

Biological Monitoring and Selected Trends in Environmental Quality

J. Samuel Suffern Darrell C. West H. T. Kemp Robert L. Burgess

MASTER

Environmental Sciences Division Publication No. 919

OAK RIDGE NATIONAL LABORATORY

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BIOLOGICAL MONITORING AND SELECTED TRENDS IN ENVIRONMENTAL QUALITY

J. Samuel Suffern, Darrell C. West, H. T. Kemp, and Robert L. Burgess

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Preface

"A National Inventory of Selected Biological Monitoring Programs" began in June 1975 to survey, categorize, document, and computerize information concerning biological monitoring programs in the United States, and to build a computer-searchable, on-line database that would serve a variety of needs for the sponsoring agencies. Over 5,000 documentary questionnaires were mailed to identified principal investigators, and over 3,000 responses have been received to date.

In the spring of 1976 CEQ asked ORNL to document trends in environmental quality as a part of their (CEQ's) annual report preparation. This was exactly the sort of use for which the database was designed, so it was searched for those monitoring programs that had indicated a change in some environmental parameter through time. Once these were identified, the database material was supplemented by published reports wherever possible. We emphasize the utility and flexibility of the Inventory in comparison to the expensive and inefficient characteristics of a standard literature search.

This report is a synthesis of the material gathered for the Council on Environmental Quality. We emphasize that data, trends, conclusions and interpretations are tentative and preliminary. We do not wish to attribute statements to investigators that responded to the inventory in the absence of published reports. Data from publications, however, stand on their own merit. In an attempt to provide maximum information to the sponsors, several interpretations are ours. Any errors remain the responsibility of the authors.

- J. S. Suffern
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ABSTRACT

SUFFERN, J. Samuel, Darrell C. WEST, H. T. KEMP, and Robert L. BURGESS. 1976. Biological monitoring and selected trends in environmental quality. ORNL/TM-5606. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 28 pp.

Under a contract with the President's Council on Environmental Quality, the National Inventory of Selected Biological Monitoring Programs at ORNL was used to identify documented environmental trends. Fish population trends were described for the Great Lakes and the Colorado River system. Trends in amphibian populations in the northeast were examined and correlated with acid precipitation. Increases in breeding success among large birds of prey were correlated with reductions in ambient levels of DDT and its residues. Geographic variation in PCB contamination was examined along with differences between aquatic and terrestrial contamination levels. Changes in air quality were documented, and their effects on plant viability were outlined. Trends in the biological effects of environmental deposition of lead were documented. Long-term changes in forest structure in the southeast were presented, and a general reduction in wildlife habitat, associated with land use practices, was documented for several areas in the US.

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INTRODUCTION

In the spring of 1976, the President's Council on Environmental Quality requested ESD's help in preparing their annual report. Specifically, they asked for identification of environmental trends, with interpretation and explanation wherever possible.

The result of that effort was a series of individual vignettes, each dealing with an identifiable biological trend. Often based on preliminary data and scattered studies, these should not be construed as a definitive statement of environmental quality. Rather they are best viewed for what they are; ecologists' best estimates of the situations, based on data available at the present time.

The project served to demonstrate the usability of the Biological Monitoring Program database at Oak Ridge, which allowed the initial identification of trends, and provided much of the documentation of same.

POPULATION TRENDS IN FRESHWATER FISHES

The Great Lakes

The Great Lakes are in a state of rapid change, with at least two of the major changes caused by human activities. First, the lakes have undergone eutrophication. This enrichment has caused extensive changes in the biological populations, including increases in algae and profound changes in the fish communities resulting in a shift from desirable species to undesirable, or "trash" fish. Other, more subtle changes have occurred in the bottom-dwelling organisms (benthos), and reductions in the level of dissolved oxygen have taken place in deeper waters. Eutrophication has been most noticeable in the lower lakes, especially Lake Erie (Sly 1976), and is least noticeable in Lake Superior, the most isolated.

A second major change was caused many years ago by the inadvertent introduction of the sea lamprey. Prior to the construction of shipping canals, the lamprey was restricted from all the Great Lakes except Lake Ontario by its inability to pass Niagara Falls. Following completion of the canals around the Falls, the lamprey spread quickly through the rest of the lakes, causing mortality among the larger (and more desirable) fish species (Smith 1972). The effect of the lamprey was to accelerate the changes in the fish community which were initiated by eutrophication and overfishing.

Lake Erie has been the most noticeably over-enriched of the Great Lakes. In 1973, research was begun to examine the effectiveness of Federal, State, and local nutrient control programs (OH/O15). To date, the study shows that the size of the anoxic area in the central basin of the lake (where there is no dissolved oxygen in the water) expanded

through 1973 (indicating increasing eutrophication), but decreased markedly in 1975. The implication of this trend is that the rate of eutrophication has begun to slow, reflecting the effectiveness of nutrient control programs in the lake basin. These results have been experienced on various water bodies all over the country. When nutrient control programs (such as improved sewage treatment) are implemented, water quality begins to improve quickly.

Lake Superior, the most pristine of the Great Lakes, represents a different situation. Lying in an isolated and undeveloped watershed, it has been spared most of the effects of intense human use. Recent studies, however, have found changes in the plankton community indicative of eutrophication and increasing levels of environmental contaminants (MN/034, Parejko 1975). While Lake Erie is beginning to reflect the effects of environmental improvement programs, the reverse seems to be the case in Lake Superior.

Fisheries in the Great Lakes reflect increasingly sophisticated management programs. The sea lamprey is being brought under control, and a productive lake trout and salmon fishery is developing as a result of broad cooperation between several state and federal fish and wildlife agencies.

Colorado River

In a study of adult fish in the Colorado River system (Holden and Stalnaker 1975), 27 stations were sampled annually from 1967-1973. The sites were predominantly in Utah and Colorado, but extended as far north as southern Wyoming and downstream to Lake Mead. While data on many species are scant and highly variable (Table 1), certain trend interpretations can be made, based on the more common species.

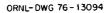
The rainbow trout (Salmo gairdneri) shows a slight increase in numbers during the period 1968-1971. This species is regularly stocked, however, and the data probably reflect a combination of stocking numbers and fishing pressure as well as survival, breeding, and habitat condition. Both the Roundtail Chub (Gila robusta) and the Bonytail Chub (Gila elegans) show marked population decrease (Fig. 1). The former has been the dominant native carnivore in the Colorado basin tributaries, and it is interesting to note that the period of decline corresponds to the completion and closing of Flaming Gorge Dam in northeastern Utah.

Two native suckers, the Flannelmouth (Catostomus latipinnis) and the Bluehead (Catostomus discobolus) show an apparent increase during the period. Historically, however, both species have changed little in either distribution or abundance (Jordan and Evermann 1896). Coupled with two additional species (plus three hybrids) of catostomids, the totals illustrate an upward population trend. This trend, when balanced with the decrease in the cyprinids, gives a greater relative abundance to the "undesirable" element of the fish fauna, which may be indicative of a

Table 1. Number of adult fish taken in the Colorado River system above Lake Mead 1967-1973^a

SPECIES	1967	1968	1969	1970	1971	TOTAL
Salmonidae				_ 1	c	
Salmo gairdneri		3	7	24	many	>34
Salmo trutta		0	15	· 7	2	24
Salmo clarki		2	0	6	0	8
Cyprinidae						
Gila robusta		180	105	60	30	375
Gila elegans		29	3	4	0	36
Gila cypha complex	22	6	26	6	1	61
Ptychocheilus lucius		71	90	127	12	300
Catostomidae	٠					
Catostomus latipinnis	•	1983	1709	2400	many	>6092
Catostomus discobolus		479	276	318	many	>1073
Catostomus commersoni		5	6	39	many	>50
Xyrauchen texanus		6	4 .	33	10	53
Catostomid Hybrids		9	8	3 9	many	>58

 $^{^{\}rm a}$ Modified from Holden and Stalnaker 1975.



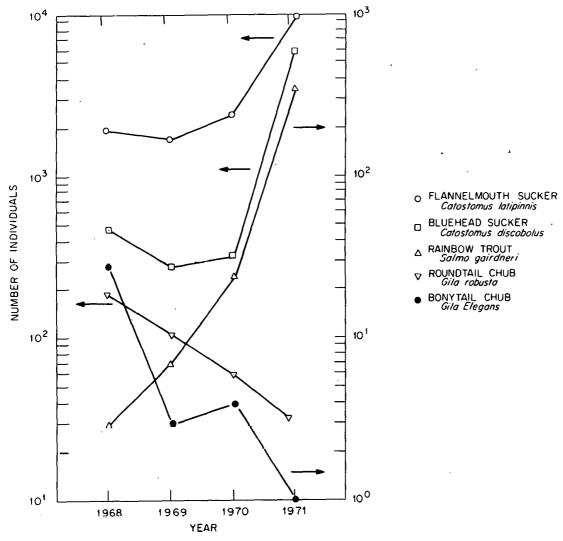


Fig. 1. Population trends in five species of fishes in the tributary streams of the upper Colorado River basin, (after data in Holden and Stalnaker 1975)

slow, though general, deterioration in quality of the stream waters in the upper Colorado Basin.

TRENDS IN AMPHIBIAN POPULATIONS

Several biological monitoring programs have identified a potentially serious problem developing across the North American continent (CN/013, CN/009, NY/088, NJ/014. Studies in the Northeast have noted a decline in amphibian populations (salamanders and frogs), but were unable to clearly define the causes until recently, when a monitoring program in New York linked low pH (acidity) of breeding ponds to reproductive failure in salamanders (Pough 1976).

The acidity of precipitation has been monitored for the past two decades, and has shown a continual increase. Acid precipitation is caused by pollutants, especially sulfur and nitrous oxides, released from fossil-fuel burning power generating stations, industrial plants, and from automobile exhausts. The pollutants react with raindrops and the product falls to earth as a series of weak acids. Based on Scandinavian experience, if the trend toward acid precipitation continues, we can expect much more serious effects than have been observed to date in the United States. In Sweden, acid precipitation from European industrial pollution has caused the extinction of fish fauna in rivers and lakes. Increased acidity has many adverse effects on organisms and processes in aquatic ecosystems (Oden and Ahl 1972). In various studies, aquatic vegetation, mineral cycling, and plankton populations all have been found to be affected (Engstrom 1971). In terrestrial systems, the effects of acid precipitation are less well documented. From the work done to date, soil chemistry, plant growth rates, and relationships between host plants and disease and symbiotic organisms can be expected to change (Burges and Raw 1967). In some cases, acid precipitation has caused heavy plant mortality, with consequent severe erosion (USDA 1975).

The problem of acid precipitation is important. Its effects on the unbuffered aquatic ecosystems in Scandinavia are well documented (Oden and Ahl 1972, Engstrom 1971) and the work of Pough (1976) indicates that the problem is beginning to become obvious in the fresh waters of North America. The effects on terrestrial systems remain more problematic, but are nonetheless real. Given the fact a trend toward worsening conditions exists, and the use of fossil fuels is increasing, the need for emission control standards, strongly enforced, is paramount if this trend is to be reversed. Otherwise, types of organisms that are highly susceptible to slight changes in the acidity of their environment may continue to exemplify continuing degradation of environmental quality.

Two species of salamanders were studied in the Hubbard Brook Experimental Forest in New Hampshire (Fig. 2) (Burton and Likens 1975). While the period of record is very short, the data show a population decrease for adults of both species. The marked increase in larval counts for one species, however, may indicate that the available data simply reflect normal density fluctuations that only a longer monitoring period would be able to clarify.

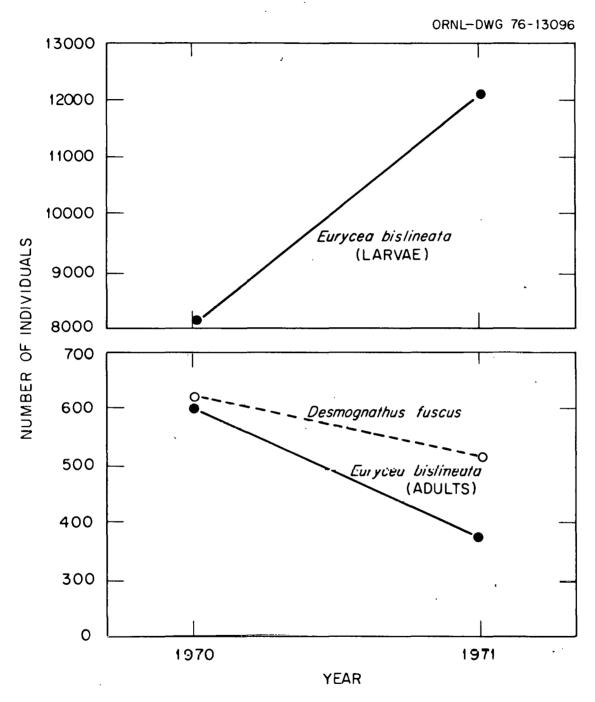


Fig. 2. Stream and streamside salamander populations in Watershed 4, Hubbard Brook Experimental Forest, New Hampshire. (data from Burton and Likens 1975)

Also in New Hampshire, newt populations were monitored for four years in relation to the amount of available habitat (Fig. 3). Data from Bennett (1970) indicate a substantive decrease from 1966 through 1968, but an upward trend in 1969. Again, the period during which the population was monitored was short, and normal fluctuations may be exemplified. No evidence was found, however, that the numbers were related to available habitat area. The habitat total dropped slightly during the survey, but without qualitative information, it is difficult to relate to the population numbers. For instance, if the areal decrease was confined to (or predominantly on) spawning grounds, then large population changes could be correlated with relatively small changes in the extent of available habitat.

TRENDS IN CARNIVOROUS BIRD POPULATIONS

There is a dramatic indication of environmental improvement in the increasing breeding success of the large, carnivorous birds. Since World War II, populations of many species had been declining, largely attributable to decreasing reproductive success. This phenomenon has been firmly linked to DDT and its derivatives, chemical contaminants that interfere with calcium metabolism and cause decreased eggshell thickness, making the eggs too fragile to survive through hatching. In addition, land use practices have reduced the amount and suitability of territory available to the birds.

In the last few years, this trend has begun to reverse. In seven of eleven studies of predatory birds (OR/O36, WI/O65, CA/112, ID/O01, IL/O42, UT/O51, MD/O04, CA/O04, NY/O65, ND/O10, Anderson $et\ al.$, 1975) with wide geographical distribution, breeding success has begun to improve. In the seven studies, bird population increases have often been correlated with decreases in the level of DDT contamination. The peregrine falcon (Falco peregrinus) is an exception to this generalization, however, as populations of this species continue to decline throughout the United States.

A clear example of the relationships between birds of prey and pesticide contamination is shown by the brown pelican ($Pelecanus\ occidentalis$) population in southern California. Figure 4 illustrates pelican fledging success and eggshell thickness contrasted with DDT contamination in anchovies, the primary food source of the birds. Both fledging success and eggshell thickness have improved as DDT contamination has gone down (Anderson $et\ al.\ 1975$). While both parameters are still below values recorded in pre-DDT times, they are substantially improved over the recent past, and constitute an indication that environmental controls, pesticide regulation, and restoration efforts can have significant positive effects on biological populations. These studies also illustrate how careful monitoring of selected species serves as a valid indicator of trends in environmental quality.

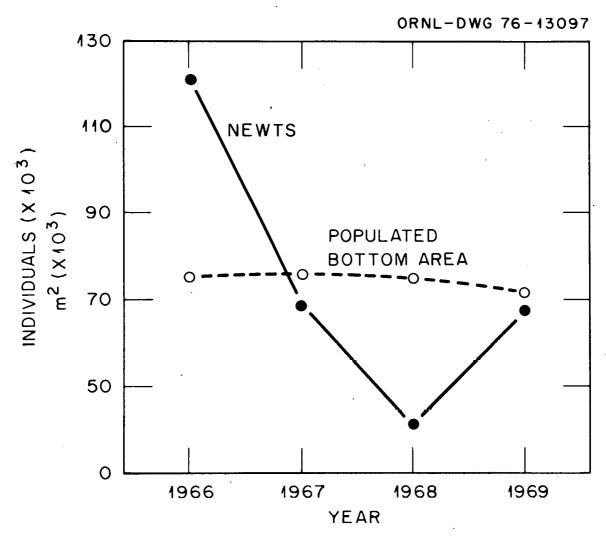


Fig. 3. Population trend of newts (Notopthalmus viridescens) in New Hampshire compared with small changes in the inhabited bottom area. (after Bennett 1970)

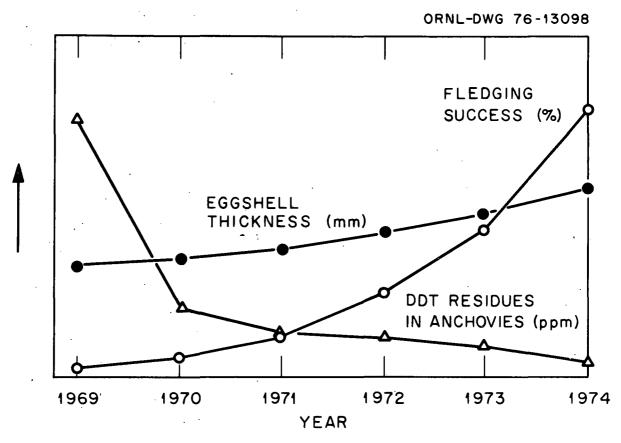


Fig. 4. Trends in reproductive measures and pesticide contamination of a food source of the Brown Pelican (Pelecanus occidentalis) over a recent six-year period. (adapted from Anderson et al. 1975)

Similar improvements in breeding success have been recorded for various populations of eagles (Haliaeetus leucocephalus and Aquila chrysaetos) and ospreys (Pandion haliaetus) in the Rockies and in some of the eastern national forests (Anonymous 1975, Grier 1969, 1974, Johnson et al., 1975, Reese 1969, 1970, 1975, 1975a, Roberts 1969, 1970). In some cases, however, reproductive success continues to decline, indicating that regional differences in the effectiveness of pollutant control programs may still exist.

ADDITIONAL TRENDS IN WILDLIFE IN RELATION TO SELECTED CHEMICALS

The National Fish and Wildlife Monitoring Program, administered by the U.S. Fish and Wildlife Service in cooperation with state fish and game agencies, has produced some broadly-scoped information on the relations between biological populations and certain environmental contaminants. Since 1967, studies have been made of fish (Hyde et al. 1974) and birds (Hyde et al. 1973) from all over the country in order to examine the accumulation of pesticides in different components of continental ecosystems (Dustman et al. 1971, Johnson et al. 1967, DC/010). These studies have shown that PCB (poly-chlorinated biphenyls) contamination varies geographically. In fish, the contamination is highest in river systems that are heavily industrialized. In duck studies, the highest levels of contamination were found in the Atlantic flyways. The Mississippi flyway had lower levels and the Central and Pacific flyways were still lower.

In other studies (NY/038, FL/003, IA/035, LA/012, CN/003, MI/015, WI/002, DC/010) of environmental contamination in different parts of the country, a general decrease in the level of DDT and its derivatives has been noted over the past few years. During the same interval, however, the levels of PCB contamination seem to have remained about the same or to have increased slightly (Butler 1973, Foehrenbach at at. 1971).

Our understanding of the behavior and toxicity of PCB's is still limited. Although they have been used in industry for several decades, only recently have we realized that they are a matter of serious ecological concern. In the last ten years, we have learned that these chemicals accumulate greatly in food chains where concentrations greater than 70,000 times ambient levels have been recorded. They can cause reproductive, developmental and metabolic irregularities, as well as death, in animals and man (Brown and Chow 1975).

The inferences drawn are that PCB contamination is highest in industrialized areas, especially the East, and tends to be most heavily concentrated in animals which feed on aquatic organisms. Studies done on more local scales in different parts of the country show the same general picture. Organochlorine pesticide contamination in the environment is decreasing, reflecting attempts at control, while PCB contamination is

either continuing at previous levels or increasing. PCB contamination, then, is still another problem demanding greater control effort. It is too early to predict eventual PCB effects on numerous biological populations. Clinical or experimental data on lethal accumulation levels of PCB's are rare. There is a need for continued monitoring of fish and wildlife on which to base future control, regulatory, and management strategies.

PLANTS AND AIR POLLUTION

Significant detrimental effects on plants have been linked to atmospheric degradation by gaseous pollutants. The responses of plants to pollution include reduction in growth rate, fewer and/or smaller fruits and seeds, premature loss of leaves, and death. Although areas downwind and in close proximity to pollution sources are the most seriously affected, the generation of atmospheric contaminants from hydrocarbon fuel combustion and various industrial gaseous discharges has become so commonplace that "geographical immunity" (isolation) is becoming more and more difficult. The primary contamination is apparently from oxides of nitrogen and sulfur from coal-fired electrical generating facilities and photochemical oxidants derived mainly from automobile engine combustion.

Figure 5 shows an example of plant effects following exposure to normal atmosphere in the vicinity of Yonkers, New York (NY/007). Fruit production of tomato plants, on both size and numbers, was significantly reduced when the plants were grown in the ambient air. By charcoalfiltering of the air (removing 60-70 percent of the photochemical oxidants) the fruit weight is increased by 50 percent over the fruit grown in unfiltered air. Similar experiments with beans, corn, and alfalfa gave similar results. Another study documented an adverse effect of oxidant air pollutants on plant succession in a mixed conifer forest in California (CA/099). Increased mortality in ponderosa pine occurred.

There are approximately 1000 coal-fired power plants, the main source of sulfur oxides, in the United States. The amount of these oxides released after combustion is determined by the original sulfur content of the fossil fuel and the treatment of the stack gas after combustion. Recent Environmental Protection Agency rulings have probably decreased the release of sulfur oxides from some generating facilities, resulting in some local improvement in air quality. Although studies which monitor growth rate and mortality of lichens (plants found to be highly sensitive to air pollution) (Nash, 1971, 1972) show improvement in air quality in the immediate area of the stacks (WI/OO1), no known investigations have documented a nationwide improvement in air quality. Instead, the studies using pine tree growth (CA/O99) and mortality as indicators show that air quality is decreasing over large regions (WI/OO1).

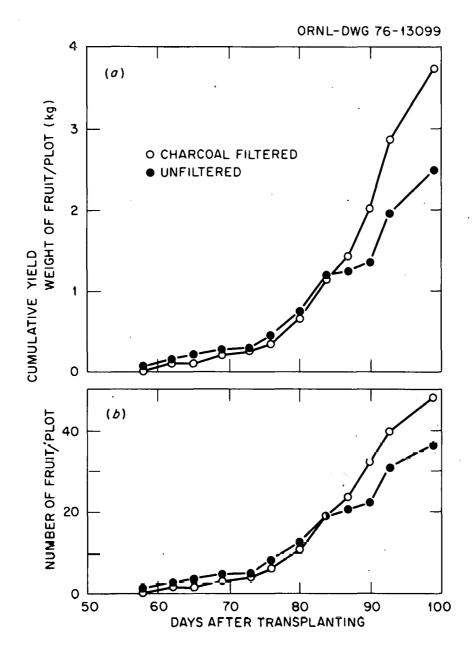


Fig. 5. Cumulative yield (fresh weight and number) of ripe fruit harvested from Fireball tomato plants grown in charcoal-filtered and ambient (unfiltered) air in Yonkers, New York. (from NY/007, unpublished)

BIOLOGICAL EFFECTS OF ENVIRONMENTAL LEAD

When deposited in terrestrial environments, lead usually remains in situ and accumulates in soils except for minor transport by animals. In a mass balance study of a watershed, 97-98% of the fly ash lead deposited was retained in the soil over a six-month period (Lindberg $et\ al.\ 1975$). Lead accumulation sometimes occurs in leaf litter rather than in soils and normal decomposition of leaf litter is reduced in heavily contaminated areas (Watson 1976). Concentrations of lead in earthworms were found to be a function of soil concentration and soil type, with no indication of biological magnification (Van Hook 1974).

In studies of lead residues in plants collected at varying distances from high-volume auto traffic in Illinois (Rolfe and Haney 1975), lead concentration in or on nearly all plant species analyzed was a function of the distance from the road and soil lead content (Fig. 6). The pattern of decreasing lead concentration with increasing distance held for varied soil types and associated plants (IL/052; Institute for Environmental Studies 1974, 1975).

Tree ring analysis for two ten-year periods (Fig. 7) indicated higher concentrations of lead in urban areas compared to rural areas, even in 1910-1920. The ratios of concentration (urban to rural) are similar for each time period (1.42 and 1.66). This suggests that contributions (sources) to each area have remained similar. Of greater interest is the four-fold increase within both urban and rural areas for both time periods.

Studies of animals from heavy-use road areas showed a general correlation between feeding habit and body tissue concentrations of lead. Insectivores (shrews) had higher concentrations of lead than herbivores (voles) or granivores (several species of mice) (IL/052). In large mammals from both urban and rural areas, higher lead concentrations occurred in animals from urban areas although absolute values were relatively low in the selected organs analyzed. Concurrent studies of amphibians, birds, and insects resulted generally in somewhat similar results (Rolfe and Haney 1975).

Aquatic biota in an Illinois drainage system were studied using an urban/rural comparison (Rolfe and Haney 1975). Fish, benthic invertebrates, and aquatic plants were anlyzed for lead content. Again, biota from urban environs contained higher concentrations (Table 2). Fish were not present in the urban stream. High winter lead content in benthic invertebrates was attributed to high surface runoff because frozen ground was relatively impermeable. Obviously, lead levels vary seasonally in aquatic systems, necessitating long-term monitoring studies for trend analysis. The only measurable biological transport of lead occurred as a result of insect drift during late summer. Aquatic systems are thus regarded as "sinks" for lead pollutants, since it appears that lead accumulates in sediments. Furthermore, several studies indicate no biological magnification from one aquatic trophic level to another (Rolfe and Haney 1975).

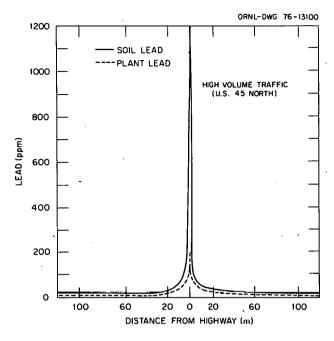


Fig. 6. Soil and plant lead in relation to distance from the highway. (from Rolfe and Haney 1975)

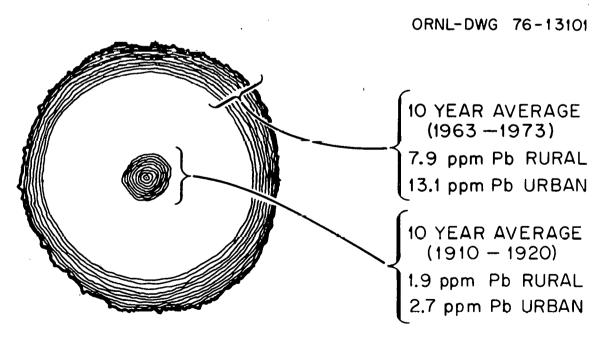


Fig. 7. Tree ring analysis of urban and rural trees. (from Rolfe and Haney 1975)

Table 2. Seasonal lead storage in the biota of the Saline Branch drainage ditch (rural) and Boneyard Creek (urban). Values are μg Pb/m²

Compartment	Organism	Summer	Fall	Winter	Spring
Rura 1	Fish	2.36	3.52	2.81	2.60
	Benthic invertebrates	24.07	27.45	60.48	40.90
	Plants	298.91 ^a			
	Total	324.34	30.97	63.29	43.50
Urban	Fish		ab	sent	
	Benthic invertebrates	112.22	874.50	4497.41	839.13
•	Plants	2608.70 ^a			
•	Total	2720.92	874.50	4497.41	839.13

a Highly variable because of biomass fluctuations. From Rolfe and Haney (1975).

FORESTRY TRENDS IN THE SOUTHEASTERN UNITED STATES

Land use changes coupled with natural successional characteristics of certain tree species may cause problems for the timber industry in the southeastern U. S. (Knight 1973). Timber management practices are also contributing to a serious reduction in the habitat of at least one endangered bird species, the Red-Cockaded Woodpecker (Lay and Sweptson 1975).

The USDA-Forest Service has maintained an inventory of forest conditions since the 1930's (Hendee 1967). Forest monitoring in the southeast has heretofore indicated a shift from abandoned agricultural land to natural pine forests or artificial pine plantations. As a result, timberland in the southeast has constantly increased since the 1930's, as evidenced by inventories as late as the 1960's. More recent inventories (Table 3), however, show the forest acreage, and especially the commercial pine timberland, is beginning in some states to decrease (Knight 1975, Knight and McClure 1975).

The increase in areal extent of mines, industrial development, landfills, airports, golf courses, subdivisions, and overall encroachment of community development has reversed the trend of a net increase of forest land as a result of agricultural abandonment. Also, the decrease in pine forest is a result of natural regeneration processes of both pine and hardwood species. Until now, the timber industry in the southeast has relied heavily upon the naturally regenerated pine which became established on abandoned cropland. This habitat is ideal for the initiation of pine seedlings, and has accounted for a large part of the commercial pine-timber in the southeast for the past several decades because the naturally established forests have been allowed to mature for harvesting. After cutting, however, natural reestablishment of pines does not occur (Boyce and McClure 1975). Instead, the usual succession is to a much slower growing and less valuable mixture of hardwood species. As pine forests in the southeast are harvested and not replanted to pine, the timber industry will have to rely more on intensive management procedures to supply the demand for forest products.

In the southeast, both hardwood and softwood growing stock has increased in the past 20 years. Softwoods (mostly pine) show a marked upward trend in the large pole sizes (8-10 inch diameter) (Fig. 8), an increase also reflected in sawtimber sizes of hardwoods, particularly trees from ten to 18 inches in diameter (Fig. 9). These trends are probably indicative of a relative stabilization of land use changes, good management practices, and a regional awareness of the need to preserve the natural resource base of the economy. While pine harvesting has been rising, the trend parallels the growth of pine, indicating that conditions are being maintained. Hardwood removal rates are declining while growth continues at an accelerated pace, leading to a forecast of excellent hardwood timber resources in the southeast for some time to come.

Table 3. Land area, by class, of major types in North Carolina, 1955, 1964, and 1974^a

Land use class	Survey completion date			Change		
	1955	1964	1974	19	64-1974	
		Acre	:S			
Forest land:						
Commercial forest land:						
Pine and oak-pine types	10,021,900	10,671,457	9,388,453	-1	,283,004	
Hardwood types	9,319,500	9,304,463	10,156,382	+	851,919	
Total	19,341,400	19,975 920	19,544,835	-	431,085	
Noncommercial forest land:		·				
Productive-reserved	340,500	372,002	433,792	+	61,790	
Unproductive	393,800	48,767	46,230	-	2,537	
Total	734,300	420,769	480,022	+	59,253	
Nonforest land:	11,192,200	10,737,671	11,030,256	+	292,585	

 $^{^{\}rm a}$ Modified from Knight and McClure 1975.

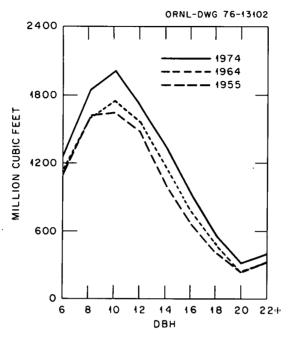


Fig. 8. Volume of softwood growing stock, by tree diameter, 1955, 1964, and 1974. (from Knight and McClure 1975)

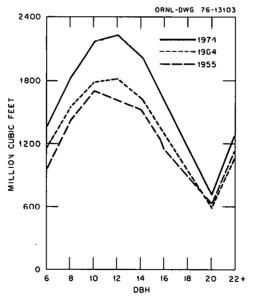


Fig. 9. Volume of hardwood growing stock, by tree diameter, 1955, 1964, and 1974. (from Knight and McClure 1975)

Throughout the eastern United States, this general trend is evident (Table 4). These data reflect total volume of all hardwood species, however, and do not convey any information on selected species. Between 1963 and 1971, sawtimber volume showed a major increase for certain oaks (Quercus spp.) and Yellow Poplar (Liriodendron tulipifera) with smaller gains for Sugar Maple (Acer saccharum) and ash (Fraxinus spp.) (Fig. 10). This was coupled, however, with more than a 30% decline in Yellow Birch (Betula lutea), and a continued drop in the amounts of Sweetgum (Liquidambar styraciflua), Walnut (Juglans nigra), and Tupelo (Nyssa sylvatica). Much of the decrease in Yellow Birch is attributable to a birch dieback epidemic in the northeast in the 1950's (Sternitzke 1974).

Another point of ecological concern in the southeast, and one related to pine-forest management practices, is the precarious status of the Red-Cockaded Woodpecker (Dendrocopus borealis) (Lay and Swepston 1975, TX/088, MS/028). This endangered species specifically requires live, mature pines for nesting. The nesting tree must "chip" well (young, fast-growing trees do not chip well), and must usually be a tree at least 60 years old with red-heart fungus. Since pine forests are usually on management cycles where trees are cut in less than 50 years, the mature pines needed for woodpecker nesting sites are disappearing. Forest management mitigates against the kind of tree required by the Red-Cockaded Woodpecker because growth is slower as the tree ages, the death rate is higher, and the tree is less profitable for the commercial timber owner. The relatively simple practice of leaving scattered stands of old pines within the known range could perhaps ensure the survival of the Red-Cockaded Woodpecker.

The gradual decrease in pine timber in the southeast and the decrease in numbers of the Red-Cockaded Woodpecker point to the need to implement a holistic approach to the management of the entire southeastern forest ecosystem. This approach should provide a means to realize the commercial benefits of the forests as well as to protect the delicate balance of nature by coupling the exploitation of natural systems with continued preservation of all component parts.

TERRESTRIAL HABITAT STATUS IN THE UNITED STATES

This assessment, based on an analysis of approximately 40 monitoring programs involving birds and mammals and their habitats, shows that industrial (AZ/010, WY/001, AZ/046) and residential development (IL/035, MD/036, MD/039, NM/029), land-use changes (M0/038, TX/006, IN/018), and forest management techniques (MT/028, MS/028) are causing a general reduction in wildlife habitat and a subsequent decrease in numbers of several mammal and bird populations. Of the programs examined, an exception to this generalization is an intensive management effort that has resulted in an increase in the wild turkey population in Vermont (VT/025). However, this particular change has been caused by a continuous "trap-and-transfer" effort over the past seven years. Bison and beaver are other species responding with increased population densities as a result of intensive management.

Table 4. Volume of hardwood growing stock on commercial forest land in 1971 and change since 1963^{a}

Region	Volume	Change	
	Million cubic feet	Percent	
North Central	57,008	+18	
Northeast	61,902	+17	
South Central	41,034	+ 1	
Southeast	40,800	+ 9	
All regions	200,744	+12	

a From Sternitzke 1974.

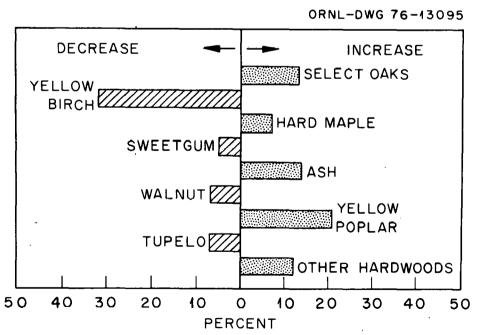


Fig. 10. Change in hardwood sawtimber volume since 1963 in the eastern United States. (from Sternitzke 1974)

The most consistent trend in habitat deterioration is related to elk in the northwestern U. S. (MT/Oll), and deer in many parts of the country (WA/O34, CA/153, Hines 1973). Several studies show that timber industry practices, e. g., road building and clear-cut methods of timber harvest, have caused a general reduction in population numbers of these big-game mammals. Since some of the population reduction is associated with timber management techniques (MT/O28, MS/O28), the decrease in numbers for a certain area may be temporary. For example, a study in western Oregon (OR/OlO) shows a decrease in elk and deer habitat for a large region after clear-cutting, but upon recovery of the forest, the carrying capacity approaches that which existed before timber harvesting.

This return to previous carrying capacity assumes that natural conditions prevail long enough to permit a recovery of the landscape to suitable habitat conditions. If the disturbance is not reversible, then both the species range and the potential carrying capacity of the region are reduced (NY/065). As mentioned above, the acreage of habitat for various organisms is being lost, but sophisticated management practices can frequently maintain or increase population densities, thus offsetting the effect of range reduction (OR/OlO). The general trend in suitable habitat acreage appears to be downward at the present time, but unfortunately, data do not exist that can project the effectiveness of maintaining viable populations, especially of big game mammals, by reducing the species range and applying more intensive management practices.

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