASSESSMENT OF THE FOREST AND RANGE LAND SITUATION IN THE UNITED STATES, RPA Review Draft, Washington, D.C., 1979.

Forest Service, U.S. Department of Agriculture, Draft Environmental Statement, Timber Management Plan, Angeles, Cleveland, Los Padres, and San Bernardino National Forests, April 1978.

Forest Service, U.S. Department of Agriculture, Forest Service Manual, Washington, D.C.

Forest Service, U.S. Department of Agriculture, Letter To Lew Moran, California Department of Forestry Director, January 19, 1979.

Forest Service, U.S. Department of Agriculture, OUTLOOK FOR TIMBER IN THE UNITED STATES, Forest Resource Report No. 20, Washington, D.C., 1973, 367 pp.

Forest Service, U.S. Department of Agriculture, ROADLESS AREA REVIEW AND EVALUATION II (RARE), California Supplement to Draft Environmental Statement, June 1978.

Forest Service, U.S. Department of Agriculture, RARE II WILDERNESS ATTRIBUTE RATING SYSTEM--A USER'S MANUAL, November-December 1977.

Forest Service, U.S. Department of Agriculture, RECREATION INFORMATION MANAGEMENT SYSTEM (RIM), Pacific Southwest Region, San Francisco, California.

Forest Service, U.S. Department of Agriculture, THE 1980 TIMBER ASSESSMENT (forthcoming), Washington, D.C., 1976b.

Forest Service, U.S. Department of Agriculture, THE NATION'S RANGE RESOURCES--A FOREST RANGE ENVIRONMENTAL STUDY, 1972.

Forest Service, U.S. Department of Agriculture, WATERSHED RESOURCE MANAGEMENT HANDBOOK, Region 5, 1978.

Forest Survey, 1979 (see Bolsinger, draft, 1979).

Forestry, California Department of, BRUSHLAND RANGE IMPROVEMENT, Sacramento, California, 1978.

Forestry, California Department of, "Forest Improvement Program Summary," Sacramento, California, 1978.

Forestry, California Department of, "Timber Projections for California-Production vs. Consumption," State Forest Notes No. 71, 1978.

Forestry, California Division of, Department of Conservation, WILDLAND SOILS, VEGETATION AND ACTIVITIES AFFECTING WATER QUALITY, Sacramento, California, 1972.

Forestry, California State Board of, First Biennial Report of the California State Board of Forestry for the Years 1885-86 to Governor George Stoneman, State Printing, Sacramento, California, 1886, 238 pp.

Fowler, Kenneth S., "On Cutting Down Trees: Socioeconomic Trade-offs of Elected Harvest Policies," Policy Analysis, 3:341, 1977.

Gerstung, Eric, California Department of Fish and Game, Personal Communication to FRAP, September 1978.

Goudey, Charles, U.S. Forest Service, Region 5, Personal Communication to FRAP, October 1978.

Gould, Gordon, California Department of Fish and Game, Personal Communication to FRAP, September 1978.

Grew, Priscilla, Director, California Department of Conservation, Memorandum, October 1978.

Hallock, Richard T., STATUS OF THE SACRAMENTO RIVER SYSTEM SALMON RESOURCE AND ESCAPEMENT GOALS, California Department of Fish and Game, in-house document, 1978, 25 pp.

Hartman, George, Soil Conservation Service, Personal Communication to FRAP, Davis, California, November 1978.

Hauge, Carl, California Department of Forestry, Timber Harvesting and Soil Erosion - Interim Report, April 1977.

Hauge, Carl; Furniss, Michael and Euphrat; Frederick, D., "Forest Practice Rules and Soil Erosions in the Coast Forest District," California Department of Forestry, 1979 Guidebook, Geological Society of America Fieldtrip, U.S. Geological Survey, Menlo Park, 1979.

Heady, H. F., RANGE MANAGEMENT, Mcgraw-Hill Book Company, 1975.

Howard, James O., CALIFORNIA FOREST INDUSTRY, WOOD CONSUMPTION AND CHARACTERISTICS, 1972, U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Resource Bulletin PNW-52, Portland, Oregon, 1974, 91 pp.

Howard, James O. and Hiserote, Bruce A., California Forest Industry-Wood-Comsumption Characteristics, 1976, U.S. Department of Agriculture, Forest Service, Resource Bulletin, PNW-80, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, 1978, 95 pp.

Hunt, H. H., "Utility Industrial Energy Center," Eugene Water and Electric Board, Eugene, Oregon, 1977.

Hunter, Brian, California Department of Fish and Game, Personal Communication to FRAP, November 1978.

John Muir Institute, Inc., EROSION AND SEDIMENT IN CALIFORNIA WATERSHEDS: A STUDY OF INSTITUTIONAL CONTROLS, for the California Water Resources Control Board, June 1979.

Johnson, L. R., Department of Forestry, University of Idaho, "Forest Residue Recovery," paper delivered at the Pacific Northwest Bioconversion Workshop, Portland, Oregon, October 1978.

Krammes, J. S. and DeBano, L. F., "Soil Wettability: A Neglected Factor in Watershed Management," Water Resources Research, Volume 1, No. 2, Second Quarter, 1965.

Kuchler, A. W., "The Map of the Natural Vegetation of California," Department of Geography, University of Kansas, Lawrence, Kansas, 1977.

Kuchler, A. W., Vegetation Mapping, Ronald Press Company, New York, 1967, vi 472 pp.

Laacke, Robert J., Report for Contract 75-1, U.S. Forest Service and Cooperative Extension, University of California, unpublished, February 1979.

Lal, Krishan, CALIFORNIA INLAND ANGLING TRENDS FOR 1971 THROUGH 1974, California Department of Fish and Game, Sacramento, California, 1979, 65(1):4-22.

Lang, Jorden; Heald, Robert C.; Stone, Edward C.; Dahlsten, Donald L.; and Akers, Robin, "Silvicultural Treatments to Reduce Losses to Bark Beetles," California Agriculture, Volume 32, Number 7, Berkeley, California, July 1978.

Lantis, David W., California: Land of Contrast, revised 2nd edition, 1973.

Leopold, Aldo, A SAND COUNTY ALMANAC, Oxford University Press, New York, 1947.

Lockett, Chief William C., Air Resources Board, Letter to Director, California Department of Forestry, February 5, 1979.

Longhurst, William M., "California Brushlands," California Agriculture, October 1978, pp. 9-12.

Longhurst, W. M.; Garton, E. O.; Heady, H. F. and Connolly, G. E., The California Deer Decline and Possibilities for Restoration, CAL-NEVA Wildlife Transactions, 1976, pp. 74-78.

Longhurst, W. M.; Leopold, A. S.; Dasmann, R. F., SURVEY OF CALIFORNIA DEER HERDS, THEIR RANGES AND MANAGEMENT PROBLEMS, Game Bulletin No. 6, California Department of Fish and Game, 1952.

Lucarelli, B., "The Energy Potential of Wood Residue Generated by California's Wood Products Industry," unreleased draft done for California Department of Forestry, 1978.

MacLean, C. and Boisinger, Charles, ESTIMATING PRODUCTIVITY ON SITES WITH A LOW STOCKING CAPACITY, Forest Service Research Paper, PNW-152, 1973.

Malain, Robert, California Department of Forestry, Personal Communication to FRAP, 1979.

Mallette, R. D. and Schlorff, R. W., A Plan for California Raptors, California Department of Fish and Game, 1978, 42 pp.

Mallette, Robert, California Department of Fish and Game, Personal Communication to FRAP, September 1978.

McKillop, William; Stuart, Thomas W.; and Geissler, Peter J., COMPETITION BETWEEN WOOD PRODUCTS AND SUBSTITUTE STRUCTURAL PRODUCTS: AN ECONOMETRIC ANALYSIS, University of California (forthcoming), 1979.

McKillop, William, Demand for Wood Products in California, 1976-2030, A Report To The California Department Of Forestry, 1979 (see Appendix Item VII).

McKillop, William, Economic Importance on Timber in California, A Report To The California Department Of Forestry, 1979 (see Appendix Item VIII).

McKillop, William, SOCIAL ECONOMIC AND ENVIRONMENTAL EFFECT OF RISING TIMBER PRICES, Report to U.S. Department of Agriculture Forest Service (forthcoming), 1979.

McKillop, William, WILDERNESS USE IN CALIFORNIA: A QUANTITIVE ANALYSIS, 1975.

McWilliams, John R., U.S. BUREAU OF MINES, Table, January 1979.

Miller, Dr. Paul R., Written Communication to P. J. Wyckoff, January 15, 1979.

Mines and Geology, Division of, STATE POLICY FOR SURFACE MINING AND RECLAMATION PRACTICE, Special Publication 51, April 1977.

Opinion Research Corp., Caravan Survey, THE PUBLIC'S PARTICIPATION IN WILDERNESS AREAS, 1977.

Oswald, Daniel D., CALIFORNIA'S FOREST INDUSTRIES — PROSPECTS FOR THE FUTURE, U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Resource Bulletin PNW-35, Portland Oregon, 1970, 55 pp.

Parks and Recreation, California Department of, CALIFORNIA OUTDOOR RECREATION RESOURCES PLAN, Sacramento, California, 1974.

Parks and Recreation, California Department of, THE PARKS AND RECREATION INFORMATION SYSTEM (PARIS), Sacramento, California.

Pinkas, Leo, "California Marine Fish Landings for 1975," Fish Bulletin, California Department of Fish and Game, No. 168, 1977, 55 pp.

Pronos, John; Vogler, Detlev R.; Smith, Richard S., Jr., An Evaluation of Ozone Injury to Pines in the Southern Sierra Nevada, U.S. Forest Service, Region 5, Report No. 78-1, December 1978.

Rae, Steve, "The Endangered Plant Program," Outdoor California, California Department of Fish and Game, Sacramento, California, July-August 1978.

Reed, A. D., THE CONTRIBUTION OF RANGELAND TO THE ECONOMY OF CALIFORNIA, Publication MA-82, University of California Cooperative Extension, Davis, California, June 1974.

Reid, Robert, California Division of Oil and Gas, Telephone Communication, November 1978.

Resources Agency, State of California, Press Release, March 8, 1979, 10 pp. plus tables.

Resources Agency, THE STATUS OF THE CALIFORNIA WILDERNESS PRESERVATION SYSTEM AND THE SECRETARY FOR RESOURCES' RECOMMENDATIONS FOR ADDITIONS TO THE SYSTEM, A report to the Governor and Legislature, State of California, January 1978.

Rice, R. M.; Rothancher, J. S. and Megahan, W. F., "Erosional Consequences of Timber Harvesting: An Appraisal," in S. C. Csallary, T. G. McLaughlin, and W. D. Striffler, EDS., American Water Resources Association Proceedings of a Symposium on Watersheds in Transition, 1972, pp. 321-329.

Rice, Raymond; Tilley, Forest B. and Datzman, Patricia A., "A Watershed's Response to Logging and Roads-The South Fork of Caspar Creek, 1967-1976," manuscript in preparation, March 1979.

River Basin Planning Staff, U.S. Department of Agriculture, WATER, LAND AND RELATED RESOURCES - NORTH COASTAL AREA OF CALIFORNIA AND PORTIONS OF SOUTHERN OREGON. MAIN REPORT: SEDIMENT YIELD AND LAND TREATMENT, prepared by USDA River Basin Planning Staff, Economic Research Service, Forest Service, Soil Conservation Service, Berkeley, California, in cooperation with the California Department of Water Resources, September 1972.

Ruderman, Florence K., Production, Prices, Employment and Trade in Northwest Forest Industries, U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, 1976.

Salwasser, H., U.S. Forest Service, Personal Communication, 1979.

Schafer, Bill, California Department of Fish and Game, Personal Communication to FRAP, September 1978.

Senate Office of Research, "Vegetation Management: A Report to the California Legislature," May 1979, 36 pp.

Smith, Richard S. and Vogler, Detlev R., Ozone Injury to Pines in the Southern Sierra Nevada, U.S. Forest Service, San Francisco, California, 1977.

Stoddart, L. A.; Smith, A. D., RANGE MANAGEMENT, McGraw-Hill Book Co., New York, 1955.

Storie, R. Earl and Wiesiander, A. E., "Rating Soils for Timber Sites," Proceedings, Soil Science Society of America, 1948, 13:499-509.

Taylor, C. E., "Energy from Waste Wood -- An Opportunity and a Challenge," Louisiana-Pacific Corporation, Samoa, California, April 1979.

Taylor, S. N., THE STATUS OF INLAND HABITAT AND FACTORS ADVERSELY IMPACTING SALMON RESOURCES IN CALIFORNIA COASTAL RIVERS, California Department of Fish and Game, Sacramento, California, 1978, 17 pp.

Taylor, Steven N., THE STATUS OF THE SALMON POPULATION IN CALIFORNIA COASTAL RIVERS, California Department of Fish and Game, Sacramento, California, 1978, 13 pp.

Teizman, R., 1974 STATE ANGLING SURVEY, California Department of Fish and Game, Sacramento, California, 1973.

Tharratt, R. C., 1971 FISHING DEMAND STUDY, California Department of Fish and Game, Sacramento, California.

Vaux, H. and Zivnuska, J., PERSPECTIVES ON PRIME LAND, California Department of Agriculture, 1975, pp. 69-90.

Vaux, H. J., and Williams, N. A., THE COSTS OF CONGESTION AND WILDERNESS RECREATION, 1977.

Vaux, Henry J., "How Much Land Do We Need for Timber Growing?", Journal of Forestry, July 1973, 71:399-403.

Water Resources Control Board, State of California, "California Water Quality Inventory, Water Year 1976 and 1977," April 1978.

Water Resources Control Board, State of California, Water Quality Control Plan Report, North Coast Basin (1B), Part II, North Coastal Basin, April 1975.

Water Resources, California Department of, "North Coastal Area Investigation, Appendix A, Watershed Management in the Eel River Basin," Bulletin 136, June 1964.

Water Resources, California Department of, The California Water Plan - Outlook in 1974, Bulletin 160-74, November 1974.

Weaver, Richard, California Department of Fish and Game, Personal Communication to FRAP, September 1978.

Welluran, Al, North Coast Regional Water Quality Control, Personal Communication, March 1979.

Western Wood Products Association, 1977 STATISTICAL YEARBOOK, Portland, Oregon 1978, 32 pp.

Westover, Hal, Bureau of Land Management, Telephone Conversation, August 1978.

Wieslander, A. E., "First Steps of the Forest Survey in California," Journal of Forestry, 1935a, 33: 877-884.

Wieslander, A. E., "A Vegetation Type Map of California," Madrono, 1935b, 3:140-144.

Wieslander, A. E.; Jensen, H. A., "Map of Vegetation Types of California," U.S. Department of Agriculture, Forest Service, Forest and Range Experiment Station, Berkeley, California 1945.

Wilson, Dennis, California Department of Fish and Game, Region I, Correspondence to James D. Pedri, California Regional Water Quality Control Board, January 1977.

Wilson, Dennis, California Department of Fish and Game, Correspondence to Warden Darrell Yount, Region 1, Regarding Summit Creek, Sediment and Bottom Invertebrate Sampling Results, Trinity County, June 1978.

Zinke, Paul, "Ten Famous Soils and How They Got There," chapter in CALIFORNIA FOREST SOILS, Division of Agricultural Sciences #4094, University of California, 1979.

Zinke, Paul and Colwell, W. L., Jr., "Some General Relationships Among California Forest Soils", chapter in FOREST-SOIL RELATIONSHIPS IN NORTH AMERICA, edited by Cheste Youngberg, Oregon State University Press, 1965.

Zivnuska, John A.; Cox, Paul; Poli, Adon and Pesonen, David, THE COMMERICAL FOREST RESOURCES AND FOREST PRODUCTS INDUSTRIES OF CALIFORNIA, University of California, California Agricultural Experiment Station, Berkeley, California, 1965, 122 pp.

GLOSSARY

ANGLER-DAY - Participation by one person in angling activity for all or a portion of one 24-hour period.

APPROPRIATIVE FISH AND WILDLIFE USE - A use of the fish and wildlife resources which results in the user gaining personal possession of a part of the resource. Hunting, trapping, angling and commercial fishing are the primary examples of appropriative use.

AUM - Defined as the amount of forage necessary to sustain a cow with calf for one month. Normally this amounts to 1,000 pounds of forage, however, the amount can vary between different references from 800 to 1,200 pounds per month.

BLM - Bureau of Land Management, Department of Interior.

BTU - British Thermal Unit, is a standard unit of heat energy. One Btu is the heat necessary to raise the temperature of one pound of water 1°F, and is roughly equivalent to the heat produced by a kitchen match.

CALVEG - Classification and Assessment with Landsat of Visible Ecological Groupings. A Forest Service project used as a basis for developing the forest land base map.

CDF - California Department of Forestry.

CHAPARRAL - A dense shrub community, normally a permanent type, dominated by evergreen shrubs or dwarf trees; areas covered with heavily branched dwarfed trees or shrubs, usually evergreen, the crown canopy of which at maturity covers more than 50 percent of the ground, and whose primary value is watershed protection.

CLIMAX FOREST - A forest that has reached its final stage of biological succession. Beyond this "climax" point the same plant ecosystem will continue to occupy an area as long as there is no disturbance and climate or soil conditions remain unchanged.

COGENERATION - The generation of process steam, process heat or space conditioning combined with the generation of electrical power which leads to an efficiency of fuel utilization greater than that resulting from the independent generation of equivalent units of process steam, process heat, space conditioning, and electrical power.

COMMERCIAL FOREST LAND (commercial timberland) - Land that is capable of producing in excess of 20 cubic feet per acre per year of industrial wood in fully stocked even-aged stands at culmination of mean annual increment and is not developed for other uses or withdrawn from timber use by statute or administrative regulation. Includes both accessible and prospectively accessible areas and both operable and prospectively operable areas.

CONSUMPTION - see Demand and Supply

CONTROLLED BURNS - see Prescribed Burns

DEMAND AND SUPPLY - Unfortunately, these terms have been widely used in resources fields to imply conditions related to, but very different from, their accepted economic meanings. The origin of this situation is easy to understand because the difficulties associated with developing supply and demand curves are considerable. Nevertheless, the result certainly fails to enhance understanding and leads many to make statements which are economic nonsense. To avoid these pitfalls, these terms have been used throughout this report in their economic senses.

Demand is a schedule of quantities of a given good and the corresponding prices at which buyers would purchase the particular quantity. Demand curves (Figure G-1) are ordinarily viewed as sloping downward and to the right because as the price falls, the amount people wish to have increases. As the prices rise, they desire fewer units. We assume there are many buyers of the good and that they understand both the market and the good's attributes. An increased demand is represented by a new curve above and to the right of that initially present; i.e., more of the good would be desired at any given price or alternatively a higher price would be commanded by the same quality. A shift of output and price along the curve does not represent a change in demand. Demand is said to be inelastic if the quantity is unresponsive to changes in price; i.e., if the curve becomes relatively vertical. The curve may be elastic in some region and inelastic in another.

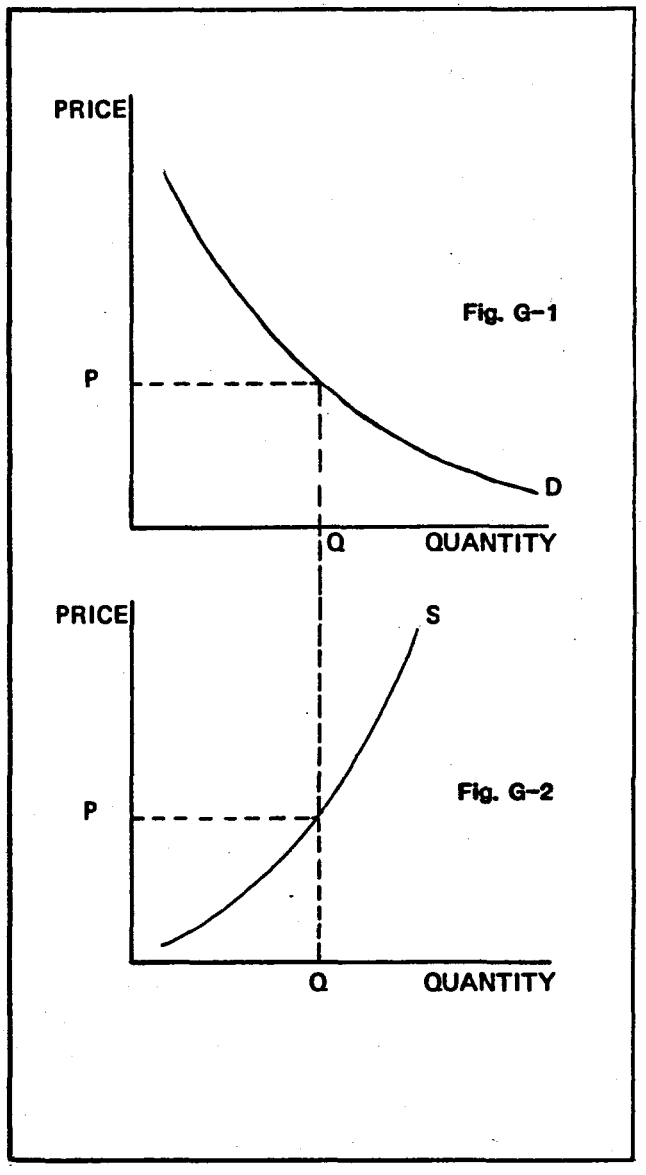


Fig. G-1

Fig. G-2

Supply is similarly a schedule of the amounts producers are willing to offer at various prices. Supply curves (Figure G-2) are generally conceived as sloping upward and to the right because the "law of diminishing returns" reduces the additional amount of a good that can be produced for each added unit of some imput. Therefore, as one attempts to produce more, his unit costs rise and he must be compensated by a higher selling price. An increase in suply is represented by a shift of the curve to the right. Supply also is said to be inelastic if the curve becomes vertical.

The intersection of the supply and demand curves for any good yields a quan-

tity, q, and price, p, (in Figures G-1 and G-2) which is said to be in equilibrium in the sense that suppliers are willing to produce as much as buyers will consume at the same price. This quantity is termed consumption and is the amount traded in the "market." Determining consumption may be difficult but its level and price is the most readily identified point of either the supply or demand schedules. Determining what could have been produced or purchased at other prices is much more difficult. Since the consumption point is perhaps the most interesting one and the individual schedules are difficult to project, attempts are often made to estimate future consumption directly from correlations with such variables as population, GNP, etc. The principal difficulty with the approach is that price tends to be divorced from the analysis. Whether a given level of a good will be consumed depends on its price relative to substitutes. As substitutes are developed - often because of rising prices - demand may shift in ways not included in a consumption projection model. By attempting to develop both supply and demand schedules, price effects will tend to be prominently displayed.

DEVELOPED RECREATION - Outdoor recreation requiring significant capital investment in facilities to handle a concentration of visitors on a relatively small area.

DISPERSED RECREATION - Outdoor recreation in which visitors are diffused over relatively large areas. Where facilities or developments are provided, they are more for access and protection of the environment than for the comfort or convenience of the people.

ELASTIC - (see Demand and Supply)

ENDANGERED SPECIES - Any species which is legally classed as in danger of extinction throughout all or a significant portion of its range.

FOREST INDUSTRY - Lands managed for timber production. The Forest Survey attempts to differentiate lands owned by firms which own wood processing facilities from those which do not. FRAP combines these categories. In earlier reports company ownerships, without wood processing facilities but which were managed for timber production, were included in the "other private" category by the Forest Survey. Where older data have been used by FRAP, adjustments have been made to shift lands from the "other private" to the "industry" category.

FOREST LAND - Land with at least a 10 percent tree canopy cover at maturity, including land formerly having such tree cover, that could be naturally or artificially reforested, includes land withdrawn from harvest of timber or other wood products. Minimum area of land recognized as forest is one (1) acre and at least 100 feet wide. This acreage must lie within or immediately adjacent to a recognized forest vegetation type map boundary and outside lands primarily devoted to food agriculture. (This definition is pointed toward aerial photo forest land delineation rather than a stocking percentage definition, and it eliminates potential forest land within the recognized productive agriculture regions of California.)

FORESTED RANGELANDS - Forested rangelands of California are defined, for the purosoe of this report, as areas which contain at least a 10 percent tree canopy and has grass, forbs and shrubs suitable for livestock and wildlife grazing.

FOREST RESIDUE - Material not harvested or removed from logging sites in commercial hardwood and softwood stands. This category also includes material resulting from forest management operations such as precommercial thinning and removal of dead and/or dying trees.

FOREST SURVEY - Renewable Resources Evaluation Research Unit, Forest Service, Pacific Northwest Forest and Range Experiment Station.

FOREST TYPES - are determined on the basis of species plurality of all live trees that contribute to stocking, considering both size and spacing. For example, a mixed conifer stand that contains 40 percent Douglas-fir, 35 percent ponderosa pine, and 25 percent white fir would be classified as Douglas-fir type because this species has the plurality of stocking.

FRAP - Forest Resources Assessment Program.

FRAPA - Forest Resources Assessment Program and Policy Act.

FS - U.S. Forest Service, Department of Agriculture.

GRID - A utility's power generation, transmission and distribution system, including transmission lines, transformer stations, etc.

HEAT RATE - A measure of generating station thermal efficiency, generally expressed in BTU's per net kilowatt-hour. It is computed by dividing the total BTU content of fuel burned for electric generation by the resulting net kilowatt-hour generation.

HOGGED FUEL - Wood residues processed through a chipper or hammermill to produce coarse chips for fuel.

HUNTER-DAY - Participation by one person in hunting activity for all or a portion of one 24 hour period.

INELASTIC - (see Demand and Supply)

LOAD FACTOR - The ratio of the average load of kilowatts supplied during a designated period to the peak or maximum load occurring in that period.

MEGAWATT - An electrical generation unit of one million watts (1×10^6 watts) or 1000 kilowats.

MULTIPLE-USE OBJECTIVES - Three somewhat different ideas are involved: (1) different uses of adjacent subareas which together form a composite multiple-use area, (2) the alternation in time of different uses on the same area, and (3) more than one use of an area at one time.

In the first two ideas it is implicit that direct competition between uses is avoided by alternating them in space or in time. The third idea involves multiple use in the sense of simultaneous use of one space and must concern itself with complementary versus conflicting activities, compatible and incompatible uses.

Where spatially coincident uses are involved at a given time, conflicts between resource users will almost always occur and the concept of such forms of multiple use should be realistically interpreted as a dominant use with secondary uses integrated only insofar as they are compatible with the first. However where the idea of incompatibility relates to the economics of productivity maximization of single resource yields, management and multiple use can perhaps be validated in terms other than single-resource production efficiency. (After Rowe and McCormack 1968)

MULTIPLIERS - In economic theory, these are functions relating a change in some total measure to a change in some component of the total (the derivative of the total with respect to the component). Knowing the "multiplier" and the amount of a small change in the component, a simple multiplication gives a prediction of the change in the total. This prediction will be accurate if the basic equilibrium equations used to derive the multiplier accurately describe the economic processes involved. (After Samuelson 1948)

MW - (see Megawatt)

NON-APPROPRIATIVE FISH AND WILDLIFE USE - A use of the fish and wildlife resources which does not reduce any part of it to personal possession -- looking at deer or listening to birds, etc.

NONCOMMERCIAL FOREST LAND - Forest land incapable of yielding crops of industrial wood because of adverse site conditions and commercial forest land withdrawn from commercial timber production through statute or administrative regulation.

OTHER PRIVATE - land are owned by operators of farms and ranches, miscellaneous noncorporate entities and companies that do not manage forest for timber production.

OXIDANT - A major group of secondary pollutants principally consisting of ozone (O_3), peroxyacyl nitrates (PAN), and other organic nitrogen compounds having oxidizing reaction formed from a photochemical process in the atmosphere. Sometimes ozone and oxidant are used interchangeably.

PACIFIC SOUTHWEST REGION - Formerly the California Region of the Forest Service, U.S. Department of Agriculture. It includes cooperative relationships in Hawaii, Guam, Northern Mariana Islands, American Samoa, and the Trust Territories as well as California, in all phases of state and private forestry and human resource programs.

PAN - Peroxyacetyl nitrate; an air contaminant.

PARIS - The Park and Recreaton Information System - computer facilitated data base used by Department of Parks and Recreation for planning purposes.

POLETIMBER TREES - Trees from 5 inches in diameter at breast height to sawtimber size, and now, or prospectively, suitable for industrial roundwood.

pphm - Parts per hundred million

PRESCRIBED BURN - 1) The planned application of fire to natural fuels, residue left on a site after a logging operation and other slash, with the intent to confine it to a predetermined area, 2) Any deliberate application of fire to an area where control is exercised in some particular respect, also see prescribed burn.

PROCESS HEAT - Heat used for the industrial process of a plant and not the housekeeping chores such as space heat.

PROCESS STEAM - Steam generated in a boiler for use in dry kilns and other manufacturing activities.

PRODUCTIVE FOREST LAND - is capable of producing 20 cubic feet per acre per year of industrial wood and is manageable for continuous timber crops.

PRODUCTIVE-RESERVED FOREST LAND - is withdrawn from timber utilization through statute, ordinance, or administrative order but otherwise qualifies as commercial forest land.

PUBLIC RESERVED - lands are federal, State, and local lands withdrawn from timber production such as parks, wilderness and other reservations. These include lands administered by almost all public agencies.

PUBLIC UNRESERVED - lands are federal, State and local areas available from timber production. Most of these lands are administered by the Forest Service.

QUAD - 1,000,000,000,000,000 Btu's or 1×10^{15} Btu's.

RANGE - Forage for grazing or browsing animals is produced by native plants and if the forage is produced by introduced species, the plants are managed as if they were native species.

RANGELAND - Land on which the potential natural vegetation (climax) is predominately grasses, grass-like plants, forbs or shrubs. It includes land revegetated naturally or artificially that is managed like native vegetation. Rangelands include natural grass-lands, savannas, shrublands, most deserts, tundra, alpine communities, coastal marshes and wet meadows. It includes land with less than 25 percent tree canopy or less than 10 percent stocking with forest trees of any size.

RARE II - Roadless Area Review and Evaluation.

RARE SPECIES - Any species which has legally been classed by the State as likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

RECREATION VISITOR DAY - Twelve visitor hours, which may be aggregated continuously, intermittently, or simultaneously by one or more persons.

REMOTE SENSING - Observing, photographing, or recording information about an object from a distance. Especially used in reference to aerial photography, satellite imagery, radar imagery, etc.

RESOURCE AREAS - Aggregates of counties for which data are compiled by FRAP and the Forest Survey. See Figure 1-3.

RIM - The Recreation and Information Management system. Provides current recreation information for National forest lands; a Forest Service System.

RPA - Resources Planning Act or Forest and Rangeland Renewable Resources Planning Act of 1974.

SAW KERF - Narrow slot cut by a saw in advancing through wood; the width of a saw cut.

SAWTIMBER - A live tree of commercial species that contains at least one merchantable log as defined by regional practices and specifications.

SCS - Soil Conservation Service, Department of Agriculture.

SILVICULTURE - The theory and practice of controlling the establishment, composition, constitution and growth of forests.

SITE - Capability of land to produce forest resource outputs. See Figure 3-1. A location, e.g. a campsite.

SOIL ASSOCIATIONS - 153 soil associations Statewide of which 26 are recognized on the forested lands of California. Each association contains two or more soil series that normally occur together.

SSA - Smoke Sensitive Areas.

STOCKER CATTLE - Those animals that have been weaned but are placed on rangeland to gain weight prior to going to a feed lot.

STOCKING - The degree of occupancy of land by trees, measured by basal area and/or number of trees by size or age and spacing compared to a stocking standard, i.e., the basal areas and/or number of trees required to fully utilize the growth potential of the land.

SUPPLY - (see Demand and Supply)

THREATENED SPECIES - Any species which has been legally classified by the federal government as likely to become an endangered species within the foreseeable future throughout all of a significant portion of its range.

TIMBER SITE CLASS - The amount of wood measured in cubic feet that forest land is capable of producing if fully stocked with suitable trees and grown to the age of mean annual culmination (70 to 80 years for most species on most sites). For all ownerships, estimated biological potential was based on tree height and age relationships and normal yield tables for natural even-aged stands of single species. For lands outside National Forests, yield table values were further discounted for shallow and/or rocky soils. Intensive forest managment activities such as fertilization, genetic tree improvement, and stocking control may result in yields that exceed the biological potential of natural stands.

TIMBERLAND - (see Forest Resources Assessment and Policy Act 1977 in the Appendix)

TREE - Woody plants having a well-developed stem and usually more than 12 feet in height at maturity, including both growing stock and cull trees.

TPZ - Timber Land Preserve Zone. A state zoning classification (see the Timber Resources Chapter).

UNPRODUCTIVE FOREST LAND - Forest land incapable of yielding crops of industrial wood because of adverse site conditions, includes sterile or poorly drained forest land, subalpine forests, and steep, rocky areas where topographic conditions are likely to prevent management for timber production. Is incapable of yielding at least 20 cubic feet per year.

VISITOR-DAY - 12 hour period of a given recreational activity.

WHEELING - The use of the transmission facilities of one system to transmit power of and for another system.

YUM-YARDED UNMERCHANTIBLE MATERIAL - A feature of some U.S. Forest Service timber sale contracts, requiring the purchaser to yard logging residues, greater than ten inches in diameter and ten feet in length, to the landing or other specified location.