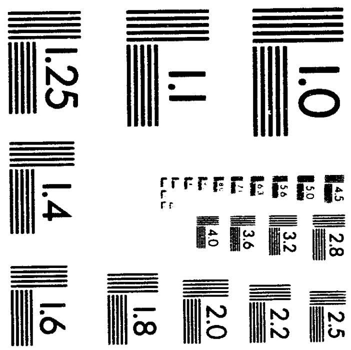
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I THINK THAT I SHALL NEVER SEE...A LOVELY FORESTRY POLICY: LAND USE PROGRAMS FOR CONSERVATION OF FORESTS

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Forestry programs are frequently invoked as having potential for mitigation of greenhouse gas emissions (National Academy of Sciences 1991). Most studies have attempted to quantify the potential impact of forest programs on carbon uptake and the potential costs of such programs. In this paper, we will attempt instead to focus on the institutional issues of the implementation of forestry programs for carbon sequestration. In particular, we explore the challenges for implementing forest programs that are:

- of increasing technological complexity; and
- in settings that depart significantly from the idealized conditions of economic models.

We start in Section 1 by examining a suite of instruments that are commonly employed to implement a given policy. Section 2 examines a relatively simple case - a tree-planting program in the U.S. - and demonstrates that there are significant difficulties involved in implementing a carbon sequestration program, even in a well-developed market economy. Section 3 focuses on other technologies in the U.S. and why the choice of policy instruments and program design is more difficult than for the simple tree-planting case. Section 4 considers implementation of forestry policies in other countries where the economies may bear less resemblance to the ideal market economy than the U.S. In those settings, the choice of policy instruments may be very sensitive to non-market considerations that are often missed in conventional policy and cost analysis.

1. Policy Instruments

A wide array of instruments exists for translation of climate policy goals into action at the national and local levels. Various combinations of these would be available for any government seeking to implement forestry programs. Such instruments may be grouped broadly under five headings: economic incentives; regulation; information; research, development, and demonstration (RD&D) programs; and direct government provisions of goods and services (DOE 1989).

Regulation is defined as legislation or rules, supported by sanctions, that are designed to limit the discretion that may be exercised by public and private decision makers. Such legal and administrative means are exemplified by rigorous effluent emission standards with large effective penalties. Efficient regulation depends on good data according to which performance standards or emissions limits can be fixed for a technology or environmental discharge. The major benefits of regulatory programs arise when the costs of obtaining the appropriate level of information are very high for a large number of dispersed decision makers. Under these circumstances the regulator is able to reduce information costs to decision makers in the form of standards. However, regulations may be administratively quite costly and inflexible. For example, certain restrictive standards, particularly those that specify the technological means to achieve environmental ends, may hinder the progress of new technologies. Rules restricting clear-cutting activities and requiring replanting following timber harvest are examples of direct regulation of forestry activity.

Economic incentives can be used to correct the undesired side effects that may arise from the behavior of private agents in pursuit of private objectives. These kinds of policy generally are designed to ensure that consumers and producers face the true costs of their decisions, but allow them a high level of discretion about how to deal with those costs. Economic incentives include any tax, fee, loan, subsidy (including directed government purchases), or rule change (such as creating a property right in marketable emissions allowances) that is designed to alter the consumption of a good or activity by changing its price relative to the prices of other items that consumers might choose freely.

The major instruments affecting prices are emission fees and subsidies, tradeable emission rights, and deposit-refund systems. Emission fees put a price on pollution and confront the emitter with the full cost of his or her actions. This has considerable political appeal as well as widely recognized properties of economic efficiency. However, uncertainty about costs of damages, emission control costs, and the effectiveness of such a system in influencing decisions reduces the attractiveness of emission fees. Additionally, the concept of paying to pollute may be unacceptable to an array of environmental advocates, while the sudden rearrangement of property rights may be highly objectionable to manufacturing interests.

The U.S. commonly employs subsidies and cost-sharing mechanisms to encourage landowners to establish or replant forest stands. Carbon offset arrangements, by which a landowner would be awarded marketable CO_2 emissions allowances in return for carbon sequestration activities, are often discussed in the context of the greenhouse effect.

Information is a commodity that is especially subject to problems of market failure. With much information, once it is produced, it is very difficult for the producer to capture its full value. Consequently, the markets for some types of information can fail to exist, or can function poorly. As a result, economic agents often are forced to make decisions with far less information than could be available to them if information markets worked better. Government can influence private sector actors to alter their behavior by improving the information available to them. Four major types of informational programs are advertising, education, moral suasion (jawboning), and signalling. These programs are more effective when combined with other types of incentives, for example, with economic incentive, regulatory, or RD&D programs. They can improve the effectiveness of those other programs by strengthening or creating informational markets that are weak or nonexistent.

Information programs can intervene at a number of points to various ends. Government may wish to increase the volume of information available or the rate at which it moves from producers to final users; it may wish to bolster memory capacity or facilitate learning, both altering the effective stock of knowledge; and it also may want to influence evaluative activities by improving information feedback loops. The U.S. Forest Service commonly uses education and advertising mechanisms to encourage owners of underproductive forest land to modify their practices to improve timber yields.

Research, development and demonstration (RD&D) programs offer another set of instruments for policy implementation. It is difficult, if not impossible, for an individual or firm undertaking basic research to appropriate the full benefits derived from it. Consequently, private agents will tend to undertake less basic research than is desirable from a society-wide perspective. Applied research, on the other hand, sometimes suffers from a common-property problem associated with the possible capture of a valuable patent by the first party to develop an invention or innovation. In these common-property situations, there is a tendency for too much research to be undertaken by multiple private parties, with the society-wide benefits from the eventual discovery being dissipated in competitive research to get the patent rights.

Demonstrations can suffer from high risks associated with expensive projects that may or may not be capable of commercialization, and from attendant free-rider problems. Once the technology is demonstrated successfully, agents who did not share in the costs and risks of the demonstration usually can use it, at least for a license fee which may fail to capture the full social value of the new technology. A major goal of RD&D strategies is to reduce risk and uncertainty, including: technological uncertainty, cost uncertainty, demand uncertainty, institutional uncertainty, and uncertainty about external and indirect effects of the technology on, for example, health, safety, and the environment. In the forestry context, RD&D activities include yield studies, developing fast-growing hybrid species, field tests of alternative management methods, and development of biomass fuel systems.

Direct government provision of goods and services may be appropriate in the case of public goods, such as air quality, that cannot be provided by the private sector. Generally, when uncertainties regarding the character and level of goods and services needed make it impossible to develop full contracts between the government and private sectors, government production may be the only viable alternative. Examples of government production of forestry services are the National Park System and the U.S. National Forest lands.

These very brief summaries and examples of implementation instruments indicate that each has characteristics that might be more or less attractive to important constituencies in U.S. society. Private sector institutions seem to favor implementation policies that maximize the discretion of individual decision makers and firms. We may therefore suppose that they will favor carrots rather than sticks. Positive economic incentives, such as subsidies and tax breaks are likely to be favorably received. Government support for RD&D, for example into biomass energy, also could be popular with this constituency, especially if private firms can enjoy proprietary control over innovations. On the other hand, the private sector may be suspicious of informational programs that hint at moral suasion, or jawboning.

At the other extreme, environmentalists, especially deep ecologists, may emphasize sticks rather than carrots. Because of concern about *regulatory capture*, environmental groups are likely to favor command-and-control regulation, uniformly applied without the exercise of discretion by regulators or regulated firms and individuals. Economic incentives may be acceptable, especially if linked to regulation. However, systems such as emissions permits are likely to be frowned upon as licenses to pollute. Information programs, particularly those designed to expose weaknesses in the compliance records of firms, also may be well received by environmentalists if information can be used as a stick to beat slow bureaucracies or sly entrepreneurs.

Regulatory agencies, on the other hand, are likely to see themselves caught between a rock and a hard place. Their orderly instincts may incline them towards the predictability and ease of monitoring associated with command-and-control regulation. However, their need to reconcile their own agendas with those of the firms and individuals they must regulate may lead them to favor a combination of economic incentives backed up by regulation. In any case, regulators are often sympathetic to demands from market constituencies for the exercise of discretion in the application of regulatory rules. Regulators' ability to exercise such discretion (for example grandfathering activities that were practiced by firms prior to regulatory rule making) is likely to be restrained in proportion to the strength of environmentalist objectors. Information is likely to be favored by regulators to the extent that it facilitates their own regulatory tasks. However, they may tend towards skepticism as to the usefulness of public information programs. In summary, we may expect regulators to favor policy instruments that combine carrots and sticks according to pressures from the other two constituencies.

These observations about institutional preferences for implementation measures are summarized in Figure 1, which defines a triangular policy space within which any mix of instruments can be located. Of course, institutional preference alone will not determine which implementation instrument will be selected. However, these disaggregated preferences are entirely ignored by the homogenizing individual self-interest assumptions of neo-classical economics.

The Reagan-Bush decade has signalled a preference for economic instruments for a wide variety of environmental policies, in contrast to the regulatory approach of the Carter years. It has been predicted that the Clinton-Gore era will see an increasing emphasis on information and RD&D as environmental policy instruments, especially in collaboration with the private sector (Rayner 1993). If the provisions of the President's Climate Change Action Plan (Clinton and Gore 1993) are any guide to the future of U.S. environmental policy implementation. this prediction is well on the way to fulfillment.

2. The Simple Case: Tree Planting in the United States

Most economic models employed to examine the effects of greenhouse gas policies concentrate on the energy sector. In these models, fossil energy fuels are treated as commodities that are traded and consumed in reliable and predictable ways. Each of these commodities is fungible and, especially for stationary energy uses, is highly substitutable for one another. They are widely traded in well-established markets where information is plentiful and prices are responsive to fairly uniform trading opportunities.

In contrast, modeling the effects of forestry policy on carbon dioxide emissions and carbon sequestration is a more difficult task. Three considerations - scientific, behavioral and programmatic uncertainty - create a very complex modeling problem. In some cases, the uncertainty applies even to the direction of expected change in both the costs of carbon sequestration and the potential accomplishments. These conditions are more properly characterized as *indeterminacy*, which exacerbates the challenges of designing and implementing appropriate policy options.

Scientific uncertainty

Several factors combine to determine the ultimate carbon yield of a given tree planting project in the U.S. These factors include the species planted, previous uses of the land, region of the country, soil type, planting practices, density of planting, management regime, and ultimate use (if any) of the timber. Although the U.S. has one of the most comprehensive databases on forestry planting, management, and yield figures, there is still little agreement regarding the appropriate yield figures to use in either analysis or regulation of carbon sequestration programs. The figures cited most often are those provided by Birdsey. These have been modified and updated over the past four years to reflect additional research (Birdsey 1990, 1992). However, in policy analysis work, many estimates of expected carbon yield vary significantly from the Birdsey figures. In his highly cited work, Nordhaus (1990) uses figures that are much lower than those of Birdsey. Others have suggested that the appropriate yield figures may be higher than Birdsey's by a factor of four.

Behavioral uncertainty

The land and timber markets in the U.S. are perhaps closer to the economists' ideal market than elsewhere in the world, yet even here it is difficult to predict how landowners will respond to various carbon sequestration programs. First, the rental rate (or purchase price - depending upon the nature of the program) is difficult to predict in a program that involves removing large quantities of land from agricultural production and planting then with a crop that has a rotation length of 25 to 70 years. For example, the rental rates under USDA's Conservation Reserve Program (CRP) are considerably higher than those observed in private market transactions (Moulton and Richards 1990). This may be due to the long-term nature of the commitment (10 to 15 years) or to the fact that contracting with the Federal Government is an inherently risky transaction.

Second, if land rental rates for relatively small quantities of land (less than 17 million hectares in the case of the CRP) are difficult to predict, the rental rates for large quantities of land (70 million hectares or more for a large-scale carbon sequestration program in the U.S.) are even more difficult to estimate. The marginal cost of agricultural land is expected to go up as more land is removed from production. Richards, Moulton, and Birdsey (1993) have tried to capture this effect by employing a factor for the price elasticity of demand for agricultural land. However, there are no reliable estimates of this factor. Adams et al. (1991) have attempted to capture these non-marginal effects through use of an agricultural sector optimization model that measures land costs in terms of losses in producer and consumer surplus. Both studies indicate that the costs of carbon capture rise steeply as large quantities of land are removed from agricultural production. However, neither provides estimates upon which a cautious decision maker would rely.

Third, little is understood about the rates at which farm land could be converted to forest land. This is similar to the technology dissemination and market diffusion problem that faces advocates of new technologies. Even if we could accurately predict the costs and prices of converting agricultural land to forest lands, we would be ill-advised to rely upon such a strategy if the program could not be implemented at a reasonable pace.

Fourth, once land is in production, there may be significant moral hazard problems associated with keeping it in production. The government has a choice of how to design its reward structure. At one extreme, it could make all of its payments to land owners at the commencement of the landowner's sequestration project. At the other extreme, it could make payments only for the amount of carbon stored greatly, delaying the flow of payments. The government may be inclined to follow the first approach because the latter approach - delaying the payments - may prove to be a significant disincentive to landowners. However, paying for the carbon sequestration in advance may lead landowners to reduce their management efforts, thereby reducing yields.

Finally, implementation of a large-scale carbon sequestration program may lead owners of existing timberland to change their management behavior. If they see the subsidized planting of new forest land as a potential source of competition for the eventual supply of raw timber, they may be induced to change plans to increase their holdings of forest acreage, to harvest earlier than they otherwise would have, and to avoid replanting recently harvested areas.

Programmatic uncertainty

Behavioral uncertainty is compounded by programmatic uncertainty, which may involve either the carbon sequestration program itself or other land-use programs. While it is common to cast economic policy instruments in general categories such as taxes and subsidies or marketable permits and offsets, there are some significant constraints facing the government's use of these tools. The Congress has a difficult time committing to any long-term tax or subsidy program (Doernberg and McChesney 1982). Similarly, the government's ability to establish long-term contracts may be hampered by its general immunity, under the doctrine of sovereign immunity, to certain types of contractual damages (Krent 1992). These observations are important in light of the role that risk plays in the landowners' decision to establish carbon sequestration activities. Richards et al.(1993) have shown that as much as 80% of the cost savings associated with inclusion of carbon sink options in a program to stabilize U.S. carbon dioxide is lost if the landowners' required rate of return on investments rises from 5% to 20%. The higher rate of return might be required, for example, if landowners viewed participation in the program as highly risky due to the Congress' inability to make a credible commitment to a series of subsidies or contractual payments.

Estimation of accomplishments of a large-scale carbon sequestration program may also be complicated by other land-use regulations and programs. For example, the agricultural subsidy programs in the U.S. may, in fact, be a competitor with a program to convert agricultural land to forest land, providing an alternative form of income for less productive land. This need not be the case, however. Restructuring the agricultural programs, such as an expanded CRP program, could provide positive incentives for establishment of tree plantations, even in the absence of an explicit carbon sequestration program.

Effect on choice of policy instrument

Simple cost analysis indicates that conversion of economically marginal and environmentally sensitive agricultural land may be one of the least expensive ways to significantly reduce net greenhouse gas emissions in the U.S. (Moulton and Richards 1990, Richards Moulton, and Birdsey 1993). However, these analyses are based upon sets of assumptions regarding the implementation mechanisms (generally government subsidies), landowner expectations, and reliability of the scientific data. In fact, the important policy implementation decisions are less apt to relate to the choice among economic incentives - taxes and subsidies versus tradeable allowances and offsets - than to some very specific design choices. For example, major restrictions on the harvest of timber from subsidized plantations will raise the level of subsidy required to induce landowners to enroll. On the other hand, lack of restrictions may cause counter-productive activities by owners of existing timberland. This, in turn, invites additional forestry regulation to prevent the counter-productive activity.

If the government faces significant legal constraints and information hurdles (scientific uncertainty and monitoring), it may seek to provide the carbon sequestration services directly by buying the inputs to production - land, labor, seedlings, and providng the management. However, this approach still faces several difficulties. First, the uncertainty regarding accomplishments remains. Second, while the transaction between the government and the private sector, along with some of the need for monitoring have been eliminated, these have simply been replaced by an internal agency monitoring problem. Third, the current political climate in the U.S. is inimical to direct government action of this sort.

Thus, implementation of a large-scale carbon sequestration tree-planting program faces significant uncertainties - scientific, behavioral, and programmatic. The government can address these through research, contractual restrictions, monitoring, and development of mechanisms for committing to long-term programs. However, reducing any of these uncertainties is costly and will reduce the cost effectiveness of carbon sequestration policies. The nature of the programmatic and political uncertainty inherent in development of a carbon sequestration program suggests that models that examine only general policy instruments - taxes and subsidies, allowances and offsets - may not capture some important factors that will determine the effects of the program.

3. Implementation challenges from technological complexity

Section 2 focused on the simplest forest technology - planting trees on marginal land. Implementation challenges increase as the desired forest technology increases in complexity. In this section, we examine four additional approaches to capturing carbon and reducing emissions that illustrate significantly greater complexity and concomitant challenges for implementation. These are:

- agroforestry
- urban trees
- forest management
- biomass for energy.

Agroforestry

Agroforestry represents a synthesis of silvicultural and agricultural practices. Generally, agroforestry practices require less energy and chemical input per unit output than annual monoculture crop approaches, but may require more land and labor. The advantage from a greenhouse gas emissions standpoint is that agroforestry systems store more carbon in the soil and biomass than annually tilled crops and may reduce CO_2 emissions from fossil fuel use.

From a policy instrument perspective, agroforestry presents all of the difficulties of conversion of agricultural land, and then some. Not only are the scientific uncertainties every bit as great, the activity itself is less well defined. There are as many agroforestry methods as there are sites on which crops can be grown. There is no standard agroforestry practice. This suggests that measurement of carbon sequestration accomplishments - a necessary prerequisite to either a carbon subsidy or emissions offset approach - is at least very costly. It may be possible to subsidize activities that are likely to lead to carbon sequestration and emissions reductions, but assessing the cost effectiveness of such programs would be difficult.

For two decades, the U.S. Department of Agriculture's Soil Conservation Service (SCS) has encouraged American farmers to modify their annual tillage practices, and move toward low-till and no-till approaches. Through their local representatives and extension agents, the SCS has also encouraged reductions in chemical and energy use, with substantial success. This approach, which involves a combination of demonstration projects, education, and moral suasion, may be adopted to encourage agroforestry and additional alternative agricultural practices that have beneficial effects on carbon sequestration and greenhouse gas emissions.

Urban trees

Planting trees in an urban environment may have a much larger impact on greenhouse gas emissions than just sequestration of carbon through photosynthesis. This is due to the modifying effect that they can have on the *urban heat island* effect, especially in warm mid- and low-latitude cities (Taha et al.1988). Dramatic differences have been documented in the cooling-energy use of homes on landscaped and unlandscaped sites, indicating, that properly placed trees, and shrubs can reduce daily air conditioning electricity use by as much as 50% (Parker 1981). The precise time frame within which such an option will reach its full potential will depend on the species planted and its growth patterns, but it is inevitably a medium- to long-term strategy.

Advocates consider planting trees in urban areas to be an inexpensive means of conserving energy, perhaps as low as 0.3-1.3 cents per pound of carbon, compared with 2.5 cents per pound for efficient appliances and 10 cents per pound for efficient cars (Akbari et al.1988). However, there is really very little experience with urban tree-planting programs of this sort. and the scientific, behavioral, and programmatic uncertainties associated with planting trees on marginal land apply. In addition, there are problems with planting large numbers of urban trees, including conflicts with infrastructure above and below ground (electric powerlines and water, gas, and sewage pipes) for which damage estimates are not included in planting costs. Monitoring the effectiveness of urban tree-planting programs presents further obstacles to any economic instrument. Modifications to local zoning ordinances to take advantage of urban trees in new development may be a plausible instrument, although regional variations in climate, geography, and demography would seem to preclude the development of efficient Federal standards. The best the Federal Government is likely to be able to do is to require that states account for urban forestry effects on energy demand in formulating zoning laws as a condition of receiving Federal funds.

Forest Management

Forests, whether newly created or existing, are managed resources. It is questionable whether any terrestrial ecosystem is truly unmanaged, although there is a huge variation in the intensity of management. Even the Amazonian rain forest is lightly managed by indigenous peoples at very low densities. Patterns of harvesting game and uncultivated forest products are forms of resource management that have all but disappeared in the U.S., although they remain important in other parts of the world. We distinguish three management strategies:

- mining the forest
- conserving the forest
- preserving the forest.

Mining the forest is the opposite of the simple case of tree planting discussed above. It is the removal of forest and conversion of forest lands to other uses such as agriculture, industry, human settlement, or degraded wasteland. Mining the forest was probably the dominant mode of forest management in the U.S. two centuries ago. Over the past two hundred years, forest management has shifted to the resource conservation mode and even to forest preservation. The overall stocks of U.S. forest land have shown a net increase throughout the 20th century. However, wide uncertainty remains about the carbon intensity of those forest stocks.

Conserving the forest is essentially rational management to ensure continued supplies of forest resources for human use. Such uses may include recreation as well as extraction of timber. Depending on a variety of factors, the instruments of conservation include various combinations of regulatory and economic instruments. However, these instruments may prove to be highly controversial. The U.S. has recently experienced increasing scrutiny of the use of public lands for timber production, and not only in old growth forests. Furthermore, from a carbon sequestration perspective, the effects of forest conservation programs are quite uncertain. Better management of forests to increase return on investment does not necessarily lead to net increases in carbon sequestration. This is because maximizing economic yields of usable timber products does not maximize the storage of carbon that may occur in low-value species of trees, in understory, and in litter. Selectively managing for high-value species may, in fact, decrease the overall carbon storage of a forest stand. Under these conditions of uncertainty, developing widespread acceptance of the policy goal may be far more critical than the selection of policy instruments that directly affect policy management practices.

Preserving the forest differs from conservation in that the goal is to ensure that the forest is never harvested and that the natural cycles of death and regeneration are permitted to proceed without human intervention. In the U.S., preservation of individual forests has been an important consequence of the Wilderness Act and has resulted in the preservation of significant tracts of first-growth forest. This program has brought important scientific, recreational, and spiritual benefits. However, we cannot say that it has resulted in increased carbon sequestration. Preserving individual plots while the demand for timber remains constant or increases merely transfers harvesting activity to other locations. For this strategy to be of interest as a carbon sequestration strategy, we would also have to look at policy instruments that influenced demand for timber. The resulting substitutes (e.g. concrete for timber in building) may actually exacerbate rather than improve net emissions. Preservation also presents another potential problem. We would guess that when most laypeople hear about reducing the greenhouse effect through forestry, they are thinking about forest preservation rather than conservation strategies. The current controversies over subsidies to timber companies through use of public lands indicate that public support for forestry programs may wane as it is increasingly understood that this is not the case.

Biomass for Energy

Biomass energy programs have the potential to recycle atmospheric carbon through the terrestrial ecosystem with little or no net emissions. To the extent that such technologies can displace fossil fuels, they have the potential to reduce emissions. However, several significant policy design problems exist.

First, biomass energy technology may be a public good that will not attract sufficient investment to be developed and produced by the private sector. A carbon tax may not be sufficient to generate the requisite level of private investment because of the existence of a whole suite (Table 1) of significant risk factors to be overcome in the commercialization of biomass energy (Cantor and Rizy 1991). Furthermore, private research may be hindered by the *public good* characteristics identified in relation to RD&D. (See the discussion in section 1 of this paper.) This, in turn, could lead to a general lack of the expertise needed both to reduce production costs and to establish an advocacy group within the industry to maintain continued research activities.

In the area of financial risk, we know that smaller or limited investors (this may include many farmers) do not conform well to general models of rational profit maximization. Informational instruments would likely be required to present convincing arguments about payback periods and explore threshold levels of acceptable risk. Technical risks relate to data on large-scale monoculture plantations, biotechnology, harvesting costs and environmental damages, and the long-term effects on ecological diversity from biomass plantations. These, along with a number of potential environmental issues, would likely require research and development subsidies. However, the issue of the government picking winners in technology development has become a highly charged political issue in the U.S., which may restrict the use of these instruments.

There is little basis on which to assess whether private motivations and information transfer activities are consistent with the objectives of public programs. However, prudence dictates that the degree to which biomass commercialization depends upon public sponsorship indicates a need to investigate and control for principal-agent risks (where sponsor and program participant may withhold knowledge from each other).

Other problems arise from the absence of related markets for input supplies, output demands, and substitute goods, as well as from a need for long-term supply contracts to mitigate the long delay in investment payback for woody biomass production.

Finally, widespread implementation of any biomass technology may lead to profound public controversy similar to that surrounding nuclear power. Biomass will alter the landscape as corn rows are replaced by large-scale coppices or woody biomass shrubs. The character of agricultural communities is likely to change. Already in the U.S. the once heroic figure of the family farmer has been partially displaced by the image of the corporate despoiler of ecosystems through profligate use of agrichemicals. When the goal of agriculture becomes energy production rather than feeding people, we might reasonably expect increasing opposition to agricultural activity.

4. Implementation Challenges from Institutional Diversity

Our focus thus far on the U.S. is not the result of parochialism. We have merely sought to illustrate the problems that arise when implementing increasingly complex forest programs for carbon sequestration and emissions reduction in a society that has perhaps the most ideal characteristics for successful application of the whole suite of conventional policy instruments listed in Section 1.

These attributes include:

- a well-developed institutional infrastructure for implementation of regulation
- an economy that is likely to respond well to economic policy instruments because it is probably closest to the economists' model of the free market
- a highly developed information industry and mass communications infrastructure, for educating, advertising, and jawboning
- a vast combined private and public annual RD&D budget for reducing uncertainties and establishing pilot programs.

To the extent that these close-to-ideal institutional conditions for conventional policy implementation are missing, we may expect to encounter further obstacles to the effectiveness of policy instruments.

For example, many developing and newly industrialized countries have excellent legal, even constitutional, provisions for environmental protection. including protection of forests. Many of these are clearly modeled on U.S. precedents.

The Brazilian *Codigo Florestal* of 1965 defines permanent areas of conservation along rivers and headwaters, prohibits the use of natural resources in national and other protected parks, and stipulates that in Amazonia, no more than 50% of land holdings may be cleared. However, monitoring and enforcement of the *Codigo Florestal* is poor to non-existent. Even where it is enforced, there are no limits on subdivision of holdings, and the law has been frequently circumvented by clearing half of a plot and reselling the remaining forested half where once again the 50% law applies. The code has been modified and supplemented several times, but funds and credits for reforestation have never been reliable, and most of the economic incentives that have appeared were applied in sub-tropical parts of Brazil where pines and eucalyptus could be grown (Hecht and Cockburn 1990).

The Brazilian Constitutional Convention of 1988 established national obligations for environmental protection. Title VIII explicitly discusses the importance of forest conservation, while Title IX provides for the implementation of large-scale regional management exercises, such as the *Planofloro* zoning program for the State of Rondonia. *Planofloro* has focused on directing economic activities into appropriate areas using economic and ecological criteria elaborated from satellite imagery and ground mapping. Unfortunately, such exercises suffer in implementation from the absence of effective regulatory agencies to enforce zoning rules, as well as from conflict with other powerful government agencies with different development priorities that receive stronger private sector backing than does forest protection.

While this is by no means a comprehensive review, it is sufficient to indicate that, while Brazilian environmental law is well developed and in certain sectors quite innovative, the implementation of those laws may tend to leave more marks on paper than on reality.

We do not single out Brazil. This is a pattern repeated again and again across the developing world (see for example, Jasanoff 1993, Petrich 1993, Perlack, Russell, and Shen 1993). Neither do we see these observations in any sense as an indictment or criticism of these governments. The harsh reality is that they all face a serious problem of scarce resources to carry out the most elementary functions of government. Competition among state agencies for whatever resources are available inevitably leaves environmental protection and forest resource management agencies without the necessary investment to establish effective monitoring and implementation programs. The shortage of program resources is exacerbated by pressures to exploit forest products to earn foreign income, and by the increasing pressures of population to convert forest-land to agricultural use and for human habitation. Under the combined weight of all these factors, the issue of optimizing across regulations, taxes, permits, education, and demonstration projects becomes increasingly academic.

Lack of implementation infrastructure may be the largest single obstacle to effective forestry policies under frontier conditions. These are situations where prior claims of indigenous populations are non-existent or disregarded, and where the ability to monitor behavior, settle disputes, and enforce rules and contracts lie with individuals and groups possessing the power to coerce (Cantor, Henry, and Rayner 1992). Unfortunately, conventional development approaches tend to dismiss these characteristics of the society as mere details of implementation when, in fact, they represent fundamental structural differences between established and frontier societies, where the institutions of civil society (essential to the functioning of regulatory regimes or efficient markets) are either severely curtailed or altogether absent.

Conventional development approaches are equally complacent about other political, economic, and cultural structures that differ fundamentally from those that we take for granted in economies that most closely resemble the U.S. model. In particular, as we move away from societies in which production and consumption are distinctly separated by the operation of the free market, we begin to appreciate more clearly that the use of land, including forested land, is intimately tied to the satisfaction of a broad spectrum of basic human needs and wants (see Figure 2). The concept of market failure is hopelessly inadequate to capture the interlocking demands and expectations of the land and the human arrangements for its multiple use. It is not an exaggeration to say that the further we move away from the market concept, the more the land itself becomes less a commodity subject to market forces and more a medium of social relations.

This situation is exemplified in the interweaving of mythology and geography upon which certain indigenous North American and Australian societies are based. In the case of many Native Australian peoples, the personification of the land is so strong that morphological features are identified as historical ancestors. The relationships of such features to one another actually represent the past history and the current family relationships of the people. If this seems an overly exotic example, it is worth remembering that many European land tenure systems, which even today may be highly localized, embody kin, family, neighborhood, community, and social class relationships, which, in turn, constrain the ability of individuals to buy, sell, rent, or exercise usufruct over land, as well as determine the uses to which it is put (Davis 1973, Stevenson 1991).

Other important changes accompany the transition from economic to social principles of human organization. Socially constrained exchange systems carry more complex information about the relationships among parties to transactions. Exchange does not depend solely on signals about price, quantity, and quality among anonymous traders, but signals status, kinship, ethnicity, calendrical periodicity, and a host of other factors essential to sustaining society. The homogeneity of *homo economicus* is replaced by localized adaptation of human society to ecological variation. This transformation is being recognized as an important factor in energy use. Whereas different societies traditionally adjusted their attire, construction practices, and work schedules according to climatic, seasonal, and diurnal variation, the tendency towards homogeneity in market-driven systems increases demand for space conditioning, lighting, and transportation. Similarly homogeneity in forestry and land-use practices may increase stress on local environments that were once protected by human adaptation. Examples include the consequences of irrigation, enforced settlement, and changes in land management practices. In these contexts, application of tools from the standard toolkit of policy instruments has provoked spectacularly perverse effects.

For 400 years, the Sherpas of the Khumbu forests of Nepal maintained a sustainable system of forest management that assured them a plentiful supply of fuelwood (Thompson, Warburton, and Hatley 1986). This system was based on a rotating village office of the *forest guardian*, who monitored villager's extraction of the resource and whose office was maintained out of the fines he was permitted to levy on those who violated the commons by excessive use. However, in the name of modernity and efficiency, the forests were nationalized during the 1950s and control was removed from local hands to those of distant bureaucrats. Once the gentle controls of community self-management were removed, people began taking too much wood from close by and not enough from further away, resulting in patchy and partial deforestation, leading to severe erosion, land degradation, and fuelwood shortages in the villages.

The situation was exacerbated when development experts, anxious to find appropriate technological solutions to a perceived fuelwood crisis provided villagers with alternative stoves to relieve pressure on the forests. Unfortunately, villagers perceived the forest as a resource convertible to farmland, rather than as a renewable resource that could now be preserved, and proceeded to cut the remaining stands of forest upon which they no longer depended for cooking and heating.

Examples of the perverse effects of development programs based on conventional economic theory are not confined to any one geographical area. They are ubiquitous. Certain traditional West African land-tenure systems are based on tenure in standing crops. Planting trees provided people with tenure in land for extended periods which also secured their right to farm annual crops on the understory. This resulted in a sustainable agroforestry system. Furthermore, the trees frequently provided cash crops for the farmers. Development economists, however, anxious to promote production of these cash crops reasoned that fewer than the optimal number of trees were being planted precisely because people did not have tenure in the land itself and, therefore, lacked security in their investment in trees. Providing tenure in the land, however, actually removed the principal tree-planting incentive. Farmers pursuing shorter term productivity of annual crops removed trees; this resulted in baked soil and loss of windbreaks, leading to soil erosion, land degradation, and the collapse of sustainable agroforestry.

Perverse effects such as these are not exceptions to the rules of formal economics, but the reality for which those rules fail to account. Economists assume *ceteris paribus* when making instrument choices just as in determining goals. The point is that *ceteris* seldom is *paribus*, and the results, as described above, are at best irrelevant, and frequently disastrous.

Of course, "Development experts have learned to their cost that the impressive arrays of policy levers displayed in the ministries of many of the less-developed countries are, all too often, not connected to anything" (Thompson, Warburton, and Hatley 1986:92). This is usually interpreted as a symptom of underdevelopment that can be remedied by nurturing market-style institutions and regulatory regimes typical of the developed world. The effectiveness of this approach is debatable, even when dealing with a relatively homogeneous commodity such as energy. It completely ignores the fact that "Land use patterns are an expression of deep political, economic, and cultural structure; they do not change when an ecologist sounds the alarm that a country is losing its resource base" (Eckholm 1976:167). If the threat of losing valuable national resources does not motivate structural change, there seems little hope that any conventional policy instrument that ignores these aspects of deep structure will persuade people to alter their behavior to obtain uncertain benefits for the global climate.

Exploiting Diversity in Policy Implementation

Perhaps the challenge for policy implementation is not to force the U.S. free market model on the world, but to design programs for policy implementation that exploit political, economic, and cultural diversity.

The first way in which we might approach this goal is to abandon the search for the "magic bullet" of implementation. The prospect of perfectibility held out by neo-classical economic theory may prove to be the enemy of the political good. Even in the case of highly developed market economies, we have noted that different constituencies may have strong preferences for different kinds of implementation instruments based on considerations other than economic efficiency. This is not to argue that we should abandon the conventional suite of policy instruments, but that we need to pay more explicit attention to the reasons for these preferences and account for the relative distribution and strength of each constituency among the parties the policy is designed to effect. This is also a powerful argument for focusing on policy implementation packages rather than on individual instruments in the process of policy design and implementation.

A second, complementary, approach is to supplement the conventional suite of policy instruments by examining indigenous traditional mechanisms of social regulation that we might harness to the policy goal of reducing greenhouse gas emissions through forestry. The traditional institutions of forest guardianship in Nepal and the traditional land-tenure systems of West Africa are obvious examples. Other instruments may be more subtle. For example, long before the evolution of the modern nation-state, religion was a powerful force in shaping individual and collective behavior. Even today, it continues to be the overriding authority in the lives of much of the world's population. Let us at once disclaim any of the fashionable romantic notions that indigenous tribal peoples universally live in spiritual harmony with the natural world. For some, lack of technology and static population size are all that stands between them and massive environmental degradation (Rayner 1989). However, for others, such as the many of the Bantu speaking peoples of Africa, forests are the dwelling places of ancestral spirits and may not be violated with impunity. Modernization of traditional beliefs through education, religious conversion, and the intrusion of outsiders into traditional territory through individualization of land tenure has led to a decline in forest cover. Cases such as these raise the interesting question of whether culture, including religion and land-tenure traditions, can be used as effective elements in a package of policy instruments.

In some cases, religious protection of forest stands is effective, but limited in geographical extent. For instance, travelers in Rajasthan have been struck by the stark contrast between the prevailing desiccated shrubbery of the countryside and the lush oases surrounding Hindu shrines (Gold 1989). These are the domains of deities within which human actions that degrade the environment are subject to divine sanctions. Both ancient and modern tales abound of the misfortunes befalling those who violate these divinely protected areas. But, whether the tale concerns the death of an elephant sent to clear a grove by a Mughul iconoclast or a contemporary fatal accident involving road building machinery, the message is clear: the groves are protected from degradation.

One such tale from Rajasthan concerns an event in the 1930s which that to have been a precursor of the modern Chipko movement. When faced with paying a tax to the Maharajah of Jodhpur or permitting his agents to cut wood, the villagers of Khejarli are reported to have responded that "To set a price is sinful." The villagers wrapped themselves around the trunks of the trees while the laborers chopped them down. One by one, 363 people were said to have been martyred to save these trees. The later emergence of the Chipko (literally "tree-huggers") movement illustrates not only the deep cultural origins of a modern social movement strategy, but also points to another strategy worthy of investigation for those interested in policy implementation: the role of social movements in both developed and developing nations. Social movements, in combination with issues of cost, played an important role in forcing advanced market societies to abandon nuclear energy. Might their encouragement and nurturing not be worthy of consideration as part of a package of policy instruments dedicated to reducing carbon emissions through forestry?

Social movements are a specialized form of social networks. Networks work in other ways that could enhance forestry programs. For example, a vigorous program of private sector tree planting was undertaken in Los Angeles immediately prior to the 1984 Olympic Games (Tree People, 1983). A large lumber company provided 600,000 drought-resistant seedlings in containers that were distributed by a fast-food chain, with postcards to be returned when the seedlings were planted. Schools and neighborhood groups also planted trees and undertook to water them for the critical first two years. Later in the program, distributors gave out more seedlings, bringing the total to more than one million. Unfortunately, there was no evaluation of the program to see what fraction survived. However, less than $1 million were spent on the entire effort, mainly for printing and advertising, which translates into less than $1 per seedling. If only 20% survive to maturity, the cost is still equal to the lowest estimate of $5 per tree for urban plantings reported in Akbari et al. (1988).

Networks can be especially powerful in highly localized situations where markets are likely to fail due to small numbers of traders, etc. Examples include successful common property regimes. Since the publication of Garret Hardin's (1968) celebrated essay, "The Tragedy of the Commons," development experts have been intent on dismantling common property regimes wherever they are encountered. The true tragedy here is that Hardin was not talking about common property at all, but about open access regimes where no controls exist over the common use of renewable resources. Yet successful, sustainable common property regimes operate all over the globe (McCay and Acheson 1990). The Solway Marshes in the north of England are managed by a combination of privately owned *stints* or grazing rights and collective control of the grazing level through a venerable local body that makes an annual assessment of the ecological status of the common and fixes the number of cattle or sheep per stint accordingly. Successful grazing commons exist in places as diverse as Botswana and Switzerland (Stevenson 1991). The same principles were implemented by the traditional forest management systems of Nepal. Such systems seem admirably suited to situations where monitoring and enforcement by central authorities is constrained and where efficient markets cannot operate. The essential features of successful common property systems include:

- clear definition of the boundary of the resource;
- a finite population of those entitled to use the resource;
- recognition of reciprocal externalities imposed by use of the resource; and
- the ability to enforce sanctions on violators.

Where central control is weak but these conditions can be satisfied, establishment of decentralized common property regimes may well be a more viable instrument of forest protection than free market mechanisms.

We have suggested some directions in which we might explore unconventional alternatives to command-and-control regulation and markets. Are there also unconventional analogues of informational and RD&D instruments?

The answer may well be yes, if we are able to muster the humility to listen as well as to speak and to observe as well as to demonstrate. Instead of merely lecturing the poor and the powerless about how to manage their resources, we can give them the opportunity to communicate their needs to the rest of us. A successful program along these lines was one that provided the Kayapo Indians of Brazil with videocameras and training in how to use them. Possession of this technology allows the Kayapo to make incontrovertible records of their negotiations and agreements with government bureaucrats and forestry companies seeking to operate on Kayapo lands. When agreements are violated, the Kayapo are empowered to seek legal remedies in court and apply moral suasion by providing the video footage to the global mass media (Turner 1992).

An unconventional analogue of RD&D programs focuses on the demonstration component. We suggest that learning from local knowledge of land use and management (including management of water resources and other essential inputs to successful forestry) may prove to be a useful tool for implementing forestry policy goals.

5. Conclusions

Although economic incentives appear to be attractive options for simple cases of tree planting on marginal lands, regulation, information programs, RD&D instruments, and even direct government production of carbon sinks may also have a role to play in designing policy implementation programs for reducing greenhouse gas emissions through forestry. The actual selection of policy instruments may depend as much upon the inherent preferences of particular institutions - private sector, environmentalist, and regulatory - as upon judgments of relative economic efficiency. Conventional economists view such preferences as obstacles to efficient policy implementation and seek to override or eliminate them. However, we suggest that these preferences are so pervasive and entrenched (because they serve other important social goals) that we might do better designing our forest policy instruments to fit them.

Furthermore, the non-economic instruments appear to increase in importance under two sets of conditions that may apply independently or simultaneously. The first of these is the increasing complexity of forestry technology. The second increase occurs as we move further from the idealized conditions of economic models to societies where land is not simply a commodity but may be a dominant idiom of social relations. We also conclude that failing to account for these different social, political, and economic structures, or treating them merely as issues of implementation, is to invite perverse policy outcomes. Policy implementation packages need to be tailored to take account of regional, national, and local diversity as well as the preferences of powerful constituencies.

Finally, we have suggested that it might be worth looking to these societies for new policy instrument concepts to supplement the conventional policy makers' toolkit. Notwithstanding the powerful tendency of neo-classical economics to homogenize human behavior and motives, in the final analysis, cultural diversity may prove just as valuable to humanity as biodiversity. The resulting forest policy implementation program may lack the loveliness of the neo-classical model, but it may be more effective.

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ABSTRACT

This paper describes a suite of instruments that are commonly employed to implement a given policy. These are initially applied to a relatively simple case -- a tree-planting program in the U.S. -- to demonstrate the difficulties involved in implementing a carbon sequestration program, even in a well-developed market economy. The choice of policy instruments and program design is more difficult with other forest technologies in the U.S. than for the simple tree-planting case. We also examine problems that arise where economies may bear less resemblance to the ideal market economy than does the U.S. economy. In those settings, the choice of policy instrument must be sensitive to non-market considerations that are often missed in conventional policy and cost analysis. We conclude that although economic incentives appear to be attractive options for simple cases of tree planting on marginal lands, regulation, information programs, RD&D instruments, and direct government investments also have a role to play in implementing forestry policies to reduce greenhouse gas emissions. The actual selection of policy instruments may depend as much upon the inherent preferences of particular institutions -- private sector, environmentalist, and regulatory -- as upon judgments of relative economic efficiency. The effectiveness of the instruments may be significantly constrained by the institutional context in which they are applied.

Table 1. Risk types and underlying issues.

FINANCIAL	Harvesting costs Productivity Crop selection Future costs and time horizon
TECHNICAL	Production scale Genetic engineering Herbicides/insecticides/fungicides Monocultures Fertilization Harvesting Irrigation
ENVIRONMENTAL	Deforestation Wood combustion Fertilizers, pesticides, herbicides Competition with food production Irrigation Ecological diversity Soil erosion Nutrient depletion Sedimentation Dust emissions
PRINCIPAL-AGENT	Effort to grow biomass crops Value of biomass to energy strategies Communication channels Needs of private-sector participants
MARKET ACCEPTANCE	Missing related markets Long time horizons Traditional demand patterns Non-proprietary information Expertise
PUBLIC ACCEPTANCE	Labor resources Occupational risk Competition for land and water Disruptions of the natural environment Biotechnology Macroeconomic shifts

Source: Modified from Cantor and Rizy, 1991.

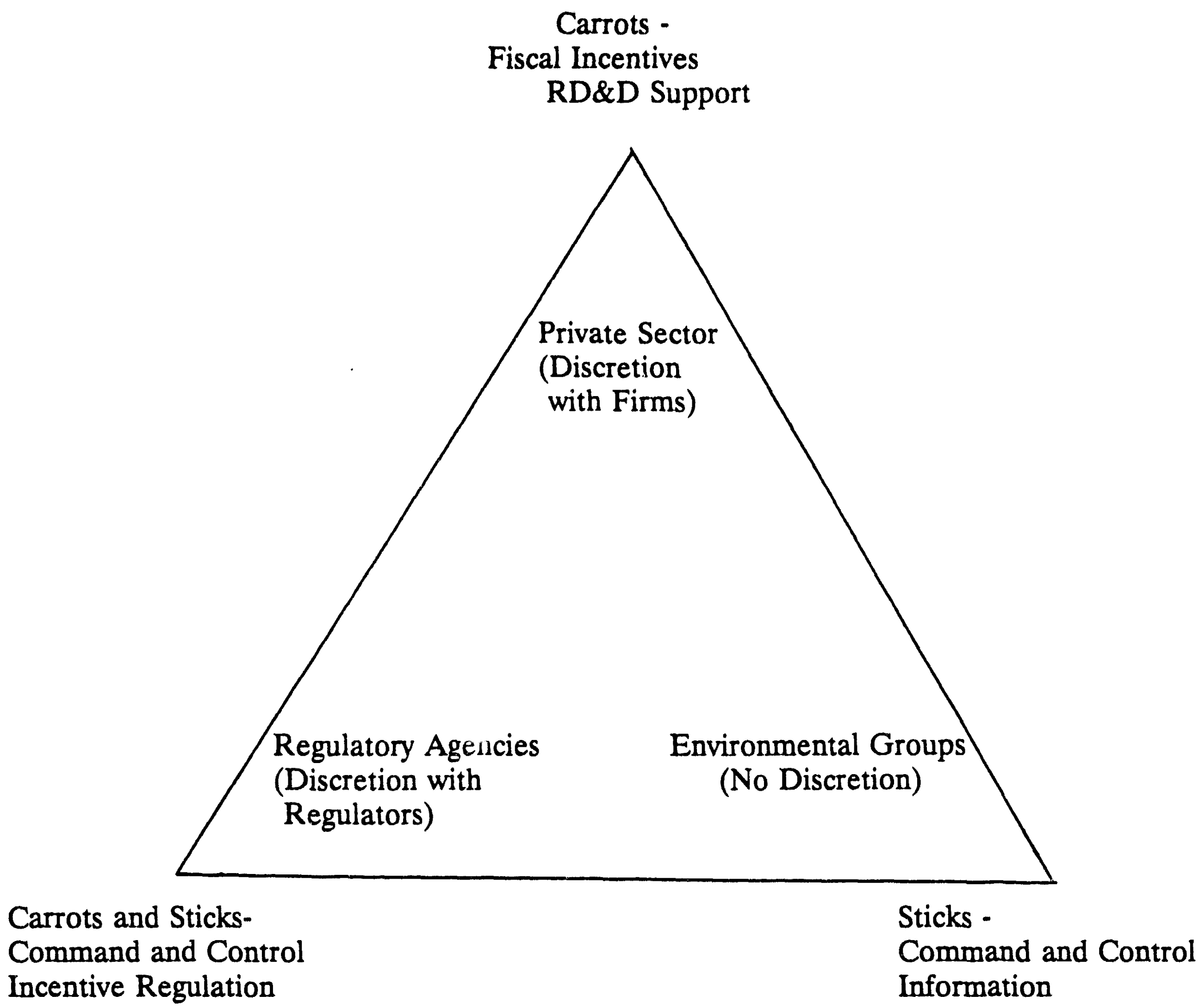

Figure 1: Policy Space for Implementation Instruments

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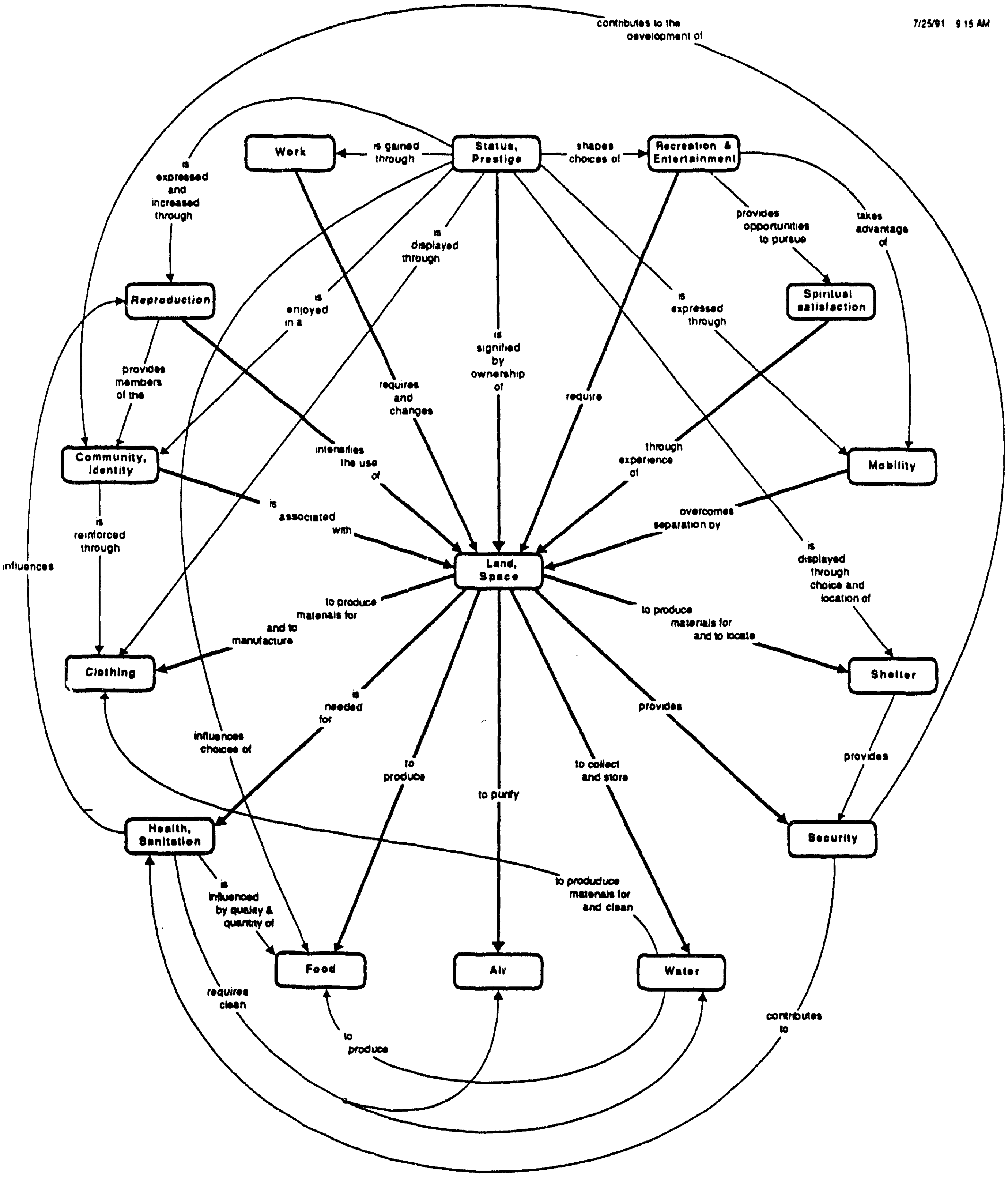

Figure 2: Human Needs and Land Requirements

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