



**USDA FOREST SERVICE
FIRST APPROXIMATION REPORT
FOR SUSTAINABLE FOREST MANAGEMENT**



P.O. BOX 96090
Washington, DC 20090-6538
Office Phone: 202-205-1033
Fax: 202-205-1546
e-mail: /s=k.jesch/ou1=w01c@mhs.attmail.com

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**REPORT OF THE UNITED STATES
ON THE CRITERIA AND INDICATORS FOR
THE SUSTAINABLE MANAGEMENT OF
TEMPERATE AND BOREAL FORESTS**

June 1997

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REPORT OF THE UNITED STATES ON THE CRITERIA AND INDICATORS FOR THE SUSTAINABLE MANAGEMENT OF TEMPERATE AND BOREAL FORESTS 1997

Chapter 1: Introduction

Forests are essential to the long-term well-being of local populations, Nations, and the earth's biosphere. The United Nations Conference on Environment and Development (UNCED), which met in Rio de Janeiro in June 1992, focused world attention on the importance of sustainable forest management as a key component of sustainable development. UNCED is also popularly known as the Earth Summit or the Rio Summit.) In adopting the Statement of Forest Principles and Chapter 11 of Agenda 21, UNCED recognized the importance of sustainably managing all types of forests, including temperate and boreal forests in order to meet the needs of present and future generations.

A year after UNCED, in September 1993 the United Nations Conference on Security and Cooperation in Europe sponsored an international seminar in Montreal, Canada on Sustainable Development of Boreal and Temperate Forests. This conference provided the conceptual basis for subsequent regional and international initiatives to develop criteria and indicators for sustainable forest management.

Following the CSCE seminar, European countries decided it was important to work as a region under the framework of the Helsinki Ministerial Declaration and its four resolutions to which they were all signatories. The European effort on criteria and indicators is now known as the Helsinki Process or the Pan-European Process.

Subsequently, Canada took the lead in launching an initiative among other temperate and boreal countries, with the specific purpose of developing and implementing internationally agreed criteria and indicators for sustainable forest management. This initiative led to the formation in June 1994 of the Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests, now known as the Montreal Process.

The Montreal Process Working Group now includes Argentina, Australia, Canada, Chile, China, Japan, the Republic of Korea, Mexico, New Zealand, the Russian Federation, United States of America, and Uruguay. These countries cover five continents and together represent 90 percent of the world's temperate and boreal forests (as well as areas of tropical forests) and 60 percent of all forests on the globe. They also account for 45 percent of world trade in wood and wood

products and 35 percent of the world's population. The Working Group is supported by a Liaison Office hosted by Canada in Ottawa.

In February 1995 in Santiago, Chile, the original ten Montreal Process countries endorsed a statement of political commitment known as the "Santiago Declaration," together with a comprehensive set of seven criteria and 67 indicators for the conservation and sustainable management of temperate and boreal forests for use by their respective policy makers at the national level. These criteria and indicators are listed at the end of this Chapter, beginning on page 1-8. Argentina and Uruguay subsequently endorsed the Santiago Declaration upon joining the Montreal Process.

The Santiago Declaration is an important step to implementing the UNCED Forest Principles and Agenda 21. It also supports the commitment made by tropical timber producer countries in January 1994 to the goal of achieving sustainable management of their respective forests by the year 2000.

The first step in the implementation of the Montreal Process criteria and indicators was an initial survey by the Liaison Office to determine the current availability of data for indicators in each country and the capacity of countries to report on indicators. Interim survey results indicate that while data availability and reporting capacity varies greatly among the 12 countries, most countries have data for and can report on 50 percent or more of the 67 indicators. The Liaison Office survey also indicates that while resolution of some of the data gaps and reporting problems would involve new research, monitoring systems, and reporting methods, others could be resolved by better defining terms and elaborating measurement approaches.

The differences in data availability and reporting capacity found by the survey reflect the wide differences among the Montreal Process countries in terms of forest character, land ownership, population, system and structure of government, and economic development. One of the great strengths of the Montreal Process is the diversity of the countries involved, which resulted in a set of criteria and indicators that should be useful to many other countries that are not members of the Working Group.

Under generally agreed guidelines, the twelve individual member countries were to produce individual first approximation reports, i.e., national reports on the conditions of the forests in each nation, to be submitted in June to the Montreal Coordinator in Ottawa. The Montreal Process Working Group would then prepare a consolidated first approximation report based on the efforts of initial country efforts to measure the criteria and indicators. The consolidated report will be distributed at the Eleventh World Forestry Congress in Antalya, Turkey, in October 1997. How the U.S. approaches its assessment of domestic sustainable forest management will be examined closely by the world forestry community and by non-governmental organizations, and judged for its honesty and thoroughness.

In preparing this report, the U.S. has obtained data from the major federal land management agencies and their dependent agencies, including the Forest Service and Natural Resources Conservation Service in the Department of Agriculture, the Bureau of Land Management, Bureau of Indian Affairs, US Geological Service, and US Fish and Wildlife Service in the Department of Interior, and the Environmental Protection Agency, among others. In addition, an extensive consultative process involved a wide array of stakeholders, including the National Association of State Foresters, the lumber and wood products industry, non-industrial forest landowners, Native American Intertribal Timber Council, various non-governmental conservation organizations and representatives of labor (e.g., the Pulp and Paper workers Resource Council), and forestry-related professional societies.

As expected, information for some of the indicators, while data is lacking almost completely for others. For most of the indicators, however, some information was available. In some cases, data has been collected only in recent years, making it impossible to determine trends; in other cases, data elements have not been measured in all locations using consistent definitions or methodologies, making it inappropriate to draw conclusions for the nation as a whole. Finally, in consultation with the various stakeholders in the U.S., it was discovered that a tremendous amount of data already exists, but which could not feasibly be incorporated into this first approximation report.

This document constitutes a first attempt of the United States to produce a report as agreed to under the Santiago Declaration. Our current ability to report is not complete and, in fact, many indicators have not been measured at all in the past. The first approximation report, then, represents a beginning in what will be an ongoing process to assess forest management and monitoring capability in the United States to help achieve the goal and commitment to sustainable forest management.

OVERVIEW AND EVOLUTION OF U.S. FORESTS

The land area of the United States currently includes 737 million acres (300.8 million ha) of forest land. These forests are complex communities of plants, animals and often people living within them or nearby. They are a significant component of the country's landscapes and vital to the ecosystems to which they contribute. Their diversity, both biologically, and in terms of the goods and benefits they provide, play a major role in the health and welfare of the nation as a whole and in particular to local watersheds, communities and economies.

These lands vary in character from the boreal forests of Alaska, to the temperate forests of most of the continental U.S., to the tropical forests of Puerto Rico and Hawaii. As such, they vary in their associated plant and animal associations, and the amenities for which they are valued.

Some 42 percent of the forest lands in the United States are owned by Federal, State or local governments. Of the remaining 58 percent, 10 percent is owned by industry and 48 percent by non-industrial private forest owners. Of this total however, 6 percent or 47 million acres (19.2 million ha) of U.S. forest land, is set aside as reserves and managed for wilderness, parks, or other classifications that exclude commercial timber harvest.

Today's forests are in part the legacy of this continent's European settlement, agriculture, and industry-driven development that began with the arrival of the first settlers. Native American subsistence-driven alteration of these lands, was by European standards, relatively small. By the close of the 19th century however, European population had expanded from 5 to 76 million, significantly changing the land's appearance. Forests were cleared for agriculture and to supply wood and other products (bark for tanning leather, fuel for household and industrial use, etc.) for the young nation's growth. This process significantly reduced most Eastern forest area but established forest-associated communities and economies that survive to the present day.

With the beginning of the 20th century, events combined to alter future forest use patterns. Westward migration placed increasing numbers of new settlements in locations lacking assured year-round supplies of quality water. Watershed protection thus became an important issue. Coincidentally, the clearing of Eastern forests prompted a westward move of the nation's timber industry. These developments focused the public's attention on the need for resource conservation. This public awareness significantly altered subsequent forest use patterns by elevating the role of government in the management of the nation's natural resources. The development of a national conservation ethic in turn led to the creation of Federal and State resource conservation laws, reserves, and management agencies.

Today, forests cover more area and are more economically productive than those of one hundred years ago. Overall water quality is better assured because of public ownership in mountain areas. Some plants and animals, once thought to be endangered, have recovered. Science, laws, and regulations provide better management guidance.

These successes are not complete however. Not all forests are healthy or productive. Many species populations are declining and, while some have not yet been formally listed on the endangered species list, they none-the-less, have become biologically rare or imperiled. Past practices (especially fire exclusion from fire-dependent ecosystems), current economics, introduced exotic plants and animals, elimination of old growth forests and unroaded areas, forest conversion to other uses, and a variety of development pressures, all combine to form stern challenges to private, State and Federal management practices. At the same time, however, the public's interest, appreciation, and involvement in natural resource issues has never been greater nor more effective in the shaping of both local and national natural resource management decisions.

DESCRIPTION OF FORESTS IN THE UNITED STATES

The vegetative cover of the U.S. varies greatly and is directly related to annual precipitation levels and available moisture. Those areas receiving substantial precipitation are predominantly forested, while semiarid and arid locations support grasses and shrubs and are often associated with irrigated agriculture and/or rangeland.

Forests are widely, though unevenly distributed across the continent. They range from the sparse scrub lands of the arid interior West, to the highly productive forests of the South and Pacific Coast. They include pure hardwood and softwood stands as well as mixtures of both. Distribution varies by state, from North Dakota with less than 1 percent of its area forested, to Maine with 89 percent of its area in forests.

To better differentiate the character and status of forests, the following definitions have been used throughout this report: *Reserves* is a formal designation of forest lands which are set aside for purposes other than the production of lumber and/or a particular dedicated use, e.g. watershed, habitat, and other values. *Timberlands* have been defined as forests capable of producing at least 20 cubic feet per acre of industrial wood annually. *Woodlands* are defined as forests that are incapable of this level of productivity.

Roughly 212.6 million hectares (525 million acres), or two thirds of the nation's forests are classified as timberlands, and the remaining 85.8 million hectares (212 million acres) are classified as woodlands. Almost 19 million of these 298.4 million hectares of forests have been set aside to be managed for primary purposes other than timber production. In total, today's forests have recovered to an area equal to 70 percent of that thought to be originally forested in 1630, or approximately one third of the nation forested at present. This level has remained essentially stable with variations of less than 0.1 percent recorded over the last 30 years.

For the most part, forest growth nationally has exceeded harvest since the 1940's, with overall volume per acre growth figures increasing by one third since the early 1950's. Regional variations continue with both minor increases and declines driven by local as well as national influences.

More than 80 percent of the nation's current domestic timber harvest comes from private lands, including about 30 percent from industrial ownerships and 50 percent from nonindustrial ownerships. While recent declines in harvest levels from public lands, especially federally owned, may be compensated for through increased imports, harvest levels from private ownerships may be called upon to make up any long term deficits. Total harvest levels continue at historically high levels, in excess of 16 billion board feet, with averages increasing regularly since the 1950's.

Forest Cover Types

The forest land of the United States spans a wide range of latitudes, elevations, precipitation levels and soil types. As a consequence, the species composition of these forests varies significantly across the continent. However, relevant geographic classifications have been developed.

The six sub-regions of Eastern forest land include 151.4 million hectares (374 million acres) of unreserved forest, in both conifers and hardwoods (Table 1-1). In the Lake States, 20.6 million hectares are forest; the Central States have 10.1 million; New England has 13 million; the Mid-Atlantic States have 24.7 million; the Atlantic States have 35.6 million; and the Gulf States have 54 million hectares.

The five sub-regions of Western forest include 127.5 million hectares of the unreserved forest, mostly in conifers (Table 1-2). In the Great Plains States, 1.7 million hectares are in forest land; in the Intermountain States, 55.1 million; Alaska has 52.2 million; the Pacific Northwest has 19.4 million; and the Pacific Southwest has 15.8 million ha).

All of the nation's forests provide some range of the multiple uses for which they are actively managed. While most of the nation's highest wood producing forests exist in the Pacific Northwest and the South Central softwood forests, other forested areas are highly productive in terms of water, habitat, recreation, or non-wood forest products such as foliage of fungi. Over the years, this array of goods and services has helped focus a history of policies designed to deal with the management of both public and privately owned lands. Several management themes are addressed in these policies:

- Fire suppression, prevention and public education to protect the forest;

Table 1.1. Eastern Forest-Type Groups.

Forest Type Groups	Million Acres	Million Hectares
White-Red-Jack Pine	13.7	5.6
Spruce-Fir	19.0	7.8
Longleaf-Slash	14.1	5.8
Loblolly-Shortleaf	49.4	20.2
Oak-Pine	32.1	13.1
Oak-Hickory	127.4	52.0
Oak-Gum-Cypress	28.7	11.7
Elm-Ash-Cottonwood	14.2	5.8
Maple-Beech-Birch	47.3	19.3
Aspen Birch	16.5	6.7
miscellaneous species	5.9	2.4

Table 1.2. Western Forest-Type Groups

Forest-Type Groups	Million Acres	Million Hectares
Douglas Fir	37.3	15.2
Ponderosa Pine	27.9	11.4
Western White Pine	.2	0.1
Fir/Spruce	53.1	21.7
Hemlock-Sitka Spruce	12.2	5.0
Larch	2.1	0.9
Lodgepole Pine	13.5	5.5
Redwood	1.1	0.4
other Western Softwoods	65.4	26.7
Western Hardwoods	45.8	18.7
Pinon-Juniper	46.2	18.9
Chaparral	6.1	2.5

- Establishing and expanding forests for sustained multiple use; and
- Improving understanding of the science of forest culture and management by research at federal and state experiment stations and universities;
- Improving the efficiency with which wood products are designed, manufactured, marketed, employed and recycled;
- Disclosure to the public of proposed activities and probable related environmental impacts, and public participation in decision making processes;
- Strong cooperation among agencies, associations, individuals, and other organizations to facilitate the management of the nation's natural resource base.
- Establishment of tree nurseries to improve the productivity of commercial forests on both public and private lands;
- Establishing and enhancing the profession of forestry and other natural resource disciplines by the establishment of accredited natural resource schools, professional societies, and the like;

In summary, the dynamics of this nation's relationship with its natural resources has generated a plateau in area and growing stock that appears to be both stable and maintainable in the face of growing demand for diversity of goods and services. Today's overall recovery of many forested ecosystems of the United States are the result of a resilience and responsiveness to management. Policies and science appear to facilitate this dynamic.

CRITERIA AND INDICATORS FOR THE CONSERVATION AND SUSTAINABLE MANAGEMENT OF TEMPERATE AND BOREAL FORESTS

Criterion 1: Conservation of biological diversity

Ecosystem Diversity

1. Extent of area by forest type relative to total forest area.
2. Extent of area by forest type and by age class or successional stage.
3. Extent of area by forest type in protected area categories as defined by IUCN or other classification systems.
4. Extent of areas by forest type in protected areas defined by age class or successional stage.
5. Fragmentation of forest types.

Species Diversity

6. The number of forest dependent species.
7. The status (rare, threatened, endangered, or extinct) of forest dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment.

Genetic Diversity

8. Number of forest dependent species that occupy a small portion of their former range.
9. Population levels of representative species from diverse habitats monitored across their range.

Criterion 2: Maintenance of productive capacity of forest ecosystems.

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| <ol style="list-style-type: none">10. Area of forest land and net area of forest land available for timber production.11. Total growing stock of both merchantable and nonmerchantable tree species on forest land available for timber production.12. The area and growing stock of plantations of native and exotic species. | <ol style="list-style-type: none">13. Annual removal of wood products compared to the volume determined to be sustainable.14. Annual removal of non-timber forest products (e.g. fur bearers, berries, mushrooms, game), compared to the level determined to be sustainable. |
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Criterion 3: maintenance of forest ecosystem health and vitality

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| <ol style="list-style-type: none">15. Area and percent of forest affected by processes or agents beyond the range of historic variation, e.g. by insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinisation, and domestic animals.16. Area and percent of forest land subjected to levels of specific air pollutants (e.g. sulfates, nitrate, | <p>ozone) or ultra violet B that may cause negative impacts on the forest ecosystem.</p> <ol style="list-style-type: none">17. Area and percent of forest land with diminished biological components indicative of changes in fundamental ecological processes (e.g. soil, nutrient cycling, seed dispersion, pollination) and/or ecological continuity. |
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Criterion 4: Conservation and maintenance of soil and water resources

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| <p>18. Area and percent of forest land with significant soil erosion.</p> <p>19. Area and percent of forest land managed primarily for protective functions. e.g. watersheds, flood protection, avalanche protection, riparian zones.</p> <p>20. Percent of stream kilometers in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation.</p> <p>21. Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties.</p> <p>22. Area and percent of forest land with significant</p> | <p>compaction or change in soil physical properties resulting from human activities.</p> <p>23. Percent of water bodies in forest areas (e.g. stream kilometers, lake hectares) with significant variance of biological diversity from the historic range of variability.</p> <p>24. Percent of water bodies in forest areas (e.g. stream kilometers, lake hectares) with significant variation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation or temperature change.</p> <p>25. Area and percent of forest land experiencing an accumulation of persistent toxic substances.</p> |
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Criterion 5: Maintenance of forest contribution to global carbon cycles

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| <p>26. Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age class, and successional stages.</p> <p>27. Contribution of forest ecosystems to the total</p> | <p>global carbon budget, including absorption and release of carbon.</p> <p>28. Contribution of forest products to the global carbon budget.</p> |
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Criterion 6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies**Production and consumption**

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| <p>29. Value and volume of wood and wood products production, including value added through downstream processing.</p> <p>30. Value and quantities of production of non-wood forest products.</p> <p>31. Supply and consumption of wood and wood</p> | <p>products, including consumption per capita.</p> <p>32. Value of wood and non-wood products production as percentage of GDP.</p> <p>33. Degree of recycling of forest products.</p> <p>34. Supply and consumption/use of non-wood products.</p> |
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Recreation and Tourism

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| <p>35. Area and percent of forest land managed for general recreation and tourism, in relation to the total area of forest land.</p> <p>36. Number and type of facilities available for general recreation and tourism, in relation to population</p> | <p>and forest area.</p> <p>37. Number of visitor days attributed to recreation and tourism, in relation to population and forest area.</p> |
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Investment in the forest sector

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| <p>38. Value of investment, including investment in forest growing, forest health and management, planted forests, wood processing, recreation and tourism.</p> | <p>39. Level of expenditure on research and development, and education.</p> <p>40. Extension and use of new and improved technology.</p> <p>41. Rates of return on investment.</p> |
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Cultural, social and spiritual needs and values

42. Area and percent of forest land managed in relation to the total area of forest land to protect

the range of cultural, social and spiritual needs and values.

43. Non-consumptive-use forest values.

Employment and community needs

44. Direct and indirect employment in the forest sector and the forest sector employment as a proportion of total employment.
45. Average wage rates and injury rates in major employment categories within the forest sector.

46. Viability and adaptability to changing economic conditions, of forest dependent communities, including indigenous communities.
47. Area and percent of forest land used for subsistence purposes.

Criterion 7: Legal, institutional and economic framework for forest conservation and sustainable management

Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests, including the extent to which it:

48. Clarifies property rights, provides for appropriate land tenure arrangements, recognizes customary and traditional rights of indigenous people, and provides means of resolving property disputes by due process.
49. Provides for periodic forest-related planning, assessment, and policy review that recognizes the range of forest values, including coordination with relevant sectors.

50. Provides opportunities for public participation in public policy and decision making related to forests and public access to information.
51. Encourages best practice codes for forest management.
52. Provides for the management of forests to conserve special environmental, cultural, social and/or scientific values.

Extent to which the institutional framework supports the conservation and sustainable management of forests, including the capacity to:

53. Provide for public involvement activities and public education, awareness and extension programs, and make available forest related information.
54. Undertake and implement periodic forest-related planning, assessment, and policy review including cross-sectoral planning and coordination.

55. Develop and maintain human resource skills across relevant disciplines.
56. Develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and support forest management.
57. Enforce laws, regulations and guidelines.

Extent to which the economic framework (economic policies and measures) supports the conservation and sustainable management of forests through:

58. Investment and taxation policies and a regulatory environment which recognize the long-term nature of investments and permit the flow of capital in and out of the forest sector in response to market signals, non-market economic

- valuations, and public policy decisions in order to meet long-term demands for forest products and services.
59. Non-discriminatory trade policies for forest products.

Capacity to measure and monitor changes in the conservation and sustainable management of forests, including:

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| 60. Availability and extent of up-to-date data, statistics and other information important to measuring or describing indicators associated with criteria 1-7. | 61. Scope, frequency and statistical reliability of forest inventories, assessments, monitoring and other relevant information. |
| | 62. Compatibility with other countries in measuring, monitoring and reporting on indicators. |

Capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services, including:

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| 63. Development of scientific understanding of forest ecosystem characteristics and functions. | 65. New technologies and the capacity to assess the socioeconomic consequences associated with the introduction of new technologies. |
| 64. Development of methodologies to measure and integrate environmental and social costs and benefits into markets and public policies, and to reflect forest related resource depletion or replenishment in national accounting systems. | 66. Enhancement of ability to predict impacts of human intervention on forests. |
| | 67. Ability to predict impacts on forests of possible climate change. |

Chapter 2

Criterion 1 CONSERVING BIOLOGICAL DIVERSITY

I. INTRODUCTION

Evaluation of biological diversity considers elements of the diversity of whole ecosystems, the diversity among species, and genetic diversity within species. The ultimate goal of conserving biological diversity is to ensure the survival of species and the genetic variability within those species. Viable breeding populations of species and their natural genetic variation are part of interdependent physical and biological systems or processes--communities or ecosystems. The successional stage, condition, and distribution of forest communities are important to fundamental ecological processes, as well as to the systems themselves and the future of species diversity associated with forests.

Data for biological diversity indicators are currently available from various sources. Analysis and interpretation in this data describes trends and identifies additional data needs. Definitions used here are based on those used in the USDA Forest Service, Forest Inventory and Analysis program (FIA). Additional definitions are taken from the USDA Natural Resources and Conservation Service's National Resources Inventory program (NRI), the USDI National Biological Survey program (NBS), the Federal Geospatial Data Committee (FGDC), and a multitude of State- and local-level natural resource inventory and survey efforts.

Care must taken in using vegetation data because of variations in its definition, e.g., forest lands must have a certain percentage of trees per acre. Care must also be used in calculating fragmentation, for example, multi-scale measures of fragmentation may be difficult to interpret or may have little meaning.

ii. INDICATOR REPORTS

A. Ecosystem Diversity

Two primary sources of natural resource data have been available on a broad scale: the FIA program and the NRI program. Standard methodologies are used in both programs. In recent years the two agencies have developed standard protocols to ensure that the methods used for future inventories will be consistent with one another. A third source for biological data is the Northern Breeding Bird Survey.

In southern States, the average cycle for FIA data is approximately 7 to 8 years. In western States, the average cycle is well beyond the national goal of every ten years. The NRI is conducted every 5 years on a national level. Data for groups of States and individual States may be compiled using the 1992 RPA database. Updated data and data for areas described by nontraditional boundaries may be compiled for groups of States, individual States, and counties,

using FIA's Eastwide and Westwide databases and auxiliary databases maintained by regional FIA projects. On a broad scale, RPA data are reliable; the determination of forest type is reasonably consistent across the country and can be used with confidence.

To date, national inventory data are available for all commercial forest land in the U.S. Inventory of reserved forest land, including wilderness areas, national parks, State parks, and some other publicly owned forest land, is underway. Trend data for smaller areas such as States, or groups of counties within states, are available for some areas from regional FIA projects. In most cases, the data are available by State for ownership, stand size class, and stocking class, etc. Information on forest type is available for 1952, 1962, and 1972.

Additional data are available from a variety of Federal, State, and local agencies, but these sources generally are not national in scope, may have limitations on compatibility both spatially and temporally, represent a wide variety of methodologies, and are often concentrated within specific ownerships. Therefore, the value of these data are limited for purposes of a national assessment.

INDICATOR 1: Extent of area by forest type relative to total forest area.

Ecological processes and viable populations of species that are characteristic of forest ecosystems are usually dependent on a contiguous ecosystem or ecosystems of a certain minimum size. Genetic diversity within a species population depends on the maintenance of sub-populations and the existence of forest ecosystems that cover a large part of their natural range. Forests may constitute all or a part of the habitat necessary for a species' survival.

Data on extent of area by forest type is presented here for 1977, 1987, and 1982. Additional information is available and a more in-depth analyses of status and trends of forest/timberland area by forest type have been reported elsewhere.

Data Summary

Area of Forest Land: With the arrival of European immigrants around 1630, the total area of forest land is estimated to have been 423 million hectares (1,045 million acres). This represented about 46 percent of the total land area. The area of forest land steadily declined as settlement proceeded, to an estimated 307 million hectares in 1907, or 33 percent of the total land area. This decline continued until the mid-1980's when a low of 295 million hectares was recorded. The Eastern U.S., particularly the Northeastern/North Central portions, experienced a majority of the decrease, having declined from approximately 263 million hectares in 1630 to 157 million hectares in 1953. Since the 1950's, the area of forested land in the East continued to decline but at a much lower rate; from 157 million hectares in 1953, to 155.6 million hectares in 1992. In

the West, the area of forest land has experienced only slight declines, from 150 million hectares in 1953, to 142.5 million hectares in 1992.

Area of Timberland by Forest Type: Between 1977 and 1992 in the eastern States, the timberland area of white-red-jack pine, oak-hickory, and maple-beech-birch increased. The area of spruce-fir, oak-gum-cypress, and loblolly-shortleaf pine remained relatively static from 1977

Table 2-1. Area of forest land in the United States by forest type and region.
(Thousands of Hectares)

	1977	1987	1992
Eastern United States			
White-red-jack pine	5,057	5,868	5,874
Fir-spruce	8,589	7,932	7,967
Longleaf-slash pine	6,904	6,394	5,780
Loblolly-shortleaf pine	20,375	19,870	20,098
Oak-pine	14,198	12,788	13,036
Oak hickory	46,038	50,586	52,475
Oak-gum-cypress	11,811	11,938	11,822
Elm-ash-cottonwood	9,435	6,111	5,920
Maple-beech-birch	15,682	19,384	20,550
Aspen-birch	8,268	7,527	6,993
Other types	...	...	2,154
Nonstocked	4,105	2,630	2,454
Unknown	...	...	504
Eastern Total	150,463	151,029	155,626
Western United States:			
Douglas-fir	15,583	16,633	17,540
Ponderosa pine	13,558	12,383	12,738
Western white pine	229	121	85
Fir-spruce	45,883	41,885	24,149
Hemlock-Sitka spruce	8,003	7,730	6,555
Larch	1,139	1,093	873
Lodgepole pine	8,586	7,365	7,191
Redwood	318	526	534
Other western softwoods	1,799	11,008	28,147
Western hardwoods	16,092	19,789	19,963
Nonstocked	2,640	2,185	2,356
Total	113,831	120,718	120,131
Other forest:			
Pinyon-juniper	19,144	20,963	19,463
Chaparral	6,263	3,278	2,647
Unknown	8,375	...	259
Total	33,782	24,241	22,369
Eastern Total	150,463	151,029	155,626
Western Total	147,613	144,959	142,499
United States	298,076	295,988	298,125

to 1992. During the same time period in the western States, the timberland area of Douglas-fir, fir-spruce, redwood, other softwoods, and western hardwoods increased. Changes for fir-spruce and other western softwoods may reflect reclassification between inventories by FIA, rather than an actual on-the-ground change in area. Of note is that the area of nonstocked timberland significantly decreased in both regions between 1977 and 1992.

Conversely, between 1977 and 1992, the timberland area of longleaf-slash pine, oak-pine, elm-ash-cottonwood and aspen-birch declined in the eastern States. In the West, the timberland area of ponderosa pine, western white pine, hemlock-Sitka spruce, larch, and lodgepole pine decreased during the same time period.

Table 2-2. Forest cover types (a), 1950-1992 in million hectares. (Source: 1992 RPA Assessment Report GTR-RM-234.)

Forest Types	1950	1970	1977	1987	1992
Softwood	137.0	136.2	132.5	138.3	149.2
Hardwood	154.2	157.6	154.2	146.2	135.9
Mixed Oak-pine wood	14.8	14.5	14.2	13.6	13.0
TOTAL AREA	306.0	308.4	300.9	298.0	298.1

Interpretation

In the eastern States, forests are maturing as represented by the increase in the area of forest types that are more representative of later stages of succession, and by the decrease in the area of forest types that are more representative of earlier successional stages. Increases in earlier successional forest types, such as cottonwood, birch, and poplar, reflect either new forest land or forest land that was harvested to the point where a completely new stand was established.

Forest lands of the United States are in the process of converting between forest types and are increasing in overall total area and stocking levels. Some forest types are not maintaining themselves at the current levels but this may result from natural successional processes or landowner management decisions. For example, the level of aspen-birch could be maintained, but it would require greatly increased harvesting or other disturbance. Currently, landowners are not interrupting the natural successional processes to ensure the long-term maintenance of forest types such as aspen-birch; however, the overall total of forest land is not impacted from swings in area between forest types.

From an ecosystem diversity viewpoint, one of the greatest concerns is for those forest types that are decreasing in area, such as aspen-birch, and for those forest types that might be increasing in area but are subject to selective harvesting, such as oak-hickory. Selective harvesting and

management does tend to remove "noncommercial" species and lower value species which can reduce the overall diversity, even while it enhances these forests from a timber production standpoint. Questions concerning wildlife habitat acreage requirements for forest types cannot be addressed with the current data.

INDICATOR 2: Extent of area by forest type and age class or successional stage.

Ecological processes and the species associated with those processes, within any forest ecosystem or forest type, are associated with vegetative structures (age of the vegetation, its diameter, and height) and successional stages (variable species of vegetation).

One of the primary reasons for evaluating age class/successional stage is that ecological processes and the species associated with those processes, within any forest ecosystem or forest type, are associated with vegetative structures (age of the vegetation, its diameter, its height) and successional stages (variable species of vegetation).

Average stand age class is based on the dominant trees in the stand. The actual stand age, however, may vary from the dominant trees. Correlation of average stand age/size class and successional stage are in the early stages of development. Projections of age class trends into the future are difficult to make because of a lack of historical trend data. Techniques used to determine the average stand age differ among the regions, especially between eastern and western regions, and need to be reconciled before nation-wide data can be collected.

Data Summary

In the east, approximately 48 percent of all forest land is classified as having an average stand age of more than 40 years old, 23 percent is between 20 and 40 years in average stand age; and 29 percent has an average stand age of less than 20 years. The age class distribution follows a general decrease through the classes (with the exception of the 80 to 89 year stand age class) as

would be expected for most biological populations. The average stand age class of forest land varies by region. The North Central region has the oldest average age classes while the Southeast and South Central have the youngest average age classes. This is probably due to the more intense harvesting levels associated with southern forests. From a diversity standpoint, the increasing average stand size bodes well for those forest types forests that represent later successional stages and for timberland in general. However, early successional forest types

such as Aspen-birch will be replaced by other forest types and specific management actions may be needed to ensure enough disturbance to provide potential regeneration of pioneering forest types. This forest type is somewhat unique in that if it ages to the point where it is large enough to be classed as sawtimber, it is probably in the process of converting to another forest type.

In 1992, almost 70 percent of all timberlands were classified as sawtimber sized in the Western U.S. The remaining area was split between seedling-sapling (13 percent) and poletimber (15 percent). In comparison, in 1977, sawtimber sized stands accounted for 66 percent, poletimber 17 percent, and seedling-sapling 12 percent of all timberlands. The totals do not sum to 100 percent due to the area of nonstocked timberland being included into the total area of timberland. The area of nonstocked timberland in the west decreased from 5 percent of the total in 1977 to 2 percent in 1992.

The area of sawtimber is increasing at the expense of poletimber, a natural occurrence if disturbance is limited. The decreased area of nonstocked perhaps reflects what is occurring across the landscape, as stands mature their stocking tends to increase. Nonstocked areas often have some stocking but it is not sufficient to qualify as stocked timberland. As stocking

Table 2-3. Area of forest land in the United States by age class and FIA region, 1992.

Age Class	Northeast	Age Class	North Central	Age Class	Southeast
(Thousands of Hectares)					
0	3,100	0	330	0	1,329
5	1,208	5	3,228	5	6,194
15	1,317	15	3,595	10	2,180
25	2,240	25	2,975	15	2,126
35	2,944	35	2,362	20	1,951
45	3,569	45	3,245	25	2,105
55	1,478	55	3,950	30	2,006
65	1,936	65	3,635	35	2,214
75	619	75	2,588	40	2,208
85	1,069	85	1,914	45	2,302
95	114	95	1,493	50	2,225
105	93	105	1,029	55	1,888
115	40	115	456	60	1,651
125	14	125	664	65	1,300
135	15	135	212	70	1,019
145	0	145	247	75	730
155	1	155	122	80	571
		165	59	85	437
Mixed	14,799	175	11	90	318
		185	20	95	169
		195	9	100	721
		250	13		
		Mixed	1,477		

Table 2-3 continued.

Age Class SW	South Central	Age	Great Class	Age Plains	Inter-Class	Age mtn	Class	Age Alaska	Pacific Class	Age NW	Pacific Class
0	2,937	0	412	0	29	0	1,396	0	1,847	0	10,623
5	3,982	15	121	5	19,681	5	41,780	5	9,324	5	1,502
10	1,700	25	46	15	1,312	15	286	15	1,151	15	221
15	1,227	35	76	25	637	25	368	25	879	25	172
20	790	45	98	35	828	35	553	35	1,019	35	195
25	2,309	55	120	45	1,326	45	513	45	1,089	45	320
30	951	65	134	55	2,250	55	515	55	1,013	55	396
35	1,885	75	182	65	3,253	65	449	65	833	65	421
40	840	85	126	75	4,526	75	765	75	699	75	375
45	1,450	95	125	85	3,869	85	434	85	577	85	478
50	665	105	46	95	3,691	95	416	95	417	95	245
55	707	115	91	105	1,159	105	348	105	199	105	49
60	320	125	22	115	2,870	115	460	115	107	115	41
65	282	135	45	125	655	125	36	125	90	125	0
70	117	145	11	135	1,916	135	246	135	57	135	16
75	351	155	20	145	540	145	97	145	42	145	10
80	145	165	13	155	1,460	155	474	155	192	155	602
85	948	175	5	165	530	165	50	165	61	165	0
90	9	185	1	175	1,039	175	151	175	41	175	6
95	0	195	4	185	373	185	28	185	35	185	3
100	37	250	12	195	663	195	72	195	13	195	22
				250	1,937	205	114	250	219	250	65
Mixed	28,431			350	280	215	131	350	100	350	24
						225	519	450	1		
						250	1,310				
						275	273				
						300+	475				

increases, these nonstocked areas are reclassified into the dominant size class which can range from seedlings to sawtimber.

Interpretation

The nation's forest land is maturing with a resulting increase older forests. Without increased levels of disturbance, this trend will probably continue into the future, allowing succession to progress. From an ecosystem diversity perspective, this maturation will lead to increased diversity of forest structure but a decreased diversity of forest types, because later successional stages continue to increase at the expense of earlier successional stages.

Higher stumpage prices suggest that some of the old-forest timberland will be harvested in the near future. The area of old and potential old forest has increased. The amount of old forest on

public lands is increasing and is likely to continue expanding there, because the public continues to demand old forests and the benefits they bring.

The forest land information provided in this Indicator includes those portions of reserved forest land that have been inventoried, as well as estimates of area by stand age class for reserved land that has not yet been inventoried. Stand age data are not available for all sample locations in the 1992 RPA data base. In such cases, the data were either not collected or not retained in permanent data sets.

The FIA programs collect stand age data at sample locations across the nation. The data are not typically included in the RPA publications or standard FIA reports, but are available from the 1992 RPA database, as well as the Eastwide and Westwide databases. Users of this information should be aware that, although techniques used to gather this data may be similar, there are some significant differences in techniques. For example, some FIA programs recognize a "mixed" age class, while some others do not. The techniques used in conducting individual FIA projects have been designed to address the needs of clientele in the respective regions and have been adapted to be sensitive to differences in forest character among the regions. Because of the differences in techniques, the data should not be combined to produce a national summary of land area by stand age class. More information about the techniques used to measure stand age is available from 29 percent has an average stand age of less than 20 years. The age class distribution follows a general decrease through the classes (with the exception of the 80 -89 stand age class) as would be expected when discussing most biological populations.

One possible proxy for the cross-tabulation of forest land area by forest type and stand age class has resulted from research on forest biomass. This is reported in biomass units under Criterion 5, Indicator 26. Estimates of stand age class for all sample locations are in the 1992 RPA database and could be used to compile forest land area information. The results, however, are subject to assumptions used in the study.

The area of forest land by age class may be derived from timberland area by broad stand size classes. Data are available for timberland area by seedling-sapling, poletimber, and sawtimber. Timberland does not reflect the overall forest situation in the U.S., however. The majority of reserved and other forest land that is not classified by size would be at least of poletimber and most probably of sawtimber size. Therefore, the trends and analyses that result would be conservative for the larger average stand size classes. The advantage of using average stand size classes for timberland is that analyses can be completed by forest type.

It is therefore not recommended that the forest type and stand age variables be cross-tabulated. As such, information contained in this Indicator show total forest land area by stand age class. Also, combining States' data that were measured by differing techniques should be avoided. In general, analyzing data on either an eastern- or western-States basis would eliminate most of the problems that stem from using data that have been gathered using radically different techniques.

One age group that is of particular interest in the U.S. is old growth forest. Forests which have been reserved from timber harvesting will remain old forest or become old forest in time, unless a natural disturbance occurs. Old growth forest on unreserved land may be lost to harvesting, land conversion, and natural disturbances, any of which could result in reclassification to either earlier seral stages or to nonforest land.

INDICATOR 3: Extent of areas by forest type in protected area categories as defined by IUCN or other classification systems.

The amount of a forest ecosystem reserved in protected areas is a measure of the social priority for its protection. Data is available in the United States for the classifications used by the International Union for the Conservation of Nature. IUCN categories include: I. Strict Protection; II. Ecosystem Conservation and Tourism; III. Conservation of Natural Features; IV. Conservation Through Active Management; V. Landscape/Seascape Conservation and Recreation; and VI. Sustainable Use of Natural Ecosystems.

There are currently no complete sources of information on America's forest land by IUCN standards. However, forest lands classified as reserved by the Forest Service include areas whose various designations by statute or administrative regulation would place them within IUCN Categories I, III, IV, or V. FIA programs are in the process of measuring and estimating the area of reserved forest land in the U.S. Data used to quantify this indicator are taken from the 1992 RPA database and only cover portions of reserved forest land that were inventoried at that time. More current and detailed information is available from each of the regional FIA programs. By definition, reserved forest lands are publicly owned. Information on privately owned "protected" forest land derived from a nationwide survey of landowners' intention to harvest (Birch, 1966).

Productive reserved lands are forested land that have statutory or administrative restrictions prohibiting the harvest of trees. Typically, these are in public ownership, though occasionally they may be privately owned. Productive deferred forest lands were unroaded forested lands that were under consideration for becoming reserved lands. Some of those lands were eventually reserved and the rest were 'returned' to a timberland classification. Because the final designation of these lands was unknown in 1977, they were classified as deferred.

Data Summary

In 1992, 19.6 million hectares (48.4 million acres), or 6.6 percent of the total area of forest land, was classified as reserved. Compared to 1977, this represented a 130 percent increase in the area of reserved forest land. There were 4.5 million hectares of reserved forest lands in the eastern States in 1992, which was about 5 percent of the total area of forest land. This increase in area of reserved forest land from 1977 to 1992, 3.4 million hectares to 4.5 million hectares, was significant because the total area of publicly owned land remained relatively constant--about 15 percent. The increase reflects the fact that a greater percentage of publicly owned land in the eastern States was classified as productive reserve in 1992 than in 1977. In the East, more than 70 percent of the reserved forest land was located in the northern portions of the region. The North is also where the majority of the publicly owned land is found, which illustrates the correlation between the total area of public land and the total area of reserved forest lands.

In addition to the Federally reserved forest land, some other public land, as well as some privately owned land, should be considered protected under one of the IUCN categories. The ownership of protected private land ranges from non-governmental organizations such as The Nature Conservancy, which will probably be as well reserved as publicly owned land; to small, non-industrial lands whose owners may intend never to harvest, but which may, if sold, become available for harvest. Whatever the distribution of ownerships and ownership intentions, some privately owned lands should be considered as protected. In a 1994 survey of private forest landowners from across the nation, 34 percent of those who responded said they never intend to harvest.

Interpretation

In most forest types, the area of reserved forest land is increasing. Generally, between 1977 and 1992, the percentage of reserved forest land by forest type groups, compared to the percentage of total forest land in each forest type group expanded. The expected future trend is a continued increase in the area of reserved forest lands.

In the eastern States, forest type groups that are most restricted are the southern conifers. Forest type groups whose reserves are limited, and which have therefore become of concern, include longleaf-slash pine, oak-pine, and loblolly-shortleaf pine. The area of reserved mid- to late-successional forest types, such as maple-beech-birch, will continue to increase, mostly in the northern U.S. In the absence of disturbance, earlier successional forest type groups, such as aspen-birch, will convert to these later successional forest types.

In the western States, almost all forest type groups, on both timberlands and reserved forest lands, are conifers. However, between 1977 and 1992, the area of reserved hardwoods in the West increased. The area of western white pine, larch, and redwood, both on reserved forest land and in total, is limited. Concerns for maintaining these forest type groups should be addressed.

There are many areas of privately owned forest land that are currently protected. A combination of inoperability and landowner intent may render some areas of forest land 'protected' although such lands have not been classified as reserved. While the total area of such land may not be known, the fact remains that a relatively large number of landowners consider all or part of their forest lands protected.

Perhaps the most important forest type groups, from a protection viewpoint, are those that represent unique ecosystems such as western Red cedar and Port Orford cedar, or are at the edge of their natural range. Data is not available for analysis of the protected status of these types.

The actual area of privately owned forest land that can be considered 'protected' under IUCN categories has not been determined. Analyses of reserved forest land by forest type in sub-regions are difficult to conduct, but with increased coverage by FIA programs, this should be possible within 10 to 15 years.

Additional information on forest land in protected areas is included under Cultural, Social, and Spiritual Needs and Values in Criterion 6, Indicator 42.

INDICATOR 4: Extent of areas by forest type in protected areas by age class or successional stage.

The distribution of reserved forest land by forest type is based on the best available technique for a given area. Very often, aerial photography has been used to quantify the area and composition associated with the FIA sample location. Estimates of stand age or succession stage require ground visits to the sample locations to measure the age of existing vegetation. The process of taking ground measurements on reserved forest land lags behind the use of other techniques and is not far enough along to provide estimates of stand age or successional stage at the national level. Some information on stand age for reserved forest land might be obtained from regional FIA programs.

Data Summary

Due to the lack of available data on regulated areas, trends in the extent of these areas cannot be discerned. However, based on the maturation of the nation's forest in general, one could assume that the same trend is occurring on reserved lands but to a greater degree since they are less susceptible to disturbances that set back natural successional processes. Therefore, because they are based on trends for lands that are available for harvest or other human-caused disturbances, estimates concerning the extent of reserved forest land by age class are probably conservative.

As discussed for Indicator 2, the maturation of America's forest land is evident in increased average stand sizes and later successional forest types. The amounts of forest land in early successional stages is decreasing, as the amount of forest land in mid- to late-successional stages is increasing. The area of reserved forest land is increasing in all regions.

There have been regional/local studies conducted of forest lands and disturbances that will substantiate these estimated trends. One study in the Lake States found that about 25 percent of disturbed areas in timberlands composed of stands older than 80 years were the result of natural events, such as fire or windthrow, and that the other 75 percent of the disturbances resulted from human-caused events, such as timber harvest. Losses to the base level of old forest in the Lake States--from disturbances between inventories--were more than offset by increases in the average stand age, and from land that had trees present in the previous inventory but not to the

Table 2-4. Area of reserved forest land in the United States by forest type and region, 1992.

(Thousands of Hectares)

Eastern United States:

Forest Type Group	Northeast	North Central	Southeast	South Central	Great Plains	Eastern Total
White-red-jack pine	59	137	11	115	10	332
Fir-spruce	101	168	4	..	..	273
Longleaf-slash pine	..	..	62	..	..	62
Loblolly-shortleaf pine	..	6	91	4	..	101
Oak-pine	2	7	24	..	2	35
Oak hickory	208	316	382	10	4	920
Oak-gum-cypress	..	3	198	..	..	201
Elm-ash-cottonwood	21	134	9	..	9	174
Maple-beech-birch	1,248	148	19	..	2	1,418
Aspen-birch	13	301	..	..	..	314
Other types	..	..	7	..	1	7
Nonstocked	..	2	..	101	..	103
Unknown	304	4	11	196	..	515
Eastern Total	1,957	1,225	820	425	28	4,454

Western United States:

Forest Type Group	Inter-mountain	Alaska	Pacific Northwest	Pacific Southwest	Western Total
Douglas-fir	1,220	..	1,242	105	2,567
Ponderosa pine	809	..	359	267	1,435
Western white pine	1	..	1	1	3
Fir-spruce	1,527	475	108	625	2,735
Hemlock-Sitka spruce	..	1,580	147	11	1,737
Larch	10	..	5	..	14
Lodgepole pine	1,438	..	15	263	1,716
Redwood	..	..	..	64	64
Western hardwoods	171	983	11	260	1,424
Other types	645	914	12	101	1,673
Pinyon-juniper	634	..	..	117	751
Chaparral	5	..	1	179	186
Nonstocked	210	325	..	..	535
Unknown	..	..	309	..	309
Western Total	6,670	4,277	2,210	1,992	15,150

United States Total

19,604

stocking level necessary to qualify those lands as forested. That is to say, that within the latter, stocking had increased to the extent necessary to qualify the areas as forest land in the most recent inventories. However, it is questionable whether these results can be applied to reserved forest lands. One might assume that a majority of the existing reserved forest lands in the Lake States will not be disturbed in the short term, based on the history of other forest lands in that region. All lands are potentially susceptible to disturbance, and eventually will be disturbed, though on reserved lands it may be hundreds of years between disturbance events. Therefore, we might conclude that aging and the subsequent progression through successional stages on reserved forest lands will be at least at the level expected on timberlands.

Interpretation

More than half of all reserved forest lands are estimated to contain stands in size classes whose dominant conifers have an average diameter (dbh, or 1.37 meters) of at least 23 centimeters, and whose hardwoods have an average diameter of at least 28 centimeters. It is also assumed that increases have occurred in the acreage of older and later successional stage forest types on reserved land and reserved forest lands in younger, earlier successional stages have decreased. While natural disturbances will result in some losses in the older age classes, such losses will likely be more than offset by gains from both the aging/maturing of the existing reserved forest lands and from additions to the current reserved forest land base.

INDICATOR 5: Fragmentation of forest types.

Fragmentation of a forest type into small pieces disrupts ecological processes and reduces the availability of a habitat. Fragmented areas may be too small to maintain viable breeding populations of some species. The distances between and among forest fragments can interfere with pollination, seed dispersal, and wildlife movement, and breeding. Ultimately, excessive fragmentation can contribute to the loss of plant and animal species that are unable to recolonize after an area is disturbed. In areas converted to agricultural purposes, remnant forest fragments will provide refuges for many, although not all, components of the original, diverse forest communities.

An increase in the level of fragmentation of forest land, while detrimental to some wildlife species, will improve the habitat for other species, especially those that prefer forest edges. The approach for this indicator is not to determine the positives or negatives of fragmentation but to attempt to quantify what has occurred and the current conditions, in order to improve the knowledge base for management decisions.

Increased interactions of people and the environment increase the likelihood of fragmentation. With ever-increasing human populations and use, forests and forest conditions are becoming more fragmented. As a result, concerns have surfaced with regard to patch size, edge, distances between habitat areas, interconnectedness, etc.

D : Summary

There are no national data sets available concerning fragmentation of forest land, although some regional studies have been produced. For example, in the Cascade Range of Oregon between 1972 and 1987 the degree of forest fragmentation increased significantly; the average patch area declined by 17 percent; and that the average patch perimeter length declined by 11 percent.

Two primary threats to neotropical migratory birds in the Midwest are habitat fragmentation and habitat loss, which are usually closely associated. Forest types associated with the midwest are central hardwoods and oak-hickory. In 1995, a map of the forest cover in Missouri, Illinois, Indiana, and Ohio, was overlaid with 1,000-hectare hexagons. It was estimated that only 6 percent of the landscape contained hexagons with more than 80 percent forest cover, while 63 percent of the landscape contained hexagons with less than 20 percent forest cover.

Fragmentation refers both to the forest patch size after land conversion, and to the size of forest patch of a certain condition, e.g., old growth, shrub, etc. Many Eastern forest types, such as oak-hickory, are disturbance-adapted ecosystems and developed with a degree of fragmentation as a part of their evolution. In association with these disturbance-oriented ecosystems, many wildlife species also developed with disturbance-oriented habitat requirements.

The question is: What degree of fragmentation can be tolerated above historical levels? Current forest management practices, landownership patterns, and transportation corridors are all contributing to an ever-increasing fragmentation of the forest environment in almost all forest types in the eastern States. Some forest types, such as aspen-birch, are probably more likely to be fragmented due to the harvesting techniques employed. For example, while aspen-birch is typically clear-cut (even-aged management), most maple-beech-birch forests are selectively harvested (uneven-aged management). Generally, clearcuts lead to increased fragmentation, whereas selective harvest does not often result in increased forest fragmentation.

On a regional and local scale, data show that fragmentation of forest land has occurred. Today, a methodology for determining national-level fragmentation of forest land by forest type is not available. Because true estimates of the historical base for factors such as tract size cannot be made, change over time is limited to a starting point of the 1970's.

There are several dimensions to the ecological impacts of the 'fragmentation effect' and several indicators are necessary to characterize it. Typically, fragmentation involves a loss of area, a decrease in the average size of habitat patches, an increase in the average distance between and among patches, and an increase in the amount of 'edge' habitats. Some work has been done to quantify forest fragmentation in the Pacific Northwest. The focus of work in the East is on fragmentation's effects on the regions' ecology, and on birds in particular. A number of forest wildlife species require a minimum size of homogeneous forest land to survive.

Different species will perceive fragmentation at different scales. This is particularly important for ecological analyses. Case studies have shown an increase in fragmentation according to indicators such as size of patches.

Interpretation

Fragmentation can be quantified, but not with a single indicator. The ideal data for quantifying are map-based. Some surrogate measures for fragmentation could be derived from point-based inventories. In the United States, vegetation maps derived from AVHRR satellite data could be used to evaluate fragmentation at a very coarse scale. Similar analyses have been done by the Food and Agriculture Organization of the United Nations (1993) for West Africa and the Amazon Basins. Fragmentation is best understood by examining trends over time, and therefore requires before-and-after information. The earliest feasible date for establishing a base line of information for the United States is 1970.

B. Species Diversity

Species diversity describes the variety of different organisms found in a particular location. It can vary from place to place, and from season to season within the same place. The traditional starting point for species relations and diversity assessment is at the community level. For such analysis, community means all the organisms in a chosen area that belong to the taxonomic group the ecologist is studying. The chosen area is usually one that the ecologist regards as a convenient entity and is willing to consider as homogeneous in some intuitive sense. It is impractical to consider every living thing in such an area--the mammals, birds, reptiles, amphibians, arthropods, and soil microfauna, together with the trees, shrubs, herbs, ferns, mosses, fungi, and bacteria. A taxonomic group that the ecologist regards as the relevant entity is usually chosen. This may be a family, order, class, or other taxon with which taxonomists are familiar, so that individuals can be fairly easily identified to species. The members of such a taxon that occur together at one place are designated a taxocene.

INDICATOR 6: The number of forest dependent species.

The most fundamental element of diversity is species number. 'Species richness' is used to represent the concept of number of species per fixed number of individuals. Species density refers to the number of species occurring per unit area. The relative abundance of individual species is called 'evenness.' Species diversity is generally accepted as embodying the concepts of both species richness and evenness. That is, species diversity is a function of the number of species present and the evenness with which the individuals are distributed within these species.

Data Summary

The availability and extent of up-to-date data on species richness and evenness depends primarily on the taxonomic group. Botanists have combed the world and described nearly all vascular

plants in the temperate regions. Today, it is rare to find a new vascular plant, at least in the United States. The World Resource Institute estimates the total number of vascular plant species in the U.S. at around 20,000. Even many groups of nonvascular plants are well understood, e.g., Bryophyta, the mosses and liverworts.

Many data sources provide information on plant species numbers, distribution and abundance. All major State universities and many private universities, maintain herbariums of the plants in their region, and many of the major museums nationwide maintain such collections. Most, if not all, of the major State universities have published manuals on plant species identification for their State, with appropriate distribution and abundance information. The exceptions are the algae and, especially, the fungi. Algae exist in every drop of soil and every drop of water on the planet. In fact, some believe algae account for nearly 90 percent of the planet's oxygen production, although this has not been proven. Fungi are important for a variety of reasons. They are the primary decomposers on the forest floor; they are pathogens for many diseases; many animals, primarily rodents, depend on them as a food source, and many higher plants require mycorrhizal fungi to function properly. The number of fungal species in the U.S. has recently been estimated at 56,800.

Two national databases deal with tree species, estimating 865 native tree species in the U.S. Forest Service FIA units conduct periodic, nation-wide, statistically based inventories of forest resources, primarily the woody vegetation, although some understory herbaceous vegetation is also inventoried. The agency's Forest Health Monitoring units conduct nationwide, statistically based inventories to assess the health of U.S. forests. These and other data are readily accessible over the internet.

There are 419 native species of mammals that regularly occur in the U.S. As with plants, most major State universities maintain collections of mammalian species within their respective States/region and publish manuals with appropriate distribution and abundance information. All State wildlife agencies conduct periodic surveys/inventories to keep abreast of wildlife resources. Today, most of these programs are based on sound statistical designs.

There are an estimated 844 forest-dependent bird species in North America. Birds have been monitored for many decades, and much has been written about recent declines. There are many important and readily accessible national databases on bird resources. The breeding bird survey (BBS), administered by the U.S. Geological Survey, has been ongoing since 1966. Hawk migration counts, sponsored by the Hawk Migration Association of North America, have some sites that have been observed for more than 50 years. Breeding Bird Censuses (BBC) determine population densities of breeding birds in specific habitats. Researchers can access a computerized database of more than 4,000 BBC's, dating back to 1937. Breeding Bird Atlases (BBA), overseen by the North American Ornithological Atlas Committee, are 5-year projects going on in each State. To date, more than 28 States have completed atlas projects to determine the distribution and reproductive status of breeding birds. Most atlases are fully computerized. The Audubon Christmas Bird Count Database (CBC) is collected to monitor population

dynamics of North American birds in winter. Ongoing since 1900, a computerized database from 1960 forward is maintained by the FWS. Additional bird demographic information are available from mistnetting, nest monitoring, and bird banding programs conducted by State agencies, universities, and the FWS.

The native herpetofauna of the U.S. includes 281 species of reptiles (about 19 percent turtles, 35 percent lizards, 45 percent snakes, and less than 1 percent crocodilians) and 240 species of amphibians (about 62 percent salamanders and 38 percent frogs). The distribution of reptiles and amphibians as a whole is not well understood. No national program of monitoring populations of reptiles and amphibians, comparable to the Breeding Bird Survey, is operational. However, the USGS has recently started an amphibian monitoring program based on call counts.

Some recent regional studies have documented declines of amphibians. Amphibian species tend to exhibit either endemic (small ranges and/or specific habitats) or widespread distributional patterns. Table 2-5 shows that the number of amphibian species suffering losses or suspected of having severe threats to their continued existence increased significantly in the last 15 years.

Table 2-5. Distribution pattern of amphibian species suffering losses.

	Number of species	
	1980	1994
Endemic	33	52
Widespread	5	33

Synergistic interactions between the effects of low pH and increased ultraviolet-B radiation (UV-B) have been suggested as possible causes of the decline and disappearance of amphibians.

The American Fisheries Society in 1979 developed a list of 198 freshwater fishes in danger of disappearing in the U.S. A decade later the list was expanded to 254 species. Ten species became extinct and 75 taxa were added in a single decade, an increase of 38 percent. About 800 species of native freshwater fishes exist in the continental U.S. There is currently no national fish monitoring program. However, many regional studies have established that fish species are not equally distributed across the nation, but tend to concentrate in larger, more diverse environments such as the Mississippi river drainage (375 species). Isolated drainages, such as the Colorado River, have low fish diversity (36 species). Arid states west of the 100th Meridian average about 44 native fish species per state, while states east of that boundary average around 138 species per state. Habitat degradation and destruction were the primary causes.

Invertebrates, members of the phylum Chordata (arthropods, flatworms, mollusks, roundworms, etc.), are a poorly understood group and were not analyzed for this report.

Insects are a vast group, with most species yet to be identified. A national insect database is available. The Hopkins U.S. System Index (HUSI) provides access to the Hopkins U.S. System, a collection of written records containing information on thousands of insect and damage specimens from forests in the United States. These insect or damage specimens were

collected by entomologists in the U.S. Department of Agriculture (USDA) and collaborators over a period of more than 80 years, including data on location, date, taxon, insect- and plant-host association, and other information in tabular or narrative form. The Forest Insect and Disease Research branch of the Forest Service began building a computerized database of the Hopkins System in 1987 which now contains about 61,000 records. Records held by the Agricultural Research Service, Systematic Entomology Laboratory, have not yet been entered in the database. Of the records in the database, 5,847 unique species are identified.

A national survey program, the Fourth of July Butterfly Count, was started by the Xerces Society in 1975, and sponsored by it annually until 1993, when the North American Butterfly Association (NABA) assumed administration. The results of the FJC, including butterfly data, count-site descriptions, and weather information on count day, are published annually. While the FJC is not a formal scientific survey, the data are nonetheless useful for studying gross population trends and butterfly diversity. For example, monarch (*Danaus plexippus*) and painted lady (*Vanessa cardui*) populations have shown dramatic fluctuations in the same years, but they usually vary in opposite directions, suggesting that the same widespread climatic events affect both species in different ways. Four regional *Lepidoptera* studies from 1993 covering the 17 western states identified 915 species of butterflies and moths. In general there were fewer species of butterflies and moths in more northern states and in states with less topographic diversity, that is, less variety in terrain.

Interpretation

Viable populations of forest dependent species require appropriate habitat, including available food, cover, and water if they are to survive. It is estimated that at least 90 percent of the total bird, amphibian, and fish species of the country, and at least 80 percent of mammal and reptile species can be found on forested land. Over time, forest cover in any area changes, either naturally or as a result of human activities. Maintaining the nation's forest dependent species requires maintaining healthy ecosystems from a landscape perspective.

Butterflies and moths, among the best-sampled insects, are useful indicators of ecological conditions and environmental change. Changes in butterfly populations have not been detected. However, there have been definite, documented declines in many forest dependent bird species, especially neotropical migrants, although populations of some forest-dwelling birds have shown increases.

Amphibian populations have also been documented as in decline. Available data seem to indicate extensive declines in the northwestern U.S. and limited declines in the southeastern U.S. Forest pests, such as the southern pine beetle (*Dendroctonus frontalis*), and pathogens such as *Phytophthora cinnamomi* are causing some serious problems. Native fish communities have undergone significant and adverse changes (reduced distributions, lowered diversity) due to deteriorating quality of aquatic habitats from over-harvesting, dam construction, and sedimentation resulting in physical, chemical, and biological effects to surface waters and

underground aquifers. About one-fourth of the native freshwater fishes are considered to be imperiled.

Forest land has declined in many areas of the country, eliminating habitat and putting increasing pressure on many species due to increased competition for shrinking resources. Migratory game birds dependent on forested wetlands and marsh have shown declines, which has been attributed to reduced quantity and quality of wetland areas.

For the most part, big-game populations seem more secure, more widely distributed, and abundant than in decades past. In fact, deprivation by elk and deer is getting to be a big issue in the West. Small game animals, such as pheasant, quail, and rabbits, have shown a decline in numbers. Other small game animals, such as grouse and squirrels, have remained stable.

According to existing data, most native tree species are neither endangered nor threatened, with a few prominent exceptions. For example, chestnut, elm, and frasier fir have been seriously affected by forest pests, causing significant impacts on eastern forests.

Decadal trends can be assessed in tree species composition and abundance, as well as growth and mortality, because many FIA plots are visited on a 10-year cycle. Trends in forest pathogens and pests can also be determined. Data on trends in mammal species are available primarily for game species and furbearers. Population trends for bird species are more abundant than for any other taxon.

INDICATOR 7: The status (rare, threatened, endangered, or extinct) of forest-dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment.

Ecological processes and the species associated with those processes within any forest type may vary according to the extent, condition, or fragmentation of that forest type.

Several sources of information on the status of threatened and endangered species are available. The most comprehensive national sources are databases of The Nature Conservancy, the USDI Fish and Wildlife Service, U.S. Environmental Protection Agency, and a private firm called BioData.

The Biological and Conservation Database of the Nature Conservancy is a dynamic atlas that includes ecological and location information about elements of natural diversity. These elements include those plants and animals or natural communities that are so rare and so significant as to merit special consideration as land-use decisions are made. Information for the data base comes primarily from two sources: a network of academicians and private and agency biologists who share information collected through their own work and research, and inventories funded through contracts or grants and resulting from the cooperative efforts of the Nature Conservancy and a variety of agencies.

Table 2-6. Numbers of threatened or endangered species.

	Plants	Molluscs	Arthropods	Fish	Herptiles	Birds	Mammals
Species (n)	503	84	57	107	43	72	58

The U.S. Fish and Wildlife Service maintains the Federal List of Threatened, Endangered and Candidate Species Database. Statistically based biological surveys are used, as well as special project inventories, to build and regularly update records in the database. Similar to The Nature Conservancy, expert knowledge comes from a network of academic, agency, and private biologists, which is incorporated into the database. Species recovery plans are tied to the database.

The EPA Office of Pesticide Programs maintains an Endangered Species by County Database, which is essentially the same information gathered by the FWS. Finally, there is the Threatened and Endangered Species Database of BioData, Inc., a small private research company in Denver, CO. BioData does not conduct field inventories, or other such work; rather they build on all public, and some private, sources of information on threatened and endangered species. BioData may well have the best database on threatened and endangered species, and for a fee anyone can query and use the database.

Data Summary

Native plant and animal diversity has declined over the past three decades, and is likely to continue to decline because of continuing human population growth and associated development. As of August 1995, there were 924 species officially designated as threatened or endangered, shown in Table 2-6. Of these 924 species, 383 are considered forest dependent. The list by broad forest type, is shown in Table 2-7.

There are more than 3,500 candidate species awaiting listing; 59 percent are plants, 27 percent are invertebrates, and 14 percent are vertebrates. The rate at which new species are being listed now exceeds 50 per year. Regions supporting many endangered species are the humid Southeast and the arid Southwest. The Pacific Northwest seems to be emerging as a new hot spot of endangered species. A recent analysis of endangered species patterns shows the greatest number of endangered species occur in Hawaii, southern California, the southeastern coastal states, and southern Appalachia.

Table 2-7. Forest dependent species that are threatened or endangered.

Land Type	All T&E	Plant	Mammal	Bird	Reptile	Amphibian	Fish	Snail	Clam	Crustacean	insect
Forest	383										
Deciduous	128	39	11	7	7	2	28	8	19	6	1
Evergreen	178	60	21	41	10	2	28	2	8	1	5
Mixed	110	34	15	16	11	4	19	2	7	2	
Wetland	71	16	15	20	7	2	8	1			2

Note: species can occur in more than one land type category.

Interpretation

Endangered species distributions are mapped at the county level of resolution. This helps in the identification of hot spots of threatened biodiversity. The databases contain what is known about habitat requirements for the listed species. Recovery plans are given in the databases, so we know what steps are currently being taken to protect and enhance the species.

It is clearly inappropriate to assume that because a particular species occurs in a county, that a viable population exists in that county. Historic trends in species listings do not solely reflect trends in endangerment. The rate of listing is most sensitive to changes in the law, budget constraints, bureaucratic processes, and policy changes that effect how many listings can occur in any time period, rather than the status of the particular species itself. As a consequence, the official list underestimates the number of species at risk of extinction.

C. Genetic Diversity

Genetic diversity is the variability of genes among individuals in a species or population. A species' evolutionary ability depends on sufficient genetic diversity to maintain immediate fitness and adaptability, which, in turn, are a function of population size, subpopulation structure, interpopulation genetic variation, mating structure, generation time, and gene flow.

Concern about genetic diversity is most serious for populations that are either naturally small and isolated, or populations that have become small because of changes in their environment or impacts from human activity such as hunting. Consequently, population size and the distribution of interacting populations are critical attributes in evaluating genetic diversity.

INDICATOR 8: Number of forest dependent species that occupy a small portion of their former range.

Information on geographic distributions of forest associated species was obtained from Natural Heritage central databases. Taxa surveyed included mammals, reptiles, amphibians, birds, and

Table 2-8. Number of forest associated species (by taxa) that occupy a small portion of their former range. (Percent of listings examined given in parentheses).

Taxa	Mammals	Birds	Reptiles	Amphibians	Fish
Number	37	30	10	13	97
(percent)	(26)	(13)	(11)	(9)	(15)

fish. Plant and invertebrate data were not available at this time from this database. There are several databases available to use in examining this question. This one was chosen because species are listed on the basis of concern by local biologists. This should present a truer picture of potential genetic erosion than a list composed only of officially listed threatened and endangered species.

Data Summary

Of all taxa examined, mammals have the apparent greatest proportion of species with reduced ranges (26 percent), while amphibians have the least (9 percent). Fifteen percent of fish species occupy smaller geographic distributions, 13 percent of the bird species and 11 percent of amphibians occupy smaller land areas than previously occupied.

Some degree of genetic erosion occurs in species which occupy small portions of their former range. These species warrant closer examination and, perhaps, management. We cannot determine the extent of genetic erosion, what proportion of the former gene pool of the species remains, or how important it may be to adaptation, survival, or potential human use. This information does not show if important phenotypic polymorphisms are being lost, although given adequate time some inferences about polymorphisms could be teased out of the available literature for a given species.

Genetic diversity is not threatened in woodland breeding birds with positive or neutral population trends. Genetic diversity may be eroding in populations of species with declining trends, depending on the severity of the decline and size of remaining effective breeding population levels. Genetic diversity is likely eroding in declining populations of anadromous fish, declines are severe in some cases and effective population sizes are known to be low.

Population levels in unmanaged species may reflect trends in genetic diversity (Frankham 1996). However this may not be the case for managed species. Existing data is not sufficient to determine the role of genetic diversity in population levels or trends in unmanaged species. Management activities such as transplanting programs and harvest have definite genetic effects, (such as founder effects, artificial selection, and increased inbreeding) which may not be evident when looking only at demographic parameters. Consequently, population levels or trends in these species may indicate only population abundance, not trends in genetic diversity.

Although there are large apparent differences between taxa in the proportion of species with reduced ranges, we cannot really say one taxa is faring worse than another. Mammals, by their nature, attract more attention and are easier to observe than other taxa such as amphibians. Consequently there is more data for mammals and it is more reliable than information for other taxa.

INDICATOR 9: Population levels of representative species from diverse habitats monitored across their range.

Representative species are defined here to include forest dependent species whose population levels are indicative of overall levels of genetic diversity for a larger group of forest species.

Data consists of population estimates for selected large game animals, harvest estimates for selected small game animals, population trends for woodland breeding birds, and population trends for evolutionarily significant units in one anadromous salmonid species, steelhead.

Population and harvest level estimates are compilations from state wildlife agencies and are displayed by broad assessment region and for four time periods to indicate trends. A state's data was included only if estimates were available for the years 1975, 1980, 1985, and 1990, and therefore some estimates are based on only a few states information. The choice of species to monitor, data collection methods, and data analysis/interpretation are influenced by management emphasis at the state level and species geographic distribution. Consequently these data are inconsistent and often unreliable. However, if states are consistent year to year in collection methods, then trends should be more consistent and reliable than the estimates themselves.

Data Summary

- Population levels for large carnivores increased during the time period 1975-1990. Overall, black bear and mountain lion increased 60 percent and 84 percent respectively. The only decrease was for black bear in the Rocky Mountains. between 1985 and 1990.
- Population levels for herbivores generally increased for the time period with localized declines for some species in some regions.
- Trends in harvest estimates may not accurately reflect population trends due to differences in hunter effort.
- Trends in harvest estimates for small game mammals with small home ranges generally declined, although one species (fox squirrel) showed an overall increase.
- Harvests of game birds show mixed trends.
- Data from the Breeding Bird Survey indicates no definite trends for the guild overall during the time period 1980-1996. Twenty-nine species significantly increased populations, populations significantly declined in 24 species, and trends were 0 or nonsignificant in 66 species.

- Overall, significantly declining West Coast Steelhead sub-basin stocks outnumbered populations with significant increases. The majority of populations, 97, showed no significant trend.

Interpretation

Existing data indicates that population levels are high enough that genetic diversity does not appear to be a major concern for most species of large carnivores, herbivores, and large game birds. Populations for these species generally increased or at least remained steady. Populations of small game mammals and birds are not as secure. Some, such as Eastern Cottontail Rabbits declined precipitously; however, genetic diversity is probably not threatened in these species because geographic distribution remains widespread and census numbers, and consequently effective breeding population sizes, remain relatively high.

There is no way to determine cause and effect relationships from this information. There may be a multitude of factors other than forest practices which cause population increases or declines.

We do not know that observed trends in one or a very few representative species accurately reflect trends or levels of larger groups, but examining trends in several species should be more indicative of trends for a group. Also, more work is needed to define groups on the basis of common genetic diversity attributes. Current groupings are based on common life histories, which may or may not reflect genetic diversity characteristics.

iii. SUMMARY FOR THE CRITERION

The conservation of biological diversity in U.S. forests has been measured by nine indicators of ecosystem, species and genetic diversity. In general, the data available for measuring this criterion are extensive and comprehensive. The following highlights reflect the significant trends and indications of this criterion in relation to the sustainability of U.S. forests.

Highlights

- The forests in the Rocky Mountains and Northeast are becoming more mature and converting to later successional states. Some forest types are in danger of not sustaining themselves at the current levels, reflecting landowner/ management decisions.
- The areas of forest land in the U.S. declined steadily from pre-European settlement periods (circa 1630) to the 1920's, primarily in the northeast and north central areas of the U.S. Since the 1920's, the area of forest land has been relatively stable.
- The Nation's forests are maturing as reflected in increases in the average size class (and corresponding average age class). This maturing will lead to increased age diversity within the various forest types, but decreased diversity between forest types. The area of old forest on

public lands is increasing and is likely to continue expanding because of fire protection and reduced harvesting.

- Generally, the percentage of forest types protected in reserved areas has expanded between 1977 and 1992.
- Older and later successional forests are a growing percentage of reserved forests while younger and earlier successional forests are a smaller percentage.
- Fragmentation of forest land is occurring. Current timber harvesting practices, landownership patterns, and transportation corridors are all contributing to an ever-increasing fragmentation of the forest in almost all forest types in the Eastern US.
- It is estimated that at least 90 percent of the total bird, amphibian, and fish species of the country, and at least 80 percent of the mammal and reptile species can be found on forested land. Although, most native species are neither endangered nor threatened, there have been documented declines in many bird species, especially neotropical migrants while other populations of forest dwelling birds have shown increases. There is concern also over declining amphibian populations in the northwestern U.S. and limited declines in the southeastern U.S.
- Migratory game birds dependent on forested wetlands and marsh have shown declines, attributed to the quantity and quality of wetland areas. Most big-game populations now seem more secure, more widely distributed, and abundant than in decades past. Small game animals, such as pheasants, quail, and rabbits, have shown a decline in numbers. Other small game animals, such as grouse and squirrels, have remained stable. Genetic diversity is likely eroding in declining populations of anadromous fish. Declines are severe in some cases and species survival is being affected because of genetic problems.

Gaps

Minimum size habitat requirements of a for specific forest types cannot be addressed with the current data. The size of tract and the successional stage of development within the forest type, cannot be currently determined.

A correlation of age class with diameter/height classes cannot be accurately made at this time.

The current data sets do not provide answers to questions related to unique ecosystems or ecosystems at the edge of their natural habitat. The area of privately-owned forest land that is protected as per the IUCN categories cannot currently be determined. Analyses of reserved forest land by forest type in sub-regions are currently difficult, but with increased coverage by FIA programs in the near future will be possible.

We cannot quantify the amounts of reserved forest land by age class or successional stage.

We cannot determine a national level of fragmentation of forest land, in general nor by forest type. Since true estimates of the historical base for factors such as tract size cannot be derived, change over time is limited to a starting point of the 1970's. The unknown question is what degree of fragmentation can be tolerated above historical levels.

Few population estimates exist for fish species. Trend information on distribution and abundance are lacking, except for a few specific regional studies on commercially or recreationally important salmonid species. Data on trends in amphibian populations are largely anecdotal.

Historic trends in species listings do not solely reflect trends in endangerment. The official list underestimates the number of species at risk of extinction because the rate of listing is sensitive to changes in the law, budget constraints, bureaucratic processes, and policy changes that effect how many listings can occur in any time period.

We cannot determine the extent of genetic erosion, what proportion of the total gene pool of the species it represents, or how important it may be to adaptation and survival. This information does not show if important phenotypic polymorphisms are being lost. Also, cause and effect relationships cannot be inferred from this information.

Population levels or trends may not reflect levels or trends in genetic diversity for managed species. Management activities such as transplanting programs and harvest have definite genetic effects, (such as founder effects, artificial selection, and increased inbreeding) which may not be evident when looking only at demographic parameters. Consequently, population levels or trends in these species may indicate only population abundance, not trends in genetic diversity.

There is no way to determine cause and effect relationships from the indicators of genetic diversity. We do not know that observed trends in one or a very few representative species accurately reflect trends or levels of larger groups, examining trends in several species is more indicative of trends for a group. Also, more work is needed to define groups on the basis of common genetic diversity attributes. Current groupings are based on common life histories, which may or may not reflect genetic diversity characteristics.

Chapter 3

Criterion 2: MAINTAINING THE PRODUCTIVE CAPACITY OF FOREST ECOSYSTEMS

I. INTRODUCTION

The area of forest land in the United States is less than it was prior to European settlement, but the downward trend stopped in the 1920's and the area of forest land on a national level has increased slightly, mostly in the East. Moreover, average stocking rates, intensity of management, and the total area under management have continually increased, and the average area of tree stands is increasing. The result is an increasing production of wood fiber on the forest lands of the U.S.

Plantations have been a part of forest management since the early 1900's. Timber plantations were established through the Civilian Conservation Corps (CCC) in the 1930's; the Soil Bank Program in the 1950's; several other tree planting incentive programs at the federal, state, and local level; and through investments by private landowners and forest industries. As plantations mature and are harvested, some are replanted for another rotation of trees, some revert back to natural stands, and some are converted to other land uses. The relative percentage of plantation to natural stands, or amount of forest area converted to other uses varies by region, but data on the specific nature of changes in forest lands is lacking.

ii. INDICATOR REPORTS

INDICATOR 10: Area of forest land and net area of forest land available for timber production.

In many countries, the traditional calculation of timber production potential has been based on total forest. However, in the U.S. this measure is less effective because spiritual, recreational, scientific, or educational values may be given priority over commodity production.

Data Summary

Information sources for productive capacity of forest ecosystems are generally the same as for biodiversity. Again, information is generally available for timberlands, but is limited for other forest lands.

In 1992, about two-thirds of the total area of forest land in the U.S. was available for timber production. Twenty-seven percent of forest land was unproductive and 6.5 percent was in

TABLE 3-1. Area of forest land, reserved forest land, unproductive forest land (less than 0.6 cubic meters per acre per year), and net forest land available for timber production in the United States by region, 1992 (Powell et al. 1993). (Thousand Hectares)

Region	Total Forest	Reserved Forest	Unproductive Forest	Net Available
Eastern Forests				
Northeast	34,552	1,957	444	32,152
North Central	33,633	1,226	700	31,707
Southeast	35,644	809	520	34,315
South Central	50,084	425	3,316	46,343
Great Plains	1,717	27	257	1,428
Western forests				
Intermountain	54,835	6,670	24,248	23,916
Alaska	52,258	4,277	41,883	6,098
Pacific Southwest	15,787	1,993	7,078	6,717
Pacific Northwest	19,620	1,826	2,475	15,318
United States	298,125	19,209	80,921	197,995

protected reserves. In the Eastern U.S., 94 percent of the total forest area was timberland, but only 37 percent was timberland in the western States. In the eastern States, the regional percentages of timberland to total forested acreage ranged from 83 percent in the Great Plains Region to 96 percent in the Southeast Region. The South Central Region had the most area of timberland - 46 million hectares (Table 3-1).

Almost 50 percent of the 52 million hectares of timberland in the West was located in the Intermountain Region, and almost 30 percent in the Pacific Northwest Region. The Pacific Southwest and Alaska Regions accounted for the remaining 20 percent of the total area of western timberland. All tracts of timberland in the West are being evaluated to determine their primary long-term uses. These evaluations may result in reclassification of western timberlands in the future.

Interpretation

Timberlands are increasing both in area and volume. Most timberlands in the East are on productive sites, and in the West they tend to be on sites with lower average annual productivity. However, some sites in the West, and especially in the Pacific Northwest, have the greatest average annual productivity of any forested land in the nation. As pressure continues for increased production of wood fiber, management will focus on highly productive sites for intense cultivation. By increasing stocking on the most productive sites, wood production could be increased without added demand on the less productive sites. Many forests, especially in the

East, are now dominated by early successional stages, which tend to have fast growing species. As these are replaced by later stages, productivity may decline.

Data for the area of timberland available for production are contained in standard reports produced by FIA and other analyses are available on a sub-regional scale throughout the country. Trend information is available for all RPA assessment dates as well as regions, States, groups of counties, and non-traditional boundaries using the RPA database, the Eastside database, the Westside database, and auxiliary databases. Supplementary data on slope, volume, timber quality, and other variables that describe availability for production can be extracted from the Eastside and Westside databases and auxiliary databases maintained by regional FIA projects. Comprehensive data are not available for other forest lands at the present time.

INDICATOR 11: Total growing stock of both merchantable and nonmerchantable tree species on forest land available for timber production

Measurement of merchantable and non-merchantable growing stock provides an indication of timber supply opportunities.

Data Summary

As the nation's timberlands have matured, the percentage of the total volume represented in sawtimber-stand size class has correspondingly increased. The net volume of growing stock on timberland in 1992 totaled 22.2 billion cubic meters, 5 percent more than in 1977. In the Eastern U.S., between 1977 and 1992 the net volume of growing stock increased from 10.6 billion cubic meters to more than 13.0 billion cubic meters. While the volume of all major species in the East increased over the 15 years, a 31 percent increase in hardwood net volume was the greatest. Softwood net volume grew by only 10 percent over the same period.

In the Western U.S., net volume of growing stock on timberland decreased slightly between 1977 and 1992. Most major conifer species groups decreased, while hardwoods increased. The largest change in the West occurred in the western hemlock species group, which declined from about 1.5 billion cubic meters in 1977 to 0.9 billion cubic meters in 1992. In 1977, about 10 percent of the total volume was in rough, rotten, and sound dead trees, by 1992, that percentage had dropped to just 8 percent of the total volume.

Net volume of growing stock on timber land in the United States is shown for 1977, 1987, and 1992 in Tables 3-3, 3-4, and 3-5, respectively. Data are compiled from inventories conducted by the USDA Forest Service, Forest Inventory and Analysis (FIA) Program. Data for tree species considered "noncommercial" are typically included in retrievals for "live-tree volume" and are available from the Eastside and Westside databases and auxiliary databases maintained by regional FIA Programs. Some information for noncommercial species is available from the

Table 3-2. Net volume of growing stock on timberland in the United States by species group and region, 1977 (USDA Forest Service 1982) (millions of cubic meters).

Eastern United States:		Other					Other	
Region	Pines	Softwoods	Oaks	Hickory	Maple	Hardwoods	Total	
Northeast	283	625	809	130	562	836	3,245	
North Central	128	226	343	45	212	666	1,621	
Southeast	1,229	123	599	89	101	694	2,835	
South Central	1,337	62	698	152	34	602	2,885	
Great Plains	0	0	6	1	1	29	36	
Eastern Total	2,977	1,036	2,455	418	910	2,827	10,623	
Western United States:		Ponderosa/			Lodge		Western	
	Douglas	Jeffery	True	Western	-pole	Other	Hard	
Region	Fir	Pine	Fir	Hemlock	Pine	Softwoods	woods	Total
Intermountain	580	462	385	41	562	658	138	2,826
Alaska	0	0	4	721	1	424	68	1,220
Pacific NW	1,706	358	480	688	160	361	298	4,051
Pacific SW	362	258	363	4	25	291	110	1,412
Western Total	2,648	1,078	1,232	1,454	748	1,733	616	9,509
United States Total		21,132						

regional FIA Programs, but has not been compiled for National figures. Additional trend data for subregions such as States and groups of counties are available from most regional FIA Programs. Projections of expected future inventories of growing stock through the year 2040 are contained in the 1993 RPA Timber Assessment Update.

Table 3-3. Net volume of growing stock on timberland in the United States by species group and region, 1987 (Waddell et al. 1989) (millions of cubic meters).

Eastern United States:

Region	Pines	Other Softwoods	Oaks	Hickory	Maple	Other Hardwoods	Total
Northeast	286	603	618	77	649	858	3,091
North Central	191	262	492	82	336	842	2,206
Southeast	1,300	139	712	96	147	839	3,232
South Central	1,414	87	955	05	75	771	3,508
Great Plains	0	54	9	1	1	31	96
Eastern Total	3,191	1,145	2,787	462	1,208	3,341	12,134

Western United States:

Region	Douglas Fir	Ponderosa/ Jeffery Pine	True Fir	Western Hemlock	Lodge -pole Pine	Other Soft-woods	Western Hard woods	Total
Intermountain	639	440	421	27	598	660	176	2,962
Alaska	0	0	0	449	1	598	119	1,168
Pacific NW	1,580	258	393	585	132	337	327	3,612
Pacific SW	360	246	359	1	24	321	219	1,531
Western Total	2,579	944	1,173	1,063	756	1,916	842	9,274

United States Total 21,408

Table 3-4. Net volume of growing stock on timberland in the United States by species group and region, 1992 (Powell et al. 1993) (millions of cubic meters).**Eastern United States:**

Region	Pines	Other Softwoods	Oaks	Hickory	Maple	Other Hardwoods	Total
Northeast	300	651	690	84	945	779	3,449
North Central	216	276	550	98	372	903	2,416
Southeast	1,318	152	774	104	166	908	3,423
South Central	1,353	91	1,022	213	102	892	3,673
Great Plains	0	55	10	2	1	36	104
Eastern Total	3,187	1,226	3,047	500	1,587	3,518	13,065

Western United States:

Region	Douglas Fir	Ponderosa/ Jeffery Pine	True Fir	Western Hemlock	Lodge -pole Pine	Other Soft woods	Western Hardwoods	Total
Intermountain	641	476	433	3	584	652	199	3,018
Alaska	0	0	0	319	1	562	120	1,002
Pacific NW	1,609	255	366	536	120	321	323	3,529
Pacific SW	392	271	402	1	26	327	213	1,632
Western Total	2,642	1,002	1,201	889	731	1,862	855	9,182

United States Total 22,247**INDICATOR 12: The area and growing stock of plantations of native and exotic species.**

Forest plantations provide a measure of forest management intensity, or of efforts to reclaim degraded lands or marginal agricultural lands. They may also indicate the creation of ecologically simplified forest types (if management does not take into account biological diversity).

Data Summary

Nationally, growing stock volume in plantations was estimated to be almost 700 million cubic meters in 1992 (Table 3-5). Plantations averaged 48 cubic meters of growing stock volume per hectare in 1992. Generally, growing stock volume per hectare is increasing as the average age of

TABLE 3-5. Area of forest land and net volume of growing stock on forest land classified as plantation in the United States, 1992.

Region	Thousands of Hectares	Millions of Cubic Meters
Northeast	218	18
North Central	1,169	102
Southeast	6,318	291
South Central	5,982	273
Great Plains	17	1
Alaska	na	na
Intermountain	44	2
Pacific NW	595	2
Pacific SW	30	5
United States	14,372	694

plantations is increasing. Records maintained since 1950 indicate a relatively steady increase in the area of timberland annually planted or direct seeded. In the 1950's, an estimated 198 thousand hectares of forest land were established by artificial means, compared to an estimated 850 thousand hectares established in the 1960's, 839 thousand hectares in the 1970's, and 1.19 million hectares in the 1980's.

In the Great Plains, nearly all tree planting efforts have been for purposes other than timber production and, therefore, are generally not represented in plantation area or volume data. Most plantations in that region are established as windbreaks, wildlife habitat, etc., producing significant volumes that may eventually be used for firewood, lumber, posts, etc. Tree planting in the West is primarily used as a tool to re-establish timberlands, typically as a supplement to natural regeneration after harvest, rather than as a tool to increase the timberland area. In 1992, less than 5 percent of the total area classified as plantation in the U.S. was in the West.

In 1992, 86 percent of the total area of timberland classified as plantation was located in the South, primarily as conifer (loblolly pine) plantations. The Conservation Reserve Program (CRP) has helped convert thousands of hectares from agricultural to timberland uses. In the South, conversion of natural stands to plantations has proceeded to the point where 45 percent of the current total pine forest originated from planting or seeding. Plantation management has reduced the area of longleaf forests from more than 24.3 million hectares in the 1950's to 1.3 million hectares by 1993. In 1970, the South had 76.7 million hectares of timberland, of which 4.9 million hectares were in pine plantation. This represented 6 percent of the total area of timberland. By 1985, 11 percent of all timberlands were in pine plantation (8.5 million hectares of pine plantations, out of 73.7 million hectares, total). While the total area of timberland was decreasing between 1970 and 1985, the total area of plantations was increasing. In the Mid-South (a subset of the South), the area of timberland in pine plantations has increased from about 330 thousand hectares in 1952 to more than 3.6 million hectares in 1985. By 1985, planted pine accounted for 9 percent of all Mid-South timberland.

In the Lake States, although the total area of timberland has increased in recent years, the area of timberland in plantations has decreased. Tree plantations in that region primarily contain conifer species. In 1992, less than 2 percent of the total plantation area was located in the Northeast.

The area in plantation will continue to increase in the South and probably remain constant in other regions.

Interpretation

Because trees less than 12.7 cm are not included in volume calculations, the total volume on plantations is difficult to determine. Survival rates within plantations are not available in the data, therefore overall stocking can vary from over-stocked to poorly stocked. This has an

important influence on volume calculations. The degree of natural regeneration in plantations, especially in the West, is not considered, and may result in a weakening of data for the West. Species composition, whether involving exotic or native species, is not feasible for the entire nation but can be determined for the South.

INDICATOR 13: Annual removal of wood products compared to the volume determined to be sustainable.

By monitoring the volume of wood and non-wood forest products removed annually, relative to the amount that could be removed sustainably, managers can consider a forest's availability to provide a continuing supply of forest products and economic and forest management opportunities. Useful indices can be derived by expressing the three components of inventory change (net growth, removals, and mortality) as proportions of inventory volume and by tracking these indices over time.

Forest Inventory and Analysis (FIA) projects have reported comparable data for 1976, 1986, and 1991, and these data are included in RPA documents. To date, inventory data are available for all timberland in the U.S. The agency is conducting an inventory of reserved forest land. It will take at least a full cycle to complete the inventory of reserved land.

Information on inventory, net growth, removals, and mortality is available on a State-by-State basis from regional FIA projects. In most cases, the data are available for a wide range of additional classification variables, such as ownership, stand size class, stocking class, etc.

Data Summary

Although net growth still exceeds removal by a considerable margin, the growth-to-removal ratio has decreased over the three dates reported, primarily due to expansion of removals and moderation of net growth (Table 3-6). One factor in the moderation of net growth has been the harvest of older softwood stands with high levels of accretion, which have been replaced

TABLE 3-6. Net annual growth, removals, and growth-to-removals ratio for growing stock on timberland in the U.S. by inventory date (Powell et al. 1993) (Millions of cubic meters).

Net Annual Growth			
Date	Softwoods	Hardwoods	Total
1976	354	267	621
1986	354	271	625
1991	339	273	612

Annual Removals			
Date	Softwoods	Hardwoods	Total
1976	283	119	402
1986	310	142	452
1991	310	151	462

Growth-to-Removals Ratio			
Date	Softwoods	Hardwoods	Total
1976	1.25	2.25	1.54
1986	1.14	1.91	1.38
1991	1.09	1.80	1.33

with vigorous young stands that do not contribute to net growth until the trees grow to merchantable size (12.7 centimeters). Total exploitable growing stock volume steadily increased during the 1950's, but has leveled-off since the 1970's. In 1992 there were an estimated 22 billion cubic meters of growing stock on U.S. timberlands. Between 1950 and 1977, exploitable softwood growing stock volume grew, and then slightly decreased to a level of almost 12.6 billion cubic meters in 1992. On the other hand, exploitable hardwood growing stock volume has consistently increased during all inventory periods, and was reported to be more than 9.4 billion cubic meters in 1992.

In 1950, 414 million cubic meters of growing stock volume were removed from the America's timberlands. Total gross growth in 1950 was estimated to be 499 million cubic meters, with a net change in growing stock volume of an additional 85 million cubic meters; compared to 218 million cubic meters in 1977 and more than 149 million cubic meters in 1992.

The trend toward chip mills for fiberboard and oriented strand board has implications for removals from forest land. Since the early 1980's chip mills have increased significantly. There are concerns about the effect on long-term sustainability of the total removal of wood fiber in harvesting operations associated with this industry. Analysis of this aspect of timber removals has not yet been done, but should be considered in future efforts.

The growth-to-removal ratio decreased from 1.54 in 1976 to 1.33 in 1991, primarily due to increased removal rates and relatively constant growth.. Growth-to-removal ratios were larger for hardwoods than for softwoods in both time periods (Table 3-7).

Table 3-7. Gross growth, annual mortality, net annual growth, and annual removals expressed as a percent of growing-stock inventory volume for the United States by inventory date (Powell et al. 1993).

Date	Annual Gross Growth			Annual Mortality		
	Softwoods	Hardwoods	Total	Softwoods	Hardwoods	Total
1952	2.4	4.1	2.9	0.6	0.7	0.6
1962	2.7	4.0	3.2	0.6	0.7	0.7
1976	3.2	4.1	3.6	0.5	0.6	0.6
1986	3.4	3.7	3.4	0.6	0.6	0.5
1991	3.4	3.6	3.5	0.7	0.7	0.7
Date	Net Annual Growth			Annual Removals		
	Softwoods	Hardwoods	Total	Softwoods	Hardwoods	Total
1952	1.8	3.4	2.3		not available	
1962	2.1	3.3	2.5		not available	
1976	2.7	3.5	3.0	2.1	1.6	1.9
1986	2.8	3.1	2.9	2.4	1.6	2.1
1991	2.7	2.9	2.8	2.4	1.6	2.1

Change factors include gross growth, mortality (gross growth minus mortality equals net growth), and removals. Gross growth averaged 2.9 percent of total growing stock volume in 1952, compared to 3.5 percent in 1991. Mortality averaged 0.6 percent of total growing stock volume in 1952 (0.7 percent in 1991), resulting in an average annual net growth, as a percent of total volume, of 2.3 percent (2.8 percent in 1991). The rate of net annual growth as a percent of total volume was larger for hardwoods than for softwoods, but both were consistently above 2 percent for almost all time periods.

In 1991, 2.4 percent of the total softwood growing stock volume was removed, compared to 1.6 percent of the total hardwood growing stock volume removed. Annual net change (net growth minus removals) as a percent of total growing stock volume, was 1.1 percent greater in 1976 (data for annual removals are not available in this format prior to 1976) and 10.7 percent greater in 1991.

Interpretation

Despite the decrease in the growth-to-removal ratio, the ratio is 1.0 or greater, representing a situation where growth matches or more than matches removal. Findings for net change suggest that additions to total growing stock volume have decreased, although removals could be increased by almost a third (an additional 150 million cubic meters annually) and yet not be above total annual net growth.

Because managers lack information for all forest lands, the total volume cannot be determined. Data related to timberlands could be expanded to include all forest lands, application of those projections would be limited.

INDICATOR 14: Annual removal of nontimber forest products (e.g., fur-bearing animals, berries, mushrooms, game), compared to the level determined to be sustainable.

Monitoring the annual volume of wood and non-wood forest products removed, relative to the amount that could be removed on a sustainable basis, provides an indication of a forest's ability to provide a continuing supply of forest products, and economic and forest management opportunities. This indicator might also be used to reflect the values that society gives to forest resources by measuring the care that is given to their management. Non-timber forest products include game and fur-bearing animals, nuts and seeds, berries, mushrooms, oils, foliage, medicinal plants, peat and fuelwood, forage, etc. Water regulation, biodiversity conservation, recreational or spiritual values, and carbon release offsets are assessed under separate indicators.

Many non-timber forest products are subject to limited regulation or are not regulated at all, either because their use is highly localized, or their harvest rates do not appear to immediately

threaten the sustainability of the resource. Many non-timber products have considerable importance to Native American Tribal members, and are specifically identified in treaty rights. However, because their economic importance or the potential impacts of their harvest are often not recognized in the larger society, individual subsistence or recreational harvesting of products are less often regulated via permits. Activities such as hunting, fur-trapping, and commercial seed or berry collecting are often not regulated.

Trends are very difficult to determine where there are no data to support analyses. In general, the majority of non-timber products depend on the integrity of habitat, and harvesting apparently does not destroy the habitat. For example, berry production is dependent upon a habitat that supports the plant that produces the berries. Berry collection in any given year does not directly affect the sustainability of berries, since only the fruiting bodies are being harvested, not the plants themselves. This holds true for all non-timber products, such as mushrooms, nuts and seeds, and berries, moss and lichens, pine straw, etc. The production of many non-timber forest products depends on keeping the forest base in place and utilizing the benefits while not impacting the overall health of the ecosystem. If the ecosystem can be managed on a sustainable basis, then non-timber benefits' production can be considered sustainable.

In cases where harvest of the non-timber product involves removing plants, such as with oils, fuelwood, foliage, medicinal plants, etc., if the habitat is maintained, then replacement with additional plants can be encouraged through active management techniques, and the sustainability of that resource can be attained.

Considerable data are available on the status of game animals, although the quality and quantity of such data varies from State to State. From a sustainability viewpoint, one can assume that of all of the non-timber products, game animal production is the most likely to be considered sustainable, due to the high level of management given to maintaining viable populations.

Interpretation

Definitive conclusions cannot be determined at this time, since no "hard" data are available on a national scale. However, with the advent of ecosystem management, which seeks to integrate biological, ecological, geophysical, and silvicultural information to develop adaptive management practices that conserve biological diversity and maintain ecological functions, the potential sustainability of non-timber products should be enhanced.

In North America, most non-timber products removed from forest ecosystems are highly localized, and productivity may vary greatly from site to site. For that reason, meaningful data on their production and sustainability nationwide are difficult to gather. For example, the production and harvest potential of mushrooms varies from one region to another, from one ecosystem to another, and from one cultural/social group to another.

The sustainability of a product that is based on the presence of habitat, as well as natural population cycles, must be determined on a long-term, temporal scale. The manager must take into account many years' harvest or production records to make any meaningful determinations or long-term management decisions.

The periodicity and movement capabilities of a forest resource often make it difficult to inventory or monitor a forest product. Many non-timber products may be inventoried during their fruiting season. If data collection is made when the fruit are not available, the results will be problematic. Because many wildlife species move from one micro-habitat area to another, the repeatability of any monitoring effort must take into consideration the fact that even though the species might not be detected, it may use the habitat that is being investigated. As a result of these and other concerns, inventory and monitoring efforts intended to assemble data for future analyses must focus on specific products and the time/spatial frames necessary to adequately measure that specific product.

In theory, the sustainability of game and fur-bearing animals depends on the balance of annual mortality (harvest plus natural mortality) and reproduction. In reality, populations are in flux because of unanticipated events such as adverse weather or disease. Therefore, the setting of seasons and bag limits is both an art and a science.

Gathering berries, mushrooms, and other specialty products is increasing in popularity. The role of these products in ecosystem functions and processes is not well understood by most resource managers. The increased economic activity brought by the wild mushroom markets has stimulated interest in research on the role of mushrooms in ecosystems but, to date, there has been no agreement on the level of gathering that might be sustainable. There are harvest data for game and fur-bearing animals that are maintained by public agencies in each State, and some data are kept on populations. The quality of data varies from State to State and aside from what has been presented in a few localized studies, there is little information on management of specialty products.

On a local scale, thousands of non-timber products' studies have been conducted. An in-depth literature review might result in a meaningful collection of such information, and allow researchers to begin to correlate relevant data from a variety of studies. In turn, this could facilitate an analysis of the sustainability of non-timber products on a regional scale. It would also be valuable to access the traditional forest related knowledge about these products held by Indian tribes to assist researchers in this analysis. Unfortunately, the time necessary to complete this task is not available for this First Approximation Report.

Traditionally, harvest regulations for game and fur-bearing animals are devised and implemented to ensure sustainability. Species managed under State jurisdiction include big game, small game, fur-bearing animals, and recreational fisheries. How regulations are promulgated varies from

State to State. Species under Federal jurisdiction include migratory birds and commercial fisheries. The U.S. is a signatory to the Migratory Bird Treaty Act of 1918. Hunting of migratory birds is prohibited unless specifically permitted by the Secretary of the Interior.

Harvest data for game and fur-bearers are maintained by agencies in each State, as are some data on populations. The quality of the data varies by State. Aside from localized studies, there is little information on the management of specialty products.

iii. SUMMARY FOR THE CRITERION

The maintenance of the productive capacity of forest ecosystems in the U.S. has been measured by five indicators of land availability for timber production, merchantable and nonmerchantable growing stock available for timber production, area and growing stock of plantations, and the sustainable removals of wood and non-wood products. The following highlights reflect the significant trends and indications of this criterion in relation to the sustainability of U.S. forests.

Highlights

- Timberlands in the United States are increasing in area and volume. Most timberlands in the East are on productive sites and, in the West, they tend to be on sites with lower average annual productivity. However, some sites in the West have the greatest average annual productivities of any forest land in the Nation, especially in the Pacific Northwest.
- Pressure is expected to continue for increased production of wood fiber. On many of the most productive sites, stocking levels can be enhanced which will enable greater volumes of wood to be produced and lessen the harvesting pressure on site with lower productivity potentials.
- There is a concern that timber volume will decline over time because of forest succession, especially in the East where many of the earlier successional forest types typically have large volumes with high growth rates.
- In the Eastern US, all major species groups increased in their net volume of growing stock on timberland between 1977 and 1992. In the Western U.S., total growing stock net volume on timberland decreased slightly between 1977 and 1992.
- Records since 1950 indicate that the area of timberland annually planted or direct seeded in the US steadily grew during the 1950's, declined in the 1960's, and has steadily increased since the 1970's. The area of plantations will continue to increase in the South and probably remain constant in other regions of the U.S.

- The growth to removal ratio of wood products has decreased in recent decades. Softwood exploitable growing stock volume for the nation grew from 1950 through 1977 and then slightly decreased slightly from 1977 to 1992. Hardwood exploitable growing stock volume has consistently increased between all inventory periods. Growth to removal ratios were larger for hardwoods than for softwoods in both time periods.
- In general, the majority of the non-timber products depend on habitat for their production. The sustainability of many non-timber forest products depends on keeping the forest base in place and utilizing the benefits while not impacting the overall health of the ecosystem.
- With the advent of ecosystem management which integrates biological, ecological, geophysical, and silvicultural information, as well as socio-economic information, to develop adaptive management practices that conserve biological diversity and maintain ecological functions, the potential sustainability of non-timber products should be enhanced.

Gaps

Detailed inventories and assessments are not available to determine productivity for forest lands that are not classified as timberlands. Also, while productivity of timberlands is reasonably well documented, the availability of that timberland for harvest cannot be known with certainty in most cases.

Total volume on plantations is difficult to determine because trees less than 12.7 cm are not included in volume calculations. Survival rates for plantations are also not included in the data and thus overall stocking can vary from over-stocked to poorly stocked; this has an important influence on volume calculations. The degree of natural regeneration in plantings, especially in the West is not considered, resulting in a weakening of the data for the West.

Total volume can not be determined because of a lack of information for all forest lands. Data related to timberlands could be expanded to all forest lands but projections would be limited in application.

The majority of the non-timber products from forest ecosystems in the U.S. are localized. Data related to their production and sustainability are very difficult to gather on a national basis due to the localized nature of their habitat and ensuing production. For example, the production and potential harvest of mushrooms varies from one region to another, from one ecosystem to another, and from one cultural/social group to another.

Chapter 4

Criterion 3 MAINTENANCE OF FOREST ECOSYSTEM HEALTH AND VITALITY

I. INTRODUCTION

People have multiple effects on forest ecosystems. Human impacts include land conversion and harvesting, suppression of natural fire cycles and floods, and the introduction of non-native species, especially pathogens. These in turn influence ecological processes and ultimately forest dependent plant and animal species.

Air pollutants are suspected to have a significant cumulative impact on forest ecosystems by affecting regeneration, productivity, and species composition over extensive areas. Correlating forest inventory and health statistics with air pollution data provides additional information on the effects of these pollutants. Increased ultra-violet radiation, caused by changes in the earth's atmosphere, also has been shown to damage plants.

Monitoring of forest structure or macro species such as vertebrates (as for Criterion 1) tends to detect changes in ecological processes only decades after they have begun. On the other hand, monitoring of very short-lived species associated with specific ecological processes such as decomposition and nutrient cycling provides an immediate indication of more subtle changes in ecological processes with potential importance to forests in the long run.

ii. INDICATOR REPORTS

INDICATOR 15: Area and percent of forest affected by processes or agents beyond the range of historic variation, e.g., by insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinization, and domestic animals.

Disturbance plays an important role in forest ecosystems. In fact, without disturbance, forests would eventually cease to function due to excessive buildup of biomass and the end of necessary nutrient cycling. The key question for this indicator is whether the magnitude of disturbance we are witnessing is outside of the range of historic variation.

New factors affecting and changing forests in the last century are exotic pests as well as pollution from industry and urbanization. Changes in land uses have also been significant, including conversion to residential, agriculture, and other uses.

Wildfire has been and continues to be one of the most significant influences on the composition and structure of forests in the United States, especially in the West. After European immigrants landed on the continent, wildfires were routinely suppressed. Previously, warm, dry forest ecosystems, comprising more than half of the forest area in the interior West, had been maintained by frequent, low-intensity fires. At higher elevations, cooler and moister forests experienced less frequent, stand-replacing fires.

A variation in these disturbances is assumed to have occurred prior to settlement of the continent by Europeans. Actions of indigenous peoples, however, contributed to the historic variation. Disturbance agents beyond the range of historic variation have been identified from past and present forest vegetation trends (species, structure, successional patterns), and trends in the direct effect of a disturbance agent, such as acres of mortality or defoliation per year.

Monitoring and recording of disturbances in our forests has taken place only over the past 20 to 80 years, depending on the disturbance agent. Observations are lacking for more distant time frames, precluding us from knowing with certainty what the historical conditions and trends may have been. Most of the information on current status and trends presented for this indicator comes from Forest Service records over the past 50 years. Insect- and disease-caused mortality or defoliation data have been gathered in ground surveys, aerial surveys, and insect trapping networks.

Insect and disease data have also been collected by the Forest Inventory and Analysis (FIA) program for State and private forest lands and by national forest inventory programs for Federal lands, along with other forest vegetation data. Both sets of data are available on about a 10-year cycle for re-measurement.

Fire data for 11 western States are available from the Intermountain Fire Sciences Laboratory. These data have been compiled from Forest Service Smokey Bear Reports, 1916-1982; and from individual agency reports, 1983-1994, which have been compiled by the Bureau of Land Management, National Interagency Fire Center, Boise, Idaho. Data collected prior to 1931 do not include National Park Service or Indian Reservation lands; and data collected prior to 1926 apparently include only forested areas. National fire data are available in Fire and Aviation Management, USDA Forest Service, National Office. Those data were compiled from regional reports and include fire data from the Forest Service, Department of the Interior, and State and private lands.

Other data pertinent to disturbance agents and processes, such as resulting impacts of tree mortality and growth, and tree damage and crown condition, are available from the Forest Health Monitoring Program. Data on specific disturbance agents have not been collected. Plots are remeasured on a 4-year cycle; and remeasurement data are currently available from some States.

Data indicating land clearance, salinization, and other human caused disturbance may be available from localized sources throughout the country, but it was not possible to gather such detail for this report.

Data Summary and Interpretation

Native Insects and Diseases: In 1995, over 90 million acres of forested land in the United States were affected by southern pine beetle, mountain pine beetle, spruce budworm (eastern and western), spruce beetle, dwarf mistletoe, root disease, and fusiform rust. This is a conservative estimate, since not all forested land had been surveyed or monitored for insect and disease damage. In addition, several million more acres contain trees affected by native insects and diseases other than those listed above.

The southern pine beetle prefers loblolly and shortleaf pine, but will attack and colonize all species of southern yellow pine, whether in pure pine stands or in stands that are mixed with hardwoods. Mountain pine beetle attacks lodgepole, ponderosa, sugar, and white pines. The acreage affected by this insect has steadily declined since reaching a historical high in the early 1980's.

The eastern spruce budworm is a native insect inhabiting over 150 million acres of spruce and fir forests in North America, including 12 million acres within the United States. Large outbreaks of this insect have been recorded since the 1770's in the eastern United States and Canada. The biggest outbreak in this century occurred in the 1920's and 1930's, due in part to the extensive harvesting of spruce. Vast areas of balsam fir were killed, and budworm did not return until the 1940's, peaking in the 1970's. Spruce forests in West Virginia decreased to about 110 thousand acres in 1986, due, in part, to spruce budworm-caused mortality as well as logging and fires in the early 1900's. In Alaska, an increasing population of eastern spruce budworm has affected extensive areas containing over-mature spruce.

The western spruce budworm is native to mixed conifer forests of the West, feeding primarily on Douglas-fir and true firs. After widespread outbreaks in the 1980's, throughout its range, western spruce budworm populations collapsed in the early 1990's and remain at low levels. Major changes in outbreak patterns have occurred since fire suppression and harvesting of non-host species became widespread in the early 1900's. In the Rocky Mountains, recent outbreaks are more severe, and in the Northern Rockies they also last longer. In Oregon's Blue Mountains, outbreaks have become more frequent and more severe since the early 1990's, although no change in outbreak duration was found.

Spruce beetle occurs throughout the range of spruce in North America. Infestations have risen exponentially in recent years, with more than 1 million acres of spruce beetle activity detected in 1986. Current spruce beetle activity in Alaska is also higher than historic levels.

Over 28 million acres in the western States are affected by dwarf mistletoes, parasitic plants that cause growth reduction, top killing, deformity, and mortality in conifers. Over 40 percent of Douglas-fir, 26 percent of ponderosa pine, and 21 percent of true fir east of the Cascades is infected. Dwarf mistletoes have increased over the past century east of the Cascades due to the suppression of fires. Fire was an effective sanitizing agent, especially for severely infected trees and stands that were more fire-prone.

In the western United States, root diseases can be found on over 6 percent of commercial forest lands of all ownerships, causing growth loss and mortality on more than 9 million acres. In Oregon and Washington, an estimated 7 to 8 percent of forested lands (three million acres) is affected by root disease. In Idaho and Montana, almost 15 percent of commercial forest land (3.3 million acres) has root disease. In the eastern U.S., root disease has been reported on over 1.8 million acres. In the Southeast, annosum root disease contributes significantly to pine mortality, reduced growth, and increased vulnerability to bark beetle attacks. There are an estimated 163.5 million acres at high or moderate risk to annosum root disease in the Southeast.

Fusiform rust is a disease that flourishes across the southeast, killing or deforming millions of slash and loblolly pine each year. The rust fungus requires both pine and oak trees to complete its life cycle; spores produced on oak leaves infect pine and subsequent spores produced on the pine, in turn, infect oak. Currently, over 13 million acres have trees infected with fusiform rust. The current level of fusiform rust is probably far outside the natural range of variation due to dramatic alterations to the natural pine forests in the southeast by intensive pine management and fire control.

Exotic Insects, Diseases, and Plants: There are over 4500 exotic free-living species in the U.S. today - approximately 2 to 8 percent of plants, insects, pathogens are introduced - some beneficial and some harmful. Of the 70 major insect pests found in US forests, 19 are exotic. The corresponding proportion of forest pathogens may be even greater. Some forested ecosystems are more impacted and threatened by exotics than others. Hawaii is an extreme example, where two-thirds of the plant species in Hawaii Volcanoes National Park are non-native.

White pine blister rust was first found in the west in 1921 and by 1956 had spread to most of the white pine forests in the western United States. It is now distributed across the entire range of western white pine from British Columbia to New Mexico and across the major part of the range of other susceptible white pine such as sugar, limber, and whitebark pine. Up to 95 percent of the original stands of western white pine and sugar pine have been killed or damaged by white pine blister rust. Indirect impacts are also experienced as wildlife habitats are modified. For example, whitebark pine, a source of food and habitat for many species of wildlife including the grizzly bear, is considered a keystone species in high-altitude ecosystems. Suppression of fires has increased competition from other species and, at the same time, reduced the clearings in stands

with whitebark pine and thus the number of places for seeds to be cached by the Clark's nutcracker, a bird that plays a key role in whitebark pine survival.

There are over 600,000 acres (254,000 ha) of Port-Orford-cedar limited primarily to coastal northern California and southern Oregon. A little over 30,000 acres (12,250 ha) are infested with root disease that was introduced in 1952 and spread primarily by movement of contaminated water and soil. A significant portion of large Port-Orford-cedar has been killed in local areas and has had important ecological impacts in reducing stream shading, long-term wildlife habitat, and large woody material in streams.

The European gypsy moth was introduced to Massachusetts in 1869. In 1995, over 1.4 million acres of hardwood forests were defoliated from New England to Virginia and Michigan. On the west coast, European gypsy moths have been trapped periodically since 1974. In 1991, the Asian form of the gypsy moth was introduced in the Northwest, and two years later in the East. Neither form of gypsy moth has become established in the Northwest and the Asian form was eradicated in North Carolina. In 1996, gypsy moth defoliation declined more than 85 percent from 1995 levels due to spread of a fungal pathogen throughout most of the gypsy moth population. In areas where the gypsy moth is spreading into new areas, the fungus has not yet caught up to the moth.

The hemlock woolly adelgid was reported on the west coast in the 1920s, but did very little damage to western forests. In 1950, the insect was introduced to the east coast. Approximately 25 percent of the 1.3 million hectares of host type have been infested in the East and some scientists believe the entire range of eastern hemlock is at risk within the next 20 to 30 years. Loss of hemlock from eastern forests will have impacts on riparian areas where hemlocks help regulate water temperature, on wildlife species that depend on hemlock stands for shelter, nesting, and foraging habitat.

Beech bark disease was found killing American beech in eastern Maine in the early 1930s, as it spread into the United States from the Canadian Maritime. By the early 1980's it had spread through New York and into northeastern Pennsylvania. The merchantable timber volume loss is significant, and the mortality continues.

Fire: The frequency and scope of wildfire has changed dramatically since European settlers increasingly laid claim to the lands in the West in the mid-1800's. Livestock grazing and the significant curtailment of burning by Native Americans were inexorably changing the landscape. By the 1930's, the Forest Service and other Federal agencies were bringing more and more effective fire suppression to the land. Fewer and fewer acres of wildfire were recorded in the 1950's, 60's, and 70's. Beginning in the 1980's, wildfires in the West began to increase again. Over 3 million acres burned in 1994, over 1 million in 1995, and an estimated 5 million or more in 1996. The primary, overriding reason for increased fires and fire susceptibility is, ironically, the unprecedented success of decades of fire suppression. That success brought increased forest

density and biomass, changes in forest composition (diminished populations of certain fire-adapted tree species such as aspen) and the resulting increases in insect and disease susceptibility and mortality, and buildup of fuels.

In the West, wildfire occurrence, patterns, and severity are probably considered, by most, to be beyond the range of historic variation. We assume here that historic variation included the very significant influence that Native Americans had with forest vegetation.

Fire behavior has not changed in southern pine forests to the extent it has in western forests over the last century. Despite increased fire suppression efforts beginning in 1930's, arson-caused fire (for pasture and insect control) and prescribed fire in managed stands kept fire at a higher level than it would otherwise have been. The proportion of forest burned is similar to historic conditions, 10 to 30 percent annually, although altered in timing and frequency. These seasonal changes have led to significant changes in southern pine forest community structure, composition, and biological diversity. A reduction in the extent of fire in some parts of the Southeast has resulted in increased oak populations which, in turn, have led to increased levels of fusiform rust.

Other Disturbances: Major weather disturbances seem to have increased in frequency and intensity in recent years, including hurricanes, droughts, and flood events, resulting in destruction of millions of acres of forest. The effects of weather on forests may also be more significant now than in the past, at least partially due to management activities which increase the vulnerability of the ecosystem. After the immediate damage of the event itself, additional mortality in weakened stands results from subsequent insect or disease attacks. Several western states including California and eastern Oregon and Washington, experienced a drought between the mid-1980s and mid-1990s. Outbreaks of some insects were particularly high during these years especially on sites that were dry and had high tree density. No data was gathered for this report about trends in frequency and severity of these weather events.

There is mounting evidence that global climate change has occurred in the last 100 years. Proposed theoretical causes of present and future changes are almost exclusively anthropogenic, resulting from increased use of petroleum, coal, and natural gas; deforestation and burning of vast tracts of land; and increased production of methane from domesticated livestock. Some scientists believe they have clear evidence showing that, on average for the world, temperatures have increased by about .6 degrees centigrade during this century. Climate models predict a global surface temperature increase averaging 1.0 to 3.5 degrees centigrade and a 50 centimeter rise in sea level by 2100. Some parts of the scientific community do not believe that global climate change is a cause for great concern.

INDICATOR 16: Area and percent of forest land subject to specific levels of air pollutants (e.g., sulfates, nitrates, ozone) or ultraviolet B that may cause negative impacts on the forest ecosystem.

A common approach for evaluating ecosystems has been to consider two broad community types, aquatic and terrestrial. This is an especially convenient division for air pollutant purposes because the important group of pollutants that affect terrestrial species (e.g., ozone and hydrogen fluoride) are, in general, different from those that affect aquatic species (e.g., sulfates, nitrates, and metals). For example, pollutants such as acid fog composed of nitrates and sulfates, are injurious to plant leaves and can contribute to watershed acidification. Consequently, categorizing monitoring programs as benefitting purely one component of the ecosystem is not always possible. For simplicity, however, we will interpret the data separately for aquatics versus terrestrial systems.

Lichens especially are good bio-indicators of forest health because they are affected very directly by pollution. They rely on atmospheric sources for their nutrition and thus are very sensitive to changes in the atmosphere. Reports of the analyses from some of these studies show lichens can be affected by oxides of sulfur and nitrogen, hydrogen fluoride, metals, organics, radionucleides and perhaps to a lesser degree by sulfated, nitrates, ozone and ammonia.

Negative impact is interpreted to mean a substantial change in the function of an ecosystem or components of an ecosystem due to the influence of air pollutants. Obvious changes are loss of species or even loss of tolerant genotypes.

Data Summary

The National Acid Deposition Program (NADP) is a nationwide network of precipitation chemistry monitoring sites. First begun in 1978, the network currently consists of about 200 sites of average weekly data.

Average sulfate ion deposition has declined around the Ohio River Valley, most noticeably between 1989 and 1995 (see Figure 4-1 for 1995). Sulfur deposition has crept lower in the west, except along the northwest coast where there has been essentially no change. Nitrate ion deposition has declined at most locations in the east especially in the southeastern US. Nitrate deposition in the west has remained about the same (see Figure 4-2).

University of Georgia and Environmental Protection Agency Ultraviolet Monitoring Network has data for only four sites and it is limited in scope. The USDA UV-B Radiation Monitoring Program was initiated in 1992 to determine the geographical distribution and temporal trends of UV-B radiation in the US. Monitoring is conducted at three sites but averaged data and trend data are not yet available. The Mercury Deposition Network is a national network started in 1993 and currently consists of 30 sites measuring weekly average total and methyl-mercury in precipitation samples. These data are readily available from the Network.

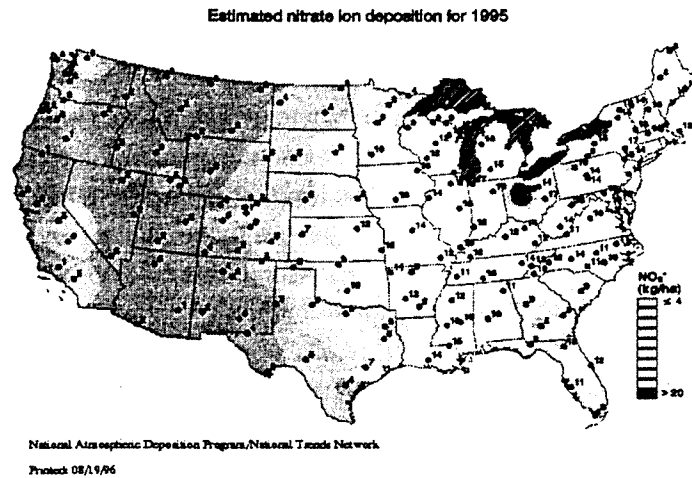
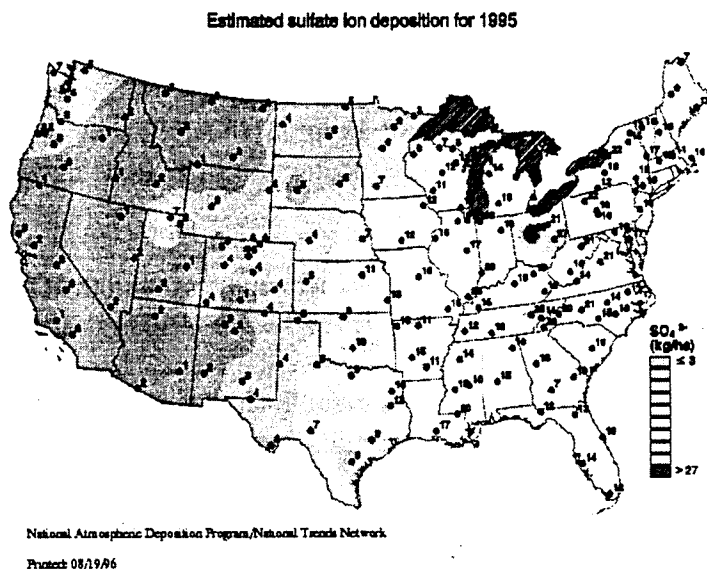


Fig. 4-1. Sulfate ion deposition.

Along the Appalachian chain (and other high elevation regions) depositions of acid compounds (sulfates and nitrates) and toxic trace elements is enhanced by the effect of the mountains. Mountains are frequently bathed in clouds which may result in atmospheric loading three to ten time greater than valley or lowland deposition. In addition, during the summer, mountain forests receive a higher dose of ozone (and possibly uvb..) than low elevation forests. The potential for multi-pollutant environmental damage to

Fig. 4-2. Nitrate Ion Deposition.
mountain forests may influence forest health and the susceptibility of mountain forests to pathogens.



Research at Mount Mansfield, Vermont indicates that some high elevation soils no longer act as net sinks for nitrate. Additional work needs to be conducted in other high forest catchments to determine the extent of this phenomenon. One of the key questions on mercury contamination in remote areas is how much

mercury deposits in the catchments of these remote areas, and how much of the mercury is exported to downstream aquatic systems.

Aerometric Monitoring consists of federal, state and local governments conducting ambient air (aerometric) monitoring of six pollutants for which exist national ambient air quality standards. Hundreds of sites operate across the US, mostly in or near populated areas. Of the six criteria pollutants, ozone is most important for forest health and is highest in the eastern US, California and some southern locations.

National annual average hourly ozone concentrations show a declining trend from 1985 to 1992. Since most of these sites are in urban areas and no other trend data exist, rural and forested ozone concentrations must be assumed by inference also to be declining. The 1992-94 data suggest that the average ozone concentrations have leveled off at about 110 ppb (.110 ppm). The Central Valley in California and the Los Angeles basin are violating the hourly average standard (120 ppb), as are much of the northeast seaboard and scattered other southern and Midwestern urban areas. The north central plains States do not regularly exceed the primary standard. While ozone concentrations are declining, the pollutant is still above an acceptable threshold in most of the east. The southern California air basin and the surrounding forested slopes stretch into the southern Sierra experience the highest persistent ozone concentrations of anywhere in the country. Many studies over the last 30 years have demonstrated that ponderosa pine, Jeffrey pine and other less wide-spread species of the region suffer from reduced energy flow and nutrient cycling.

The Interagency Monitoring of Protected Visual Environments (IMPROVE) network is one of the highest quality air monitoring programs for forested areas in the US. Thirty IMPROVE sites and about a dozen more IMPROVE-look-alike sites are in place today. The data are used to monitor visual air quality in National Wildernesses, Parks and Refuges.

The North American Maple Project (NAMP) is an international program instituted by the USDA Forest Service and the Canadian Forest Service in 1987. Its objectives were to: 1) determine the rate of change in sugar maple condition; 2) determine if changes in sugar maple condition differ due to management or level of atmospheric pollution; and 3) identify possible causes of sugar maple decline.

Nine years of annual, quality controlled, crown condition data indicates that over the natural range of sugar maple, the resource is generally healthy. There are a number of localized problems where causal agents (drought or insects) caused significantly worse health ratings. There is no significant difference in sugar maple health based on management regime, and trees in both sugarbushes and natural stands responded similarly to stress. Sugar maples exposed to high levels of sulfate and nitrate deposition had significantly worse health ratings than trees exposed to medium or low levels of deposition.

The Forest Health Monitoring Program (FHM) operates lichen and ozone monitoring in a portion of the 21 states that have the FHM permanent plot sampling grid. A full lichen census is available in some states and ozone-sensitive plants are monitored in some. Both of these data sets are available but not fully summarized yet. Other efforts are more sporadic and decentralized.

Data on the average fine sulfate aerosol concentrations for two recent successive three year periods, suggest that a slight reduction in sulfur aerosol has occurred in the west. The addition of sites in the mid-Atlantic area and Alabama revealed higher concentrations than the highest observed in the area previously but even most continuous sites showed no significant change in concentration over the six year period. Average fine aerosol nitrate concentrations seem to have declined most noticeably in California while the lack of detail in 1989 in the east may have masked a higher deposition then.

Interpretation

Although the National Acid Precipitation Assessment Program (NAPAP) report concludes that the vast majority of forests in the US and Canada are not in decline, the stress imposed by acidic deposition may contribute with other more significant factors, including climate, pests and disease, to the decline of some communities such as the red spruce in the higher reaches of the northern Appalachian Mountains.

NAPAP also concludes that although acid deposition may contribute in the long term to the leaching of nutrients from soils with low buffering capacities, there is no evidence that this has yet affected terrestrial biota.

Our ability to relate declines in growth and yield to exposures to pollutants such as ozone are limited because of the substantial gaps in our knowledge of air quality in many forested areas due to a shortage of monitors. Ambient levels of ozone do appear to be decreasing, but some forests may or may not show any positive effect immediately from this decline because of secondary impacts.

This indicator demonstrates some improvement in the overall health of forested ecosystems. For aquatic systems the situation is less clear because of the buffering capacity of soils and water systems. However, sulphate and nitrate deposition appear to be declining as well.

INDICATOR 17: Area and percent of forest land with diminished biological components indicative of changes in fundamental ecological processes (e.g., soil, nutrient cycling, seed dispersion, pollination) and/or ecological continuity (monitoring of functionally important species such as nematodes, arboreal epiphytes, beetles, fungi, wasps, etc.).

This indicator is intended to provide insight into whether key ecological components or processes, or ecological continuity, are changing in a negative way, suggesting the sustainability of a forest ecosystem may be declining or in jeopardy. This report focuses on ecological components and processes, because there are some definitions available to do so, and the lack of definitions concerning functionally important species as indicators of ecological continuity. Recent research supports the concern for nutrient loss and suggests acid rain can induce soil aluminum toxicity in some cases.

Key ecological processes may be defined as those essential to the long-term health and sustainability of forest ecosystems. Generally they are processes that are the most essential and fundamentally affecting all species. For example, nutrient cycling is an essential process because diminished cycling of nutrients will cause degradation of forest ecosystems.

The primary literature databases used for this search were TreeCD, Agricola, Biological Abstracts, and CAB. From Tree CD, Agricola, CAB, and World Wildlife literature data bases voluminous records are available but there was insufficient time to complete a review of the data. Little data exists on area and percent of forests where ecological processes have been affected.

The impact of biomass removal on ecosystem nutrient reserves has been recognized for a century. Initially, scientists predicted nitrogen to be a nutrient of concern in harvest removals, though today estimates suggest that natural and pollution nitrogen inputs to ecosystems generally balance removals in harvests. Modern research stresses the depletion of phosphorus and calcium from U.S. forest ecosystems. However, nitrogen depletion has been a concern in frigid conifer ecosystems of the northeast and northwest.

Data Summary

Harvest-caused nutrient losses in runoff and leaching are common, though carefully planned logging can limit impacts to about four times background levels in Eastern forest ecosystems. Specific areas with vulnerable soils are those in the coastal plain and piedmont regions in the eastern U.S. In the western U.S. scientists identify ecosystems with steep slopes as prone to debris avalanches following harvests. These events increase erosion dramatically. Early research at the Hubbard Brook long term ecological research site in New Hampshire stimulated great concern over harvesting because of potential impacts of nutrient losses on water quality. Later research revealed that the measured nitrate losses in streamwater at Hubbard Brook were unusually large compared to other ecosystems.

Great concern for atmospheric deposition of acid rain was met with heightened awareness as areas of forest declines were reported in northeast Adirondack and southern Appalachian spruce - fir and northeastern sugar maple forest ecosystems in the 1970's and 1980's. The U.S. National

Acid Precipitation Assessment Program reported several findings in 1991 that relate to the health of forest ecosystems:

- The great majority of U.S. forests are not affected by decline;
- Acidic precipitation may have lessened spruce resistance to injury in high elevation northern Appalachian ecosystems;
- Insufficient evidence exists to directly link sugar maple decline in the northeast to acidic deposition, though a relationship may exist;
- A reported regional decline of southern pines is not supported by the evidence;
- Acidic deposition is a lesser immediate concern, but may have long term damaging effects on soil fertility.

Acid nitrogen and sulfur deposition patterns are concentrated in the northeastern U.S. where industrial outputs are greatest. New York, Pennsylvania, and Ohio appear to exhibit the largest wet deposition of acid rain there. In the southern region Texas, Florida, Louisiana, and Tennessee produce large quantities of nitrogen and sulfur pollutants. Western region pollutant deposition remains low, though scientists there report many soils in the Sierra Nevada to be sensitive or very sensitive to damage from acid deposition.

There is substantial susceptibility to degradation from acid rain in the South as well. Ten percent of southern soils are sensitive to aluminum toxicity with additional acidification and 59 percent of soils there are susceptible to increased leaching of critical nutrients. Fifty-six percent of the Maryland landscape receives acid rain in excess of the expected critical load. Southeastern Appalachian spruce soils are more susceptible to acid rain damage than the northeastern spruce-fir ecosystem soils. Scientists in the northeastern region suggest acid deposition may be causing forest declines in spruce-fir ecosystems of the northern Appalachians and Adirondacks and in sugar maple ecosystems, though most evidence is inconclusive.

There were significant distribution losses of United States forested wetlands between 1940 and 1980. The greatest losses of forested wetlands during the 1940 to 1980 period in descending magnitude occurred in the north central (1,900,000 hectares), south central (1,900,000 ha), southeast (500,000 ha), and rocky mountain (355,000 ha excluding Arizona and New Mexico) regions in the U.S.

Summary Table 4-1 defines the percent change in ANPP (annual net primary productivity) as the change from maximum values achieved in early stand development compared to values for older forest stands.

In general, there is adequate data to determine the human activities and natural influences that disturb the forest and affect many key ecological processes. However lack of monitoring of the relevant biological components precludes a reliable estimate of the area of forest land affected by changes in fundamental biological processes.

iii. SUMMARY FOR THE CRITERION

The maintenance of forest ecosystem health and vitality have been measured by three indicators: processes and agents of disturbance; land and forest area susceptible to air pollutants; and forest land with diminished biological components indicative of fundamental changes in ecological processes and continuity. The following highlights reflect the significant trends and indications of this criterion.

- In 1995, over 90 million acres of forested land in the U.S. were affected by southern pine beetle, mountain pine beetle, spruce budworm (eastern and western), spruce beetle, dwarf mistletoe, rood disease, and fusiform rust. In addition, several million more acres contain trees affected by native insects and diseases other than those represented in this report. Presently there are over 4500 exotic free-living species in the U.S. Some levels of native insects and diseases are still within their natural range, while others are not. Exotic insects, diseases, and plants are, by definition, outside their natural range. These pose a great threat to many of our ecosystems.

Table 4-1. Annual Net Primary Productivity Declines for Forest Age-Sequence Studies In Various Climates. (Data compiled by Gower, McMurtrie, and Murty (1996) from the results of previous studies by other authors)

Biome	Species	Location	Range of Stand Ages (years)	% Change ANPP
Boreal	<i>Larix gmelinii</i>	Siberia	50-380	-51
	<i>Picea abies</i>	Russia	22-138	-58
Cold temperate	<i>Abies balsamea</i>	New York	0-60	-66
	<i>Pinus contorta</i>	Colorado	40-245	-76
	<i>Pinus densiflora</i>	Japan	18-390	-54
	<i>Populus tremuloides</i>	Wisconsin	8-63	-4
	<i>Populus grandidentata</i>	Michigan	10-70	-24
	<i>Pseudotsuga menziesii</i>	Washington	22-73	-45
Warm temperate	<i>Pinus elliottii</i>	Florida	2-34	-34
	<i>Pinus radiata</i>	Puruki, NZ (Tahi)	2-6	0
		(Rua)	2-7	-20
		(Toru)	2-8	0
Tropical	<i>Pinus caribaea</i>	Nigeria	5-15	-4
	<i>Pinus kesiya</i>	India	1-22	-33
	Tropical rainforest	Amazonia	1-200	-45

Note: The percent change in ANPP (annual net primary productivity) is the change in ANPP from maximum values achieved in early stand development compared to values for older forest stands.

- The behavior of wildfire in extent and severity is now most likely outside the natural range of variation in many ecosystems, especially in the West and Southeast. Records of area of wildfire across the U.S. show decreasing acreage in the 1950's, 1960's, and 1970's. In the West, wildfires began to increase in the 1980's to an estimated five million acres in 1996.
- The Southern California air basin and the surrounding forested slopes stretching into the southern Sierra Mountains experience the highest persistent ozone concentrations of anywhere in the country. Many studies over the last 30 years have demonstrated that Ponderosa Pine, Jeffrey Pine, and other lesser species of the region suffer from reduced energy flow and nutrient cycling.
- A national report concluded that the vast majority of forests in the U.S. are not in decline due to the stress imposed by acidic deposition. However, acidic deposition may contribute to the decline of some plant communities such as the Red Spruce in the higher reaches of the northern Appalachian Mountains.
- Modern research stresses the depletion of phosphorus and calcium from U.S. forest ecosystems compared to historical concerns of nitrogen depletion, which is still a concern in frigid conifer ecosystems of the northeast and northwest.
- Specific areas with soils vulnerable to harvest-caused nutrient losses through runoff and leaching are those in the coastal plain and piedmont regions in the eastern U.S.
- The greatest losses of forested wetlands during the 1940 to 1980 period occurred in the North Central (1,900,000 ha), South Central (1,900,000 ha), Southeast (500,000 ha), and Rocky Mountain (355,000 ha, excluding Arizona and New Mexico) regions of the U.S.

Disturbance is part of the natural forest ecosystems. In fact, without disturbance, forests would eventually cease to function due to excessive buildup of biomass and the end of necessary nutrient cycling. The effects of native insects and diseases, fire, exotic pests (introduced insects, diseases, and plants), and weather, to some extent, on forest vegetation were addressed. In many cases, the combined occurrence of more than one disturbance produced the changes in forest composition that we observe today.

Gaps

There are substantial gaps in knowledge of air quality in many forested areas, limiting our ability to relate declines in growth and yield to exposures to pollutants such as ozone.

Lack of data precludes the analysis of area of forests affected with diminished biological components or ecological processes. In some cases, data does exist, but it has not yet been

analyzed in enough depth to allow conclusions to be drawn. Long term monitoring and analysis of these elements needs to be designed and implemented.

Chapter 5

Criterion 4 CONSERVATION AND MAINTENANCE OF SOIL AND WATER RESOURCES

I. Introduction

Soil and water are basic to all of the other resources in the forest. Without their conservation and maintenance, no other resources will survive. Forests are also an important part of the earth's hydrological cycles, especially in the regulation of surface and ground water flow. Documenting the results of research currently underway will provide a stronger foundation for understanding both human and natural-caused changes in the physical, chemical and biological properties and processes of both land and water resources.

Assessment and ongoing monitoring of the physical and biological characteristics of forests have been and continue to be regular practice on public and industrial ownerships, and on some non-industrial lands. These programs provide an extensive data base of soil, water, and related resources over time.

Some areas of Federal lands are set aside at the Federal, State and occasionally, local level for protection of their basic values such as wilderness, wild and scenic rivers, and outstanding native resource waters. In addition to set-asides, regulation of land uses and practices to protect soil and water is provided at different levels of government through a variety of approaches.

ii. Indicator Reports

INDICATOR 18: Area and percent of forest with significant soil erosion.

The loss of soil must inevitably influence the vitality and species composition of forest ecosystems. Extensive areas of soil erosion can have a major effect on aquatic ecosystems associated with forests, recreational opportunities, potable water supplies and the life span of river infrastructure such as dams.

Erosion concerns tend to be at the local scale and centered on management practices. Much of the forest land in the Eastern United States is on former agricultural lands which were abandoned at least in part because of erosion. However, even on short rotation, intensively managed forest lands, these former agricultural soils are being regenerated. Erosion on forest land is most likely at the time of harvest or management activity. Harvest methods, road building, and other soil disturbance can affect the severity of erosion. Prescribed burns that get too hot and expose the root layer can also affect erosion. Other factors are topography and the severity of rainstorms and their timing. With best management practices, mitigation measures, and care in building roads and skid trails, erosion should not be a major problem.

Data Summary

Current knowledge is lacking for estimating the erosion rates from forested areas, because the rill erodabilities of forest lands in either undisturbed or disturbed conditions are lacking. Also unknown are the impacts of upland forest conditions on downstream aquatic ecosystems because there has been only limited development of models for sediment transport through steep forest stream networks.

The Natural Resources Inventory (NRI) is conducted by the USDA, Natural Resources Conservation Service at 5-year intervals. This inventory provides a "snapshot" of land cover and use, soil erosion, prime farmland, wetlands, and characteristics of other natural resources. NRI data is collected for non-Federal lands of the United States: the 48 contiguous states, Hawaii, Puerto Rico, and the U.S. Virgin Islands, but not Alaska. The focus of data collection is on soil, water, and related resources on farms, non-Federal forests, and grazing lands.

The plot layout in the NRI consists of a grid of 800,000 points within permanent sample units (PSUs) on non-federal and federal lands. A stratified random sample is taken every 5 years, but Federal lands are not sampled.

Data is collected which can be used in modeling soil loss on forested lands. Data are for cover factor, the erosion control practice, the slope percent, and the slope length. The 1982 NRI data includes sheet, rill, and gully erosion types. The 1987 and 1992 NRI data sets cannot be used to estimate soil loss because Universal Soil Loss Equation (USLE) data were not collected separately for forested lands.

A new erosion prediction technology is being cooperatively developed by a number of Federal agency and university cooperators. This technology describes the erosion processes, rather than empirical relationships, and predicts not only erosion, but sediment yield, making in an appropriate tool for predicting water quality as well as soil quality. This approach has been shown to be as good as, or better than the USLE in predicting soil erosion on USLE plots. The model makes use of a daily climate descriptor, soil properties, management (which describes rates of vegetation regrowth and degree of disturbance), and topography. In forest conditions, rainfall simulation and natural runoff data collection have been collected to run the model for forest roads and harvest areas. Generally, a reasonable data set now exists for predicting road erosion and sediment yield across a riparian buffer area. Simplified relationships are being developed to allow rapid estimation of sediment yield from roads to upland channels.

Trends in soil loss can be derived from the 1982, 1987 and 1992 NRI data, if the 1982 data is used as a base-line and the model is extended for all forested lands in 1987 and 1992. Because of data limitations, assumptions will have to be made for the model and documented well.

Analysis indicates that forest erosion is predominantly due to forest roads and wild fires. Current work at the Rocky Mountain Research Station will allow estimating road surface erosion and

sediment yields from roads entering waterways by developing a database of typical road topographies, soils, and distances to watercourses for a given climate. Much of this information is readily available, but the technology has not yet been tested. There are still some major unknown factors in estimating erosion rates triggered by wildfires. The most important gaps in current knowledge are the nature and spatial distribution of impacts on rill erosion, the dominant form of upland surface erosion.

Interpretation

Soil loss can be modeled for 1997 using the 1982 using the 1982 NRI data using a data element called "treatment needs" which includes all erosion types (sheet, rill, gully and ephemeral) and data elements called "critical eroding areas" and "degree of erosion" or erosion classes on all lands. This was done for the Nation as a whole in 1982. A similar analysis was completed for the 1992 NRI data in 1994 and revised in 1995.

Tables 5-1 and 5-2 provide interpretations of the 1982 and 1992 NRI data for non-Federal forested lands. Additional data is available for:

- Estimates of average annual wind erosion by 1982 land cover/use;
- Percentage of each major land use/cover category for which erosion exceeds the soil loss tolerance (T);
- Estimated average annual rates of sheet and rill erosion, by State; and
- Estimated average annual rates of wind erosion, by State.

Some assumptions can be made to predict soil loss for Federal forest lands using 1982 USLE data. The results could then be added to non-Federal forest land soil loss estimates to obtain a

Table 5-1. Estimates of average annual erosion on 1982 grazed and ungrazed forested non-Federal lands.

Wind Erosion	Sheet and Rill Erosion	total
grazed / ungrazed	grazed / ungrazed	grazed / ungrazed
1,000 tons: 3,975 / 253	154,836 / 215,186	158,812 / 215,438
tons/acre: 0.1 / 0.0	2.3 / 0.7	2.4 / 0.7
1,000 acres: 66,057 / 327,657		

Table 5-2. Estimated average annual sheet and rill erosion in relation to soil loss tolerance (T) on 1982 non-federal lands.

<T			T-2T			>2T		
1,000 tons	1,000 acres	tons /acre	1,000 tons	1,000 acres	tons /acre	1,000 tons	1,000 acres	tons
99,073	370,587	0.9	35,173	9,740	3.6	235,776	13,387	17.6

National figure. On Federal lands, the categories would have to be adjusted to address land uses including undisturbed forests, areas harvested, and areas disturbed by prescription burning, wildfires, and roads.

INDICATOR 19: Area and percent of forest land managed primarily for protective functions. e.g. watersheds, flood protection, avalanche protection, riparian zones.

This indicator provides a measure of forest land allocated primarily for the protection of valuable environmental amenities associated with clean air, water, soil, flood and avalanche protection, etc. (public health and safety functions). Good results will confirm the degree to which society values ecosystems and protects them.

Some areas of federal lands are set aside for protective functions as identified in their respective planning processes. Special resource areas are protected on the basis of amenity values such as wilderness or wild and scenic rivers, as well as safety or functional resource values. Most States also have areas set aside for similar protective functions. Data showing such areas and objectives for their protection are available on a State-by-State basis. Additional analysis will be required to provide national figures, because of inconsistencies in definitions and use or management restrictions.

In addition to set-asides, regulations on Federal lands and in best management practices in those States that have them allow for protection of streams through buffer zones where trees are not harvested. Analysis of management at the watershed level is becoming increasingly important to assess the implications for sustainability.

Some jurisdictions manage watersheds specifically for quantity and quality of water, but data on the total area is not currently available. Flooding and other disasters in recent years may also cause jurisdictions to consider precluding selected types of development in areas vulnerable to severe impacts resulting from these events.

When lands are managed for multiple uses, it is difficult to attribute the area just to the protection functions. Developing this information on a national basis will be complex and time consuming, but could better reveal the extent of protection for various ecosystem functions.

INDICATOR 20: Percent of stream kilometers in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation.

Changes in historic stream flow and the timing of flow, resulting in flooding and/or dewatered streams, can reflect on the health of aquatic ecosystems and the management and conservation of associated forest areas and downstream agriculture areas. This may indicate the extent to which water supply conditions are affected by forest management.

Data are gathered at the locations of stream gauges, but the relationship between an individual gauge and a specific length of stream in forested catchments needs to be defined. The United States Geological Survey (USGS) maintains a large network of stream gauging stations across the US, so data is potentially available. Streamflow records go back to the late 1800's. However, data sets, analyses and reports for forested catchments have not been assembled. USGS data are reliable. Results could also be reported by major aquatic ecoregions, and displayed in map form nationally at some future date.

Assessments of data measuring "natural" streamflow in the conterminous U.S. link increasing streamflow to changes in global climatic conditions. These data indicate that unimpaired streamflow has increased in nearly all regions of the conterminous United States since the early 1940's. They also show that, with one exception (New England), all of the observed positive trends occurred in autumn and winter.

Analysis of current trends may indicate significant impairment of the nations waters in some forested areas or regions. Data is available to provide a general summary for the type of change in historic stream flow and/or timing of flow, but has not been gathered and analyzed for this report. Impacts or changes to water quality, quantity and timing vary by region of the United States and trends for forested lands could be shown. Land use history and ownership may provide additional insight.

The National Inventory of Dams is maintained by the U.S. Army Corps of Engineers. This data set contains 1995 and 1996 data with plans for annual updates. The database contains information on 75,187 dams including dam name, location, size, capacity, etc. This information is used to assess safety hazards posed by dams in the U.S. and to analyze needs and target resources for navigation, flood control, water supply, hydroelectric power, environmental restoration, wildlife protection, and recreational projects. The Nature Conservancy is developing an Index of Hydrologic Modification that may provide more predictions of aquatic resource modification.

INDICATOR 21: Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties.

Forest ecosystems recycle most of their nitrogen, phosphorus and other nutrients through the soil. Soil organic matter also is a major component of the global cycling of carbon. Being at the soil surface, organic matter status strongly reflects ecosystem disturbance. Soil organic matter is important for water retention, carbon storage, and soil organisms and is an indication of soil nutrient status. Changes in soil organic matter can affect the vitality of forest ecosystems through diminished regeneration capacity of trees, lower growth rates, and changes in species composition.

There are standard definitions of soil organic matter as well as standard procedures for measuring it, but sufficient data are not available to make reliable estimates in most regions. Some

estimates have been made from existing soils databases, but the reliability of these estimates is unknown. There is limited probabilistic data in forested areas.

Studies have been conducted or are underway throughout the United States where changes in soil organic matter are monitored for different intensities of forest management. For example, the Long Term Soil Productivity research initiative (LTSP) by the Forest Service was initiated in 1989 evaluate timber management impacts on long-term soil productivity. By modeling losses of soil organic matter in the LTSP studies, with statistics on forest management practices by regional ecological units, a relative estimate can be shown for all forest lands with significantly diminished soil organic matter. This might be done also for other soil nutrients removed by harvesting or lost by leaching or in smoke after prescribed fire. These measurements can be related to results of fertilizer studies where growth response to additions of nutrients is measured. At least 10 years of study is needed to be able to estimate trends in the United States after installation of LTSP studies, which is 2 to 10 years past the present. Responses from treatments may be slow to develop. More robust data may have policy implications as it becomes available later.

During the last half century soil organic matter levels have increased in many forested areas of the eastern U.S. as forests recover from past exploitative use (e.g. clearing, cutting for charcoal, widespread grazing) and increase their biomass, both above ground and below. In some areas of the west, there probably was a slight overall decline in this indicator.

INDICATOR 22: Area and percent of forest land with significant compaction or changes in soil physical properties resulting from human activities.

Nutrient and water availability to forest vegetation is dependent on the physical ability of roots to grow and access nutrients, water, and oxygen from the soil. This in turn is dependent on soil texture and structure. Subsurface hydrology can also be affected by soil compaction resulting from extensive human activities. Compaction of the surface soil reduces water infiltration, resulting in more runoff. This can increase erosion, reduce biomass production and impair watershed function.

Data Summary

Like soil organic matter, soil compaction can be assessed by the Long Term Soil Productivity research initiative. Changes in soil bulk density and soil strength are measured at the initiation of a LTSP study and at least every 5 years thereafter. Because of the large number and diversity of soils in the LTSP studies, researchers expect eventually to have a good approximation of the forest soils in the country.

Repeated measurement in the LTSP studies will also provide researchers with information about the effects of compaction on plant growth, both for trees and for associated vegetation. Recovery rates of soil after compaction are also being studied. The effects of understory vegetation

(especially grasses), climate, clay type, and other factors on the recovery rates will also be determined.

By modeling significant compaction or change in soil physical properties with statistics on forest management practices for the United States by regional ecological units, a relative estimate can be given for all forest lands with significant changes in soil physical properties and reduced productivity.

The LTSP studies will need to be continued for at least 10 years to develop an adequate data set. Also, research can not be extrapolated to estimate the effects of compaction on ecological regions that are not included in the study, currently the New England states and Oregon and Washington.

Grazing of forest land has decreased in some areas, so the extent and severity of compaction probably have decreased. However, areas of forest land intensively used for recreation have increased in many areas, increasing the potential for compaction in heavy use zones. Much logging equipment is larger than in former years, but operators are more sensitive to damage. Overall, the trend in forests with respect to physical damage to soils is difficult to assess.

Major challenges remain in the analysis of soil properties. Soil scientists agree on what compaction is, but there is wide disagreement on what measurement(s) truly reflect compaction (for example, bulk density, penetrometer readings, visual estimate of structure). Few quantitative, probabilistic data are available. Also, there is disagreement on how to assess the extent and effects of compaction and estimates of the severity of compaction on forest land are subject to dispute.

INDICATOR 23: Percent of water bodies in forest areas (e.g. stream kilometers, lake hectares) with significant variance of biological diversity from the historic range of variability.

Biological diversity is a critical indicator of the health of aquatic ecosystems. Organisms that live at the bottom of water bodies (benthos populations) are sensitive to a variety of possible changes, including silt, oxygen levels, and temperature. Such changes may be the result of changes in upland forest areas illustrating the extent to which aquatic biodiversity has been affected by forest management.

Although aquatic biological data have been gathered for many years, only recently has there been an effort made to develop and implement consistent methods on a National scale in Federal programs. There is not yet sufficient data to quantify changes in aquatic biodiversity in forest areas at the National level.

The new National Water-Quality Assessment (NAWQA) Program of the U.S. Geological Survey (USGS) has recently developed a set of biological sampling protocols to provide national consistency in collecting samples of biological communities and characterizing physical habitat

conditions. It will be almost a decade before the NAWQA Program is able to describe what happened during the last few years of the 20th Century, and historical data is lacking as well. However, the resources available to NAWQA for forest environments may not be intensive enough to provide adequate data for this indicator. Regardless of the level of detail obtained in the data, the number of indicator sampling sites in forested areas that will be necessary to quantify this indicator still needs to be determined. Also, the majority of sampling sites are located in streams and well sites, so other water bodies (lakes, ponds, reservoirs, etc.) may not be adequately sampled.

The surface waters component of the EPA Environmental Monitoring and Assessment Program (EMAP) is designed to estimate the current status, extent, changes, and trends in the indicators of the biological condition of our Nation's waters. This program monitors indicators of pollutant exposure and habitat condition; seeks associations between human-induced stresses and ecological conditions; and provides periodic statistical summaries and interpretive reports on status and trends at the regional and national scale. However, the same problems described for NAWQA may also apply to EMAP.

The Second RCA Appraisal describes the use, conditions and trends of the soil and water resources on non-Federal lands of the United States, documenting resource conditions based on the 1982 Natural Resource Inventory. For the Appraisal, data were analyzed at the major land resource area level and aggregated to land resource regions, or multi-state farming regions.

EPA maintains a national database called the STORage and RETrieval (STORET) system which contains over 200 million observations of water quality monitoring data from multiple data sources, both public and private. STORET is designed to collect and disseminate basic information on chemical, physical, and biological quality of the nations waters. It is a repository of water quality data, including information from ambient, intensive survey, and effluent water quality monitoring of the waterways within and contiguous to the United States.

Since the data were collected over several years and by various organizations, the collection and analysis methods and equipment vary. This makes it difficult to ensure the comparability of the data from one organization to another. Users have not entered into the present system the needed information to document the quality of the data even though the data have met all of the quality control requirements generally considered acceptable for the collection and analysis of water data.

EPA is currently modernizing the system to make it easier to access data, store information about data quality and equipment used to acquire the data, and expand the fields to store biological and habitat information. Once the new system is implemented in late 1998 or early 1999, data from various studies and organizations will be more readily comparable. Links to other systems such as modernized USGS data systems will also be increased so STORET users have access to additional data as well.

Data from biological field surveys within and adjacent to forested lands would be most useful in addressing this indicator. A correlation of station geographic location and description with the proximity forest lands would indicate available information. In some instances, biological field surveys may not exist for non-Federal or Federal forest lands, and information will have to be modeled from existing field survey data.

Interpretation

The biological components of water resources in all ecosystems of the U.S. are declining. A large variety of indicators demonstrate this point. For example, more than 70 percent of the original floodplain forests in the country have been converted to urban and agricultural use, and 34 percent of fish, 75 percent of unionid mussels, and 65 percent of crayfish have been classified as rare to extinct. However, at this time, we cannot quantify National trends in aquatic biodiversity specifically in forest environments.

The Second RCA Appraisal provides some data showing probable sources of water quality problems affecting aquatic habitat, by stream mileage affected, as presented in Table 5-3. It estimates the extent of damage from all sources to aquatic habitat in rivers and streams, indicating that more miles of streams are damaged by non-point than point sources.

Table 5-3. Probable sources of water quality problems affecting aquatic habitat, by stream mileage affected (1982).

Probable Source	All Streams		Perennial Streams	
	miles	percent	miles	percent
Silviculture/logging	71,736	7.5	68,981	10.3

Sediment contributes to other pollutant problems because pesticides, nutrients, and other contaminants are absorbed to the soil particles. Erosion from all sources is the origin of 80 percent of the total phosphorous and 73 percent of the total Kjeldahl nitrogen in the Nations waterways. The Second RCA Appraisal provides an estimate of erosion and associated pollutant discharge into waterways of the United States, presented in Table 5-4.

Environmental.

Indicators of Water Quality in the United States is a 1996 report prepared by EPA's Office of Water. This report indicates that methods for biological monitoring of lakes are under development.

Table 5-4. Estimated water pollutant discharge resulting from erosion on all forested lands in the United States.

Erosion	Pollutant Discharge		
	Total suspended solids (million tons/yr)	Total phosphorous (million tons/yr)	Total Kjeldahl N (thousand tons/yr)
783	344	495	1,035

Consequently, there are not enough data to confidently report the number of lakes that support healthy aquatic life. However, 9 percent of the nation's rivers and streams and 50 percent of all estuaries have been monitored. Of those aquatic systems that are regularly monitored, 50 percent of each category were found to support healthy aquatic life.

Location and description data in the STORET database will be useful in identifying stations that are within and adjacent to all forested lands. Coefficients can be provided which indicate a significant change in the aquatic ecosystem from siltation, oxygenation, and/or temperature fluctuation causing an adverse affect on benthos fauna. The extent of water bodies (streams and lakes) where benthos fauna may be adversely affected might be estimated from extensive road construction (siltation, change in pH from acid rock) and other forestry practices that have the potential of causing a significant change.

INDICATOR 24: Percent of water bodies in forest areas (e.g. stream kilometers, lake hectares) with significant variation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation or temperature change.

Monitoring of water quality over large areas of forest land serves as an initial indication that activities within or outside that area may be affecting ecosystem health. This may indicate the extent to which water quality conditions are affected by forest management.

Nationally consistent water quality data sets, analyses, and reports for forested catchments have not been assembled. However, this could be accomplished in future years in a manner similar to that currently used for National reporting by the USGS and EPA. For example, The National Water Summary for 1990 to 1991 uses a Nationally consistent data base and methods of statistical analysis to document stream water quality in the US, Puerto Rico, and the Western Pacific Islands.

Few water-quality data collection programs are National in scope. The USGS Hydrologic Bench-Mark Network began in 1964 and monitors 55 of the Nation's streams that are minimally affected by human influence. The USGS National Stream Quality Accounting Network (NASQAN) began in 1973 and monitors the quantity and quality of water that flows from major drainage basins. The EPA, beginning in 1974, has prepared a series of biennial National Water Quality Inventory reports to Congress which are based on individual reports prepared by the States as required by section 305(b) of the Clean Water Act. Also, about a thousand State and local agencies participate in the Federal-State Cooperative program, however differences in sampling methods and criteria, sample handling methods, and analytical techniques result in inconsistent and incomparable data for national or regional analyses.

Two Federal water-quality monitoring programs currently underway will enhance our databases for future analyses -- the USGS National Water Quality Assessment Program and the US EPA Environmental Monitoring and Assessment Program, both described above for Indicator 23. Early in the 21st Century, these programs will have gathered enough data needed to document

statistically significant trends at the national level. Since the sources or consequences of stream contamination are strongly associated with specific regions of the country, results should be reported by major aquatic ecoregions.

The National Water Summary shows that concentrations of several of the traditional water-quality indicators (fecal coliform bacteria and total phosphorus for example) decreased during the 1980's and provide evidence of progress in pollution control during the decade. Trends in the concentrations of other traditional indicators (dissolved oxygen and nitrates) changed little.

The extent of water bodies with a significant change in water quality can be assessed using STORET data and modeling techniques including panametric data of water bodies within and adjacent to forested lands. Geographic locations and descriptions of stations would have to be correlated within a certain proximity to forest lands. In some instances, water quality data may not exist for Federal lands, and predictions would have to be made. By looking at annual sampling sites beyond and within forested areas, trends in significant change may be observed and displayed geographically.

Location and description data will be useful in identifying stations that are within and adjacent to forested lands. Coefficients can be provided which indicate a significant change in the aquatic ecosystem from siltation, oxygenation, and/or temperature fluctuation causing an adverse affect on benthos fauna. The extent of water bodies (streams and lakes) where benthos fauna may be adversely affected might be estimated from extensive road construction (siltation, change in pH from acid rock, etc.) and other forestry practices that have the potential of causing a significant change.

INDICATOR 25: Area and percent of forest land experiencing an accumulation of persistent toxic substances.

The primary source of persistent toxic substances would be industrial waste and pollution. Although some forest land may be affected by adjacent industrial activity, the total area is unknown and is probably small. Some forest land may be affected by mining operations for arsenic, cadmium, copper, lead, mercury, and zinc. In general, however, these operations are of concern for water quality rather than forest area.

Concerns over accumulation of toxic substances tend to be at the local scale. Dumping of toxic wastes and waste accumulation produced by wood preservatives has occurred on some forest lands. Toxic substances may also accumulate as a result of various management practices, such as application of fertilizers or herbicides. EPA maintains a database which provides the location of Superfund sites in forests but there is no data available for sites of smaller magnitude or lower toxicities that do not qualify for Superfund cleanup.

EPA's Permit Compliance System (PCS) was developed to meet the informational needs of the National Pollutant Discharge Elimination System (NPDES) under the Clean Water Act. This system tracks permit compliance and enforcement status for the NPDES program. It was designed to support the operational and reporting needs of regional and State personnel as well as EPA's Office of Enforcement and Compliance Assurance. The PCS has information on pollutants regulated by permits for major and minor facilities. It contains the amount and location of pollutants being discharged to water sources from major facilities such as wastewater treatment plants and factories. A user can also determine when facilities have violated their permits indicating unsafe levels of pollutants are being discharged into water sources.

In EPA's National Watershed Assessment Project (NWAP), data layers have been developed from national data sets to address watershed condition and vulnerability. Among other elements, this data base describes toxic pollutant loadings discharged annually in a watershed above the discharge limits allowed by the National Pollution Discharge Elimination System permits. This provides a measure of pollutant stress in a particular watershed. Location data is included so a relationship of point sources to forested lands can be determined.

Table 5-5 shows results of surveys completed by thirty-six States and Tribes in which toxicants are reported in 160,335 miles of rivers and streams. The survey covered only 5 percent of the Nation's 3.5 million river miles for toxic contamination, but elevated concentrations of toxicants were detected in 25 percent of the surveyed rivers and streams. Thirty-four States and Tribes reported that they sampled toxicants in more than 7.5 million

acres of lakes, reservoirs, and ponds. These surveys represent 18 percent of the Nation's 40.8 million lake acres. The States and Tribes found elevated concentrations of toxicants in 29 percent of the sampled lake acres. Seventeen States sampled for toxicants in 23 percent of the Nation's estuaries detecting elevated toxic concentrations in 26 percent of the 7,865 square miles of estuarine waters that were sampled.

Table 5-5. Percentage of surveyed waters with toxic contamination.

Waters	Percent with toxic contamination
Rivers and Streams	25
Lakes	29
Great Lakes	9
Estuaries	2
Ocean Shore	1
Source: Based on 1994 Section 305(b) Reports from States and Tribes; National Water Quality Inventory 1994 Report to Congress, EPA 841-R-94-001, March 1994 Washington, DC 20460, p147.	

iii. Summary for the Criterion

Highlights

- Erosion concerns tend to be at the local scale and centered on the quality of management practices.

- Assessments of data measuring "natural" streamflow in the conterminous U.S. establish the link between increasing streamflow and changes in global climatic conditions.
- During the last half century, soil organic matter levels have increased in many forested areas of the eastern U.S. as forests recover from past exploitative use (e.g. clearing, cutting for charcoal, widespread grazing) and increase their biomass, both above ground and below. In the West, however, there probably was a slight overall decline in this indicator.
- The overall trend in forests with respect to physical damage to soils is difficult to assess although grazing has decreased in some areas which would decrease the extent and severity of compaction, while recreation use has increased which would increase the potential for compaction in heavy use zones.
- In the United States, the biological components of water resources are declining. For examples, more than 70 percent of the original floodplain forests in the country have been converted to urban and agricultural use, and 34 percent of fish, 75 percent of unionid mussels, and 65 percent of crayfish have been classified as rare to extinct.
- Preliminary assumptions from regional and localized data sources suggest that concentrations of several of the traditional water-quality indicators (fecal coliform bacteria and total phosphorus, for example) decreased during the 1980's. Accordingly, they provide evidence of progress in pollution control during the decade. Trends in the concentrations of other traditional indicators (dissolved oxygen and nitrates) changed little.

Gaps

Trends that are limited to forested catchments cannot be determined at this time.

Sufficient data are not available in most regions to make reliable estimates of the area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties.

Data are lacking to quantify changes in aquatic biodiversity in forest areas at the national level. Little quantitative, probabilistic data are available. There is disagreement on how to assess the extent and effects of compaction. Estimates of the severity of compaction on forest land are subject to dispute

The primary source of persistent toxic substances would be industrial waste and pollution. Although some forest land may be affected by adjacent industrial activity, the total area is unknown and is probably small.

Chapter 6

Criterion 5 MAINTENANCE OF FOREST CONTRIBUTION TO GLOBAL CARBON CYCLES

I. INTRODUCTION

Human activities are influencing the chemistry of the Earth's atmosphere in ways that are not fully understood but which could ultimately affect forest ecosystems in significant ways. The buildup of greenhouse gases is accelerated by fossil fuel burning, deforestation, livestock production, agricultural activities, and the widespread use and release of chemical compounds such as CFC's.

Forest productivity may be altered by the resulting changes in temperature, precipitation, and nutrient availability, as well as the direct effects of pollution. Changes in species composition and cover type may also occur. Scientists are predicting that insect and disease outbreaks could increase and water yield and streamflow timing may be altered. Soil, stream, and lake acidification has already occurred. Pollution, climate stress, and land use changes all interact to affect the responses of forests and rangelands to naturally occurring stresses. Increasing pressure to use land by the growing numbers of humans may exacerbate these natural and human-caused stresses.

Measurement of forest biomass focuses on the role of temperate and boreal forests in the Earth's carbon cycle, and the response of forests to changes in the atmosphere, especially in levels of carbon. Ultimately, the information available through measurement of these indicators could lead to more effective mitigation measures and development of strategies to minimize atmospheric changes, thus helping to insure the sustainability of forests not only in the United States, but around the globe.

ii. INDICATOR REPORTS

INDICATOR 26: Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age class, and successional stage.

The accumulation of biomass as living vegetation, debris, peat, and soil carbon (carbon pool) is an important forest function in regulating atmospheric carbon. The production rate of biomass is also a measure of forest health and vitality.

Biomass estimates are developed from data compiled from inventories conducted by the Forest Service, Forest Inventory and Analysis (FIA) projects, using conversion factors derived from biomass studies. There are some areas of the nation that have not been inventoried, notably parts

of Alaska and some reserved forests, and there is little information on lands of low productivity or 'reserved' lands. A greater limitation is that there are no inventories statistically designed over large regions for actual biomass measurements, because it requires destructive sampling.

Biomass may be estimated for 1977, 1987, and 1992. Inventories were not necessarily taken in the featured year. Inventorying just one State may take 2-3 years, so available data are updated to reflect what is believed to be the conditions in the featured years.

Table 6-1. Forest ecosystem biomass (million tons dry weight) on productive forestland in the United States by forest type and age class, 1992. (Estimates developed from a USDA Forest Service database described in Powell and others, 1993, and conversion factors in Birdsey, 1992.)

	Age-class (years)					Uneven- Aged
	0-24	25-49	50-74	75-99	100+	
Eastern U.S.:						
Spruce-Fir	46	88	152	125	56	212
Oak-Hickory	362	2,075	1,866	1,118	316	2,854
M-B-B	219	719	535	386	204	886
Pines	421	1,297	522	126	55	956
Oak-Pine	120	369	310	92	17	750
Bottomland- Hardwood	127	593	839	426	152	1,229
Nonstocked& other	6	11	8	3	2	0
Aspen-Birch	61	195	227	78	8	50
Total:	1,362	5,347	4,460	2,354	810	6,937
Western U.S.:						
Douglas-Fir	874	427	431	498	860	0
Ponderosa and W. White Pines	212	32	143	372	337	0
Spruce-Fir	640	28	60	207	569	0
Hemlock-Sitka Spruce	133	20	28	74	616	0
Lodgepole Pine	56	8	54	207	347	0
Larch	1	2	19	56	109	0
Redwood	3	37	54	27	23	0
Other Hardwoods	61	195	157	211	88	0
Pinyon/Juniper and others	9	2	1	3	11	0
Total:	1,989	751	947	1,374	2,960	0

Estimates of biomass may be developed for groups of States and individual States using FIA's Eastwide and Westwide databases and appropriate conversion factors. The inventories are statistically designed to provide State-specific estimates. Tree carbon estimates are developed from data compiled from inventories conducted by the FIA projects using conversion factors derived from biomass studies, and wood-to-carbon estimates from forest products literature.

Estimates of carbon storage in the soil, on the forest floor, and in the understory were developed using models based on data from forest ecosystem studies. No inventories specifically designed to quantify carbon in different ecosystem components over large regions have been made, although the USDA Natural Resource Conservation Service (NRCS) is testing protocols for total carbon in a forest ecosystem to include measurements of the forest floor. Some FIA projects have recently begun measuring coarse woody debris.

Soil carbon may be estimated on a national level using NATSGO database from the Natural Resource Conservation Service, or at the State level using STATSGO. A county-level database is being constructed. These geographic databases are based on a combination of soil surveys and expert knowledge. Estimates of tree carbon may be developed for individual states and groups of states using FIA's databases and conversion factors.

Another source of biomass estimates is Cost, et al. (1990), but estimates are presented only by State and softwood/hardwood type, and do not include trees smaller than 12.7 cm dbh.

Interpretation

We believe this information is only sufficient to characterize the indicator for "commercial forest land" or productive forest lands. As discussed in the methodology section, many areas of U.S. forest land have not been adequately sampled by FIA. Some data for western national forests are unavailable. Estimates for non-tree carbon are based on models rather than original data.

Forest Inventory and Assessment and the Natural Resources Conservation Service inventories should be conducted on all forest lands rather than current focus on timberland. Data on non-tree components (forest floor, coarse woody debris, soil carbon, and understory vegetation) should be collected along with the statistical samples for timber. Meanwhile, we are developing better models and locating more comprehensive data sources for these ecosystem components.

INDICATOR 27: Contribution of forest ecosystems to the total global budget, including absorption and release of carbon (standing biomass, coarse woody debris, peat and soil carbon).

Generally, flux estimates are made indirectly, by taking the difference between inventories (as compiled for Indicator 26). Direct, instantaneous measurements of carbon fluxes are only applicable to very specific areas and are highly variable throughout the day.

Estimated carbon inventories have been made for 1977, 1987, and 1992. In flux estimates, volume on reserved lands was assumed to grow at the same rate as volume on similar unreserved lands, and for national forest lands harvest and growth rate projections were derived from national forest plans.

Table 6-3. Carbon and carbon flux in conterminous United States forest ecosystems, 1992, and Alaska, 1987 (Birdsey and Heath, 1996, Birdsey, 1992).

Region	<u>Inventory</u> (billion metric tons)		<u>Avg. Annual C Flux (1987-1992)</u> (million metric tons/year)	
	Standing		Standing	
	C Biomass	Soil C	C Biomass	Soil C
North	4.025	9.35	67	148
South	5.192	6.27	37	31
West	4.838	8.05	-6	-3
Alaska	2.488	11.45	na	na
US total	16.543	35.21	98	176

na=not available

Assumptions used in flux estimates: volume on reserved lands assumed to grow at same rate as volume on similar unreserved lands, and for National Forest lands harvest and growth rate projections are from National Forest plans.

Interpretation

At present we cannot determine the flux for a specific year, but must infer the yearly flux from successive estimates of long-term trends over several decades. There are statistical methods available to apply to this estimation problem, but this has not yet been done rigorously. Direct flux estimates could be made for a network of sites, but the cost would be prohibitive. However, a network of sites is being implemented for the US and analysis of this data could prove fruitful.

INDICATOR 28: Contribution of forest products to the global carbon budget.

The ecological and sustainable management of production forests and the long lasting use of forest products can be a factor in controlling the amount of carbon entering the world's atmosphere.

Estimates of carbon in forest products is based on removal estimates from FIA project inventories, from timber product surveys compiled at the national level, and from various other sources, such as special studies of organic material in landfills. These estimates, which are usually presented in volume units, have been converted to mass (carbon) using analogous procedures for Indicators 26 and 27. Estimates of harvested carbon are available at the regional and national levels. Annual products statistics have been fairly reliable since about 1950.

Researchers need more information about carbon decay rates in products, which may be measured in length of product life. There is considerable uncertainty about carbon released in burning fuelwood, as well as the amount emitted from logging residue. Estimated carbon inventories are approximated at 10- to 15-year intervals beginning with the year 1900. Reliable data are first available for around 1950.

Data Summary

Table 6-4. Cumulative end-use of carbon from wood harvested in U.S. from 1900-1995 (Heath and others, in press)

	(Petagrams)
Products	2.3
Landfills	1.8
Energy	4.1
Emissions	3.6

Table 6-5. Avg annual end-use carbon flux, 1992. (Heath and others, in press)

	(Teragrams)
Products	20
Landfills	17
Energy	-48
Emissions	-50

Note: A negative flux indicates more carbon is being released to the atmosphere.

Interpretation

Removals estimates from FIA data are subject to the same limitations as described for Indicator 26. Special studies of carbon decay rates in products are needed.

iii. SUMMARY FOR THE CRITERION

Highlights

- The USDA Natural Resource Conservation Service (NRCS) is testing protocols for measuring total carbon in forest ecosystems.

Gaps

Some areas of the nation have not been inventoried for forest ecosystem biomass, notably parts of Alaska, and there is less information on lands of low productivity and reserved lands.

No inventories have been specifically designed to measure carbon in different ecosystem components over large regions.

Chapter 7

Criterion 6 MAINTENANCE AND ENHANCEMENT OF LONG-TERM MULTIPLE SOCIO-ECONOMIC BENEFITS TO MEET THE NEEDS OF SOCIETIES

i. INTRODUCTION

Maintenance and enhancement of forest resources to meet the needs of societies require the rationalization of competing uses in ways that reflect human values. It is notable that values pertain for both direct (commodity, employment, income) and indirect (education, scientific knowledge, spiritual) uses, and that resources that have little or diminishing value will inevitably be converted to other uses. Therefore, understanding the diversity of values held for forests, as well as the shifts in priorities of their use, is critical to developing an overall measure of sustainable forest management.

ii. INDICATOR REPORTS

A. Production and Consumption

Production and consumption indicators that describe the level at which products and services are valued by society over time indirectly convey a sense of societal values. In contrast, economic benefits can be measured directly through the production of value-added products and trends in per capita consumption.

There are a number of uncertainties in measuring production and consumption trends. For example, the duration of an increase, or downturn, sufficient to produce a "trend" is variable. Linear regression of data trends versus time illustrates this point. If a positive coefficient is shown with respect to time, the trends could be regarded as increasing; however, the same finding might result from a very erratic or unstable trend that was, on average, increasing. Moreover, a production or consumption trend may be increasing in absolute terms, but decreasing in per capita terms.

With the increase of human populations worldwide, it will be a greater challenge to maintain production and consumption at current levels on a per capita basis than to maintain them on a volume-produced basis. The latter course would be accompanied by declining resources for some groups of people. Relative to time, it is important to be clear whether production has the potential to be maintained or increased in the future or whether it has actually been maintained at certain levels in the past, up to the present, and into the future). An example of this dichotomy can be found in USDA Forest Service timber harvests, wherein harvests may be managed on a

more sustainable basis today even though annual harvest have declined by roughly 75 percent in the past ten years.

To evaluate the economic sustainability of a trend in harvest of forest products, one could evaluate the impact on ecosystem function. This requires information on tree species and sizes to be harvested; expected intensity of growth within the harvest area; and, the species and sizes of trees remaining after harvest.

Secondly, the use of composite and/or of substitute materials can also affect the ability to sustain production and consumption of wood and non-wood products. This is especially true when a wide range of species, sizes of wood and recycled wood/paper are considered for production. However, recycling does have limited applications.

Production and consumption indicators 29 to 34 examine both

wood and non-wood products. Wood

products are defined according to major product categories in the SITC 3-digit groupings (FAO 1994), Revision 3. Standard Industrial Classification (SIC) codes for value-added data correspond with the SITC groupings, and are given in Table 7-1, with conversions from British units to metric units based on international conversion factors listed in the Forest Products Yearbook series of FAO in 1994. All values are in 1987 U.S. dollars, adjusted for inflation using the implicit GDP price deflator in the 1987 Economic Report of the President.

Table 7-1. Standard Industrial Class Codes and SITC Groupings.

SIC	SITC	Major Product Category
2411	245	Roundwood
	246	
	247	
2421	248	Sawn-wood
2426		
2429		
2435	634	Wood-based panels (excluding non- structural)
2436		
2611	251	Wood pulp
2621	641	Paper and paperboard
2631		

Currently, the U.S. does not maintain a comprehensive listing of non-wood forest products that reflects a national consensus on definitions. One major study describes marketing opportunities for specialty non-wood products by categories of aromatics, berries, fruits, cones, seeds, and forest botanicals. Uses for these categories of products are: flavorings, medicinals, pharmaceuticals, greenery, transplants, florals, honey, mushrooms, nuts, syrup, and weaving and dyeing materials (Thomas and Schumann 1993). This list is used as a starting point for these indicators.

For purposes of this analysis, the following definitions are applied to each indicator in the set of production and consumption indicators:

- *Value-added* is defined as the value of shipments minus the cost of materials, supplies, containers, fuel, purchased electricity and contract work. This measure of manufacturing activity is used to compare the relative economic importance.

- *Supply* is equal to the volume of production of a product plus imports from other countries. *Consumption* is derived from the balance of production, minus exports plus imports from international trade.
- *Gross Domestic Product* (GDP) is the total value of all goods and services, or outputs, produced in the United States. The value of output produced by American-owned entities overseas are not included in GDP calculations.
- The value of wood production reflects primary production only in each product category.
- *Recovered paper utilization rate* is the amount of recovered paper consumed at paper and board mills, divided by the new supply of paper and board. The *recovery rate* is total paper recovered divided by new paper supply and board. The recovery rate is the higher of the two, because it includes U.S. exports of waste paper and paperboard. The recovered paper utilization rate is the preferred indicator, because it measures the country's willingness to use recycled material.

INDICATOR 29: Value and volume of wood and wood products production, including value-added through downstream processing.

A long-term trend of value and volume of wood and non-wood forest products indicates that the forest is providing benefits to society, perhaps predisposing societal behaviour that supports sustainable management of the forest. Increased value reflected in the price for wood products could encourage more forest investment. However, there is a point at which increasing value and quantities may indicate over-exploitation.

Production volumes for this indicator are taken from Forest Service reports. The value of production is calculated in two ways. Where data are available, the value of production equals average price times volume of production. However, the value of production is highly dependent on the selection of average price for the product category. Value of shipments is reported in the Census of Manufacturers and is used in lieu of volume times average price when a consistent, reliable price series is not available. Data are from consistent sources of Forest Service reports, U.S. Department of Commerce, Bureau of Census surveys, several industry data sources and international data from the U. N. Food and Agriculture Organization. The Forest Service data for volume of production are consistent with other sources, such as industry reports. Value-added data from the Census of Manufacturers are quite reliable because of standardized statistical procedures that have been in place since 1890, and cover at least 98 percent of the value of shipments for all manufacturers in the SIC category.

In terms of scale, many sources have Statewide and county level data for specific products. Reporting procedures vary, however, among sources; therefore, only national data are reported here by major product category.

Data Summary

Two- to three-fold increases in production of all major products indicate consistent yet balanced industry activities throughout the forest sector from 1960 to 1992. Total roundwood production peaked in 1988 at approximately 530 million cubic meters, before falling off to more than 514 million cubic meters by 1992. Real values of roundwood production were fairly stable throughout the first 25 years, rising sharply in 1991 to about \$26 billion dollars (in 1987 dollars). Value-added as a proportion of total value of production improved slightly over the 30-year period.

Trends in sawn-wood production (Fig. 7-2) showed changes similar to those of roundwood production, increasing from about 77 million cubic meters in 1960 to more than 100 million cubic meters in 1992. Peak sawn-wood production occurred also in the late 1980's. The value-added from sawn-wood production, as a proportion of total value, actually decreased in real terms over the 30-year period, as did the proportion for wood-based panels. The value-added data for wood-based panels may not reflect the maturity of the oriented-strand board (OSB) industry in the late 1980's and early 1990's, which may account for this diverging trend. Wood-based panels more than tripled in volume of output between 1960 and 1992, showing the strongest growth in production.

America's pulp and paper sector has shown very strong growth in volume production. Value of production showed a downturn in the last decade or two, possibly correlated with excess pulping capacity during a period of rapid increases in paper recycling, or perhaps due to gains in production efficiency, such as through capital economies of scale associated with larger and

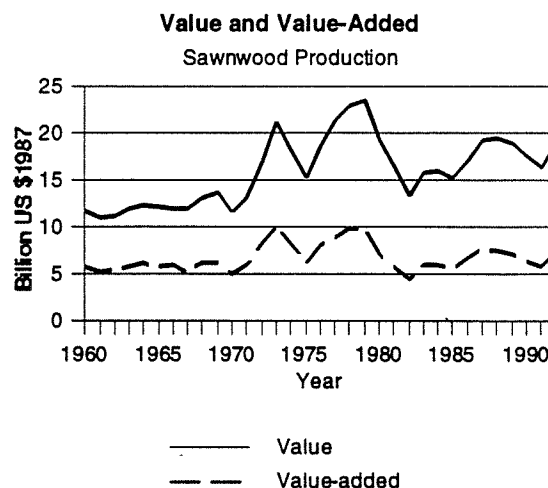


Figure 7-1.

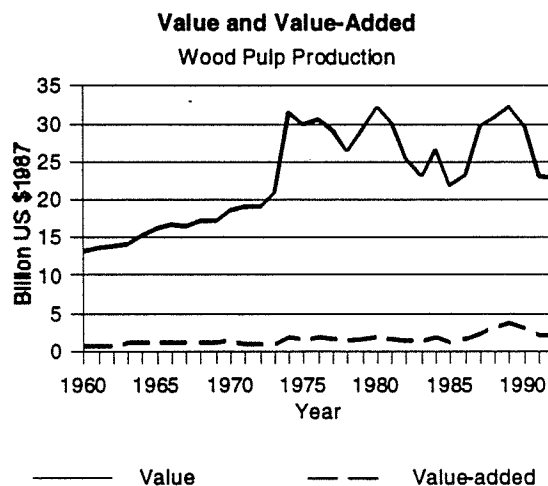


Figure 7-2.

newer facilities (Figure 7-2). If the instability in the data are correct, it may be an indicator of concern, suggesting that society may be placing inconsistent value on these categories of forest products. On the other hand, lower costs at times of consistently higher output suggest that society is producing more of these products more efficiently and using them more widely.

Interpretation

Currently, available data indicates that the processing sectors of wood products in the United States have shown strong growth and steadily increasing values of production, reflecting increased quality and value to the consumer. This suggest an increasingly positive societal value for these products. Wood processing industries, by steadily increasing production of wood products, have at least partially met society's increasing needs. Per capita needs for various products, however, may not be met to the same degree if product prices are increasing. Increased investment by the forest industry in response to an increase in value may correct this in the long term, within limits.

Economic data alone do not indicate the extent to which the wood products industries are able to sustain levels of product benefits for society, especially considering population growth. The data show only that current levels of production are sustainable in relation to the supply of raw material as indicated by data for criteria 1-5. Data have not been measured in a way that allows us to determine whether other factor inputs into production, such as labor, energy, and capital, are adequate to sustain the use of forest products.

We also cannot determine any direct measure of the industries' ability to sustain current uses of forest products based on value-added. A change in value-added indicates economic value created by the industry using the resource. Value-added measures are useful primarily to compare the relative economic importance of manufacturing among industries and geographic regions. A declining value-added, or a value-added increasing at a slower rate than in other industries, may indicate that the industry's size cannot be maintained.

Volume of wood commodities production can only be an indicator of movement away from production sustainability when considered in light of our changing ability to increase forest growth--while sustaining ecosystem functions--and our changing ability to provide more product benefits per unit of roundwood input.

The increasing value of wood products reflects the value individual consumers and businesses, through purchases, place on the products. Increasing unit prices as indicators of increasing economic scarcity may be only partially due to increasing physical scarcity. Although increasing physical scarcity may also indicate a move away from production sustainability, it is important to note that restrictions on some public timber harvests are a created scarcity that in turn can drive up the commodity price. Increasing unit prices may also be caused by society's placing greater

value on the products. Price must be examined with consumption to determine if the value of the product has actually increased.

INDICATOR 30: Value and quantities of production of non-wood products.

As with Indicator 29, a long-term trend of stable to increasing value and quantities of non-wood forest products may indicate that the forest is providing benefits to society and that society is therefore more likely to desire to manage the forest on a sustainable basis. There is a point at which increasing value and quantities may indicate over exploitation, however.

Only limited data are available to quantify this indicator. Data for non-wood forest products are available in some State reports and summaries of agriculture and forestry statistics. Several sources were used to compile a rough estimate of some quantities and values of non-wood forest products. The Census of Agriculture database has extensive information on farm production of several products that fall into the non-wood forest products category; yet, cultivated production

cannot be distinguished from production resulting from direct extraction from the forest. In many cases, Census data do not provide the value of production, only the quantities. Data is also available from the USDA Forest Service and should be considered for use in future data summaries.

Although a number of local and regional marketing studies have been prepared by private consulting firms; there are no known national statistics on all non-wood forest products. Therefore, these data are incomplete estimates and are not considered highly reliable. These limitations prevent identification of significant trends in production of non-wood products.

Data Summary

Considering the incomplete nature of the data, the total quantity and value of non-wood products in the U.S. may be more than \$1 billion. The bar chart (Figure 7-3) describes the value of a very small sample of some domestically produced non-wood products. Products such as mushrooms had a value of close to \$650 million in 1987. The increased demand for wild mushrooms from forests of the Pacific Northwest in the last decade suggests how production of a single non-wood

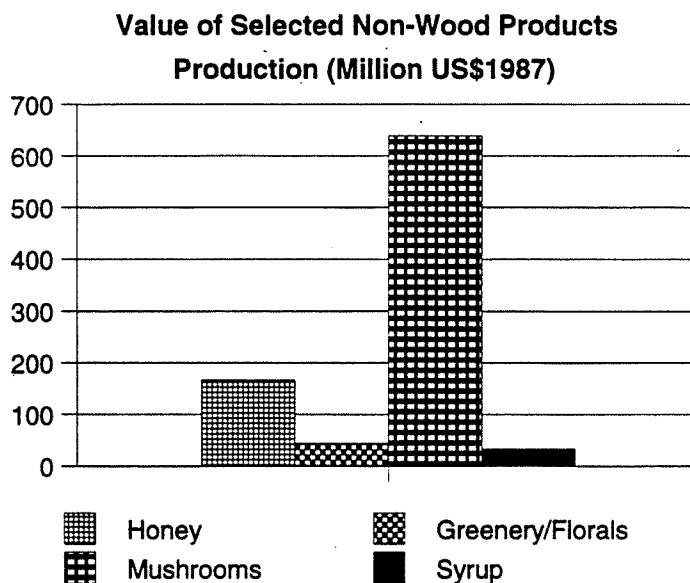


Figure 7-3

product can add significant value to the forest resource for a region. Similar values placed on other non-wood products are expected to show steadily increasing trends in the near future. Accordingly, the value of non-wood products in the U.S. is probably grossly underestimated, given such data samples.

Interpretation

Due to the unavailability of data for many non-wood products, the full value to society of non-wood commodity production cannot be determined at this time. Moreover, the lack of comprehensive historical data prevents evaluation of trends in production and value. These gaps are particularly critical when comparing commodity production to the diversity of growing demands for forest resources.

INDICATOR 31: Supply and consumption of wood and wood-products, including consumption per capita.

Society has a long-demonstrated need for timber-related products that are used daily and affect the quality of life for everyone. A long-term trend of stable to increasing domestic supply and consumption of wood and wood products may be an indicator that these services of the forest can be sustained. A more comprehensive understanding requires consideration of the relationship of imports on domestic consumption, and comparison of U.S. per capita consumption to per capita consumption in other countries. Moreover, there is a point at which increasing supply and consumption may indicate over exploitation.

There are a variety of periodic sources, both private and public, that provide data on forest products supply and consumption. Each year the U.S. supplies data, by Standard International Trade Classification (SITC) code, to international publications of forest products statistics prepared by the United Nations. The data presented here originate from annual Forest Service reports of forest production and consumption statistics, and are aggregated into major forest products categories of: roundwood, sawn-wood, wood-based panels, wood pulp, and paper and paperboard.

The primary data for this indicator is a series of Forest Service publications that have been maintained since the early 1950's. These publications were interrupted in the late 1980's, and more recent data are not yet available. To maintain consistency when comparing data from other production and consumption indicators we have presented only the period from 1960-1992.

Data Summary

Forest products supply and consumption have generally increased over the 33-year period beginning in 1960 (Figure 7-4). Earlier data, going back to 1900, would reveal that there was a notable decline in solid wood product output and consumption over the first half of this century, while pulp, paper, and paperboard production and consumption have increased consistently since 1900. This is in line with the increasing volume of production shown previously and, again, provides proof of society's increasing use of pulp and paper commodities. Per capita consumption of pulp, paper, and paperboard has increased by more than 60 percent since 1960, which is a substantially greater increase in consumption than for solid wood (lumber and wood panels combined).

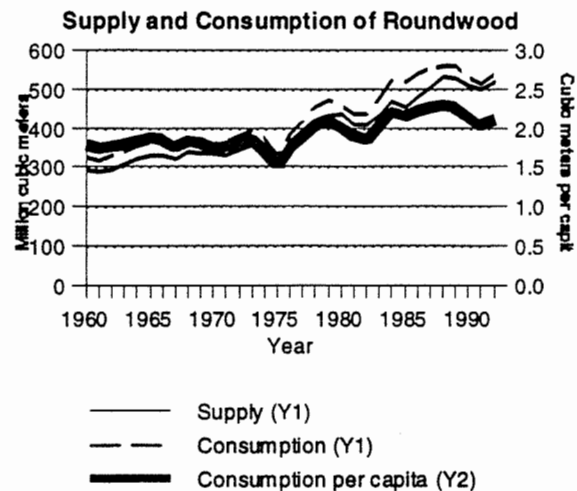


Figure 7-4.

Interpretation

Society's increasing dependence on wood products is evidenced by stable or steadily increasing per capita consumption rates for all wood products. However, currently available data do not allow us to determine to what extent the supply of wood products has been met by domestic resources, as opposed to the supplementary supply America imports from other countries. This distinction is critical when evaluating domestic production sustainability implications, as well as global impacts. In some cases, the increased supply of wood products is being met more and more by imports, e.g., of softwood lumber, reflecting reductions in public timber production and insufficient investment by the private sector. U.S. reliance on outside sources of supply are not reflected in this indicator; therefore, a complete assessment of the sustainability of our domestic resources is lacking.

INDICATOR 32: Value of wood and non-wood commodity production as a percentage of Gross Domestic Product (GDP).

A trend of stable or increasing commodity production as a percent of GDP indicates that the wood products industry is being sustained and competitive with other industries in the economy. The higher the percent, the more society may value the forest resource and be willing to manage it on a sustainable basis. There is a point, however, where a high percent may indicate over exploitation and over dependence on the forest industry.

Data for this indicator are not available for non-wood products. Available wood products data have been taken directly from the value of wood (Indicator 29) and from the GDP values listed in the 1987 Economic Report of the President. Data for wood products are considered reliable and are presented from 1960 to 1992.

Data Summary

The value of primary wood products' contribution to our national income has fluctuated slightly, with a declining trend overall (Figure 7-5). Peak contributions occurred in the late 1970's at 3.7 percent (in 1987 dollars), falling to just over 2 percent by 1992. It should be recognized that these data reflect only primary product value and not the total contribution to national income by the wood-products sector. [See discussion in the interpretation section below.] Because data are not available, the contribution of non-wood forest commodity production to national income was not estimated.

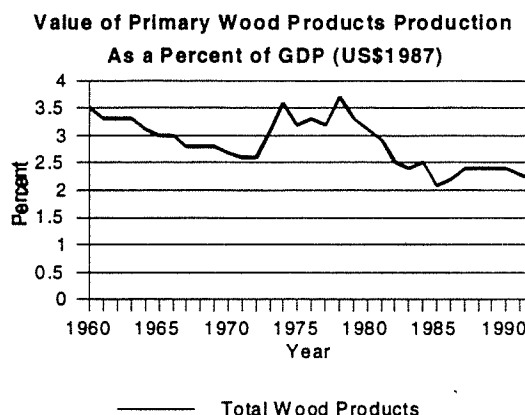


Figure 7-5.

The data allow us to determine that the contribution of primary wood commodity production to national income has remained significant over at least the last 30 years, although it has declined slightly in recent years. It is important to note that only primary production is considered here. This suggests that the secondary and additional levels of production in U.S. manufacturing, which use primary wood products as inputs and end-use value added, provide even greater contributions to national income than reflected herein.

The trend in value of primary wood products relative to GDP indicates the value consumers place on primary wood products relative to the value placed on all production. Even if the percentage of value from primary wood products in GDP is decreasing, society may be over-exploiting the resource. Conversely, a trend of increase indicates an increasing relative value, e.g., shifts in timber management (increased growth) that may not necessarily indicate over-exploitation. Comparison of these indices with those of Criteria 1 through 5 is necessary to answer these questions.

It should be recognized that these data do not adequately measure the total contribution of wood products to national income. This is particularly critical for the pulp and paper commodities sectors, where the value of such secondary products contributes to education, transfer and storage

of knowledge, safe and efficient product shipment and packaging, human health, and safety, among others.

With regard to sustainable production, the levels of sustainable economic activity have not been determined.. Whether the trend in contributions of wood products to national income will continue to decline, or will increase in the future, is also not apparent from this indicator. We also cannot determine whether trends in the values of production, discussed in Indicator #29, are sustainable, in particular with regard to changing resource supplies and technological change.

INDICATOR 33: Degree of recycling of forest products.

A trend of increasing recycling indicates that society values the resource. Forests may be more likely to be managed sustainably because recycling eases the pressure for timber harvest.

Data are available only for paper and paperboard, and are considered authoritative; these data have been reported for the U.S. as a whole. End products have international markets, and there are well established markets for waste paper and paperboard. There has been a substantial increase in the recycling of solid wood products, such as pallets, but complete data are not available.

Data Summary

Using data gathered as early as 1950 and before reveals a significant increase in recycling in recent years, due primarily to curb-side pickup and other programs intended to keep paper out of landfills. Over the past 3 years, billions of dollars have been spent on expanding recycling capacity, and it is likely that the recovered paper utilization rate will continue to increase (Figure 7-6).

Interpretation

The data show that the consumer's willingness to use recycled paper and paperboard products is increasing substantially. The data presented are likely conservative estimates of the total level of wood materials recycling potential in the United States.

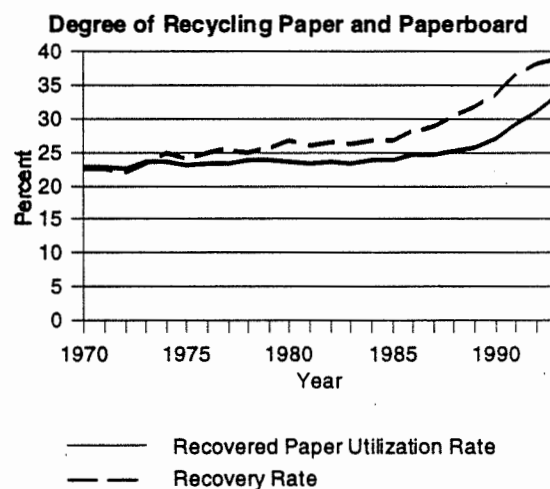


Figure 7-6.

The extent and level of consumer use of recycled materials is only clear for those wood products for which data is maintained. Additional data will be needed to project the level of sustainable recovery of recycled materials in the industry. More complete data are also needed to determine the rates of recycling for all wood products.

INDICATOR 34: Supply and consumption/use of non-wood products.

A trend of stable to increasing domestic supply and consumption of non-wood products would indicate that the forest is supplying benefits to society and that society is likely to manage it on a sustainable basis. However, data are not available to indicate either supply, or consumption and use, of non-wood products in any meaningful way (see discussion for Indicator 29).

B. Recreation and Tourism

Management of natural resources for recreation and tourism implies the active expenditure of funds, labor, and materials, as well as the designation of specifically identified sites and areas to accommodate recreation users. Availability may imply permitted access to forest land for recreation and/or active designation of funds, labor, materials, and sites to accommodate users. As a first attempt at specifying an indicator for forest land managed for general recreation, availability will be the operational concept. For each ownership or government jurisdictional category, availability assumptions and measurement must be treated separately.

As a first approximation, the measure of non-industrial, Federal and State lands, area of land available for recreation will be weighted by the proportion of the ecoregional division that is forested under a particular ownership category, based on the 1992 Natural Resources Inventory (NRI) by the Natural Resources Conservation Service.

Corporations owning lands for production of timber, pulpwood, minerals, livestock and/or recreation/tourism manage only 5 percent of the rural, private land area in the U.S. Typically, most of these lands are available for recreational uses, but usually they are available only to persons or groups who have signed or otherwise agreed to a lease for use rights. A very small portion of corporate ownerships have been designated or are managed primarily for recreation, with the exception of lands used as resorts and areas managed for hunting. Data covering these lands are not included in this report.

Individuals, families, and various forms of non-corporate partnerships own approximately 95 percent of the rural, private land area in the U.S. The availability of such lands for outdoor recreation may be reserved for the exclusive use of owner and friends, leased to individuals or groups, or open to the general public. Very few of these areas are managed exclusively or explicitly for outdoor recreation.

National forests, national parks and monuments, wildlife refuges, Bureau of Land Management lands, Corps of Engineers projects, Tribal lands, military lands, and a variety of other Federal ownerships comprise America's Federal estate. Except for military lands (bases for the most part), Federal lands are available for general outdoor recreation. Some portions of the Federal estate are managed specifically for public recreational uses, e.g., campgrounds, wild and scenic rivers, recreation trails, wilderness, national recreation areas, and parks. Because most Federal lands (except military facilities) are considered to be available for general recreation and tourism, total Federal forested area can be used to approximate this category of available recreation area. As a first approximation, the estimated county-level area of Federal lands available for recreation will be weighted by the proportion of each county that is forested.

State parks, State forests, State reservoirs, and a variety of lesser State properties comprise the country's State lands. With few exceptions, e.g., tree nurseries of negligible total area, all are available for recreational uses. Local governments hold only a small proportion of America's land area. Municipal and county parks provide close-to-home opportunities for Americans across all social strata. As a first approximation, the area of State lands available for public recreations will be weighted by the proportion of each county that is forested.

Recreational facilities managed by government and by private or other quasi-public entities include: recreational vehicle (RV) campgrounds, campsites, hunting and fishing preserves, picnic grounds, parks, downhill and cross-country skiing centers/resorts/areas, natural resource tourist attractions, hiking trails, visitor centers, wildlife viewing sites, greenway trails, picnicking sites, and rail-trail miles.

The Forest Service 1989 RPA Assessment lists the following activities under outdoor recreation: Developed and primitive camping, day hiking and walking, whitewater rafting, sailing and other boating, sightseeing and pleasure driving of highway motor vehicles, motor boating and waterskiing, bicycling and mountain biking, nature study and photography, picnicking, family gathering, pool swimming, outdoor swimming, coldwater fishing, warm freshwater fishing, big game hunting, wildlife observation, visiting prehistorical sites, relaxing, and "no main activities."

The level of recreation and tourism use is measured as "millions of the U.S. population aged 16 years or older who reported participating in outdoor recreation activities, and the average and median number of days they participated in such activities over the previous 12 months. Levels were estimated for the nine Census Divisions of the U.S., and then aggregated for a national estimate.

Table 7-2. Area and percent of land available for recreation by ownership, over time.

Ecoregion	Alaska Forest Land	Federal Forest Land	State Forest Land	Private Non- industrial Forest Land	Total Forest Land
210		7795.96	1594.34	20846.16	30236.46
220		8200.53	2290.93	18777.99	29269.45
230		12002.88	1326.11	39795.34	53124.33
240		11754.88	135.69	3806.11	15696.68
250		367.38	89.96	404.42	861.76
260		4880.18	239.72	0	5119.90
310		4145.35	35.67	120.43	4301.45
320		892.09	11.67	2.14	905.90
330		20325.03	282.15	541.67	21148.85
340		10029.39	56.66	184.22	10270.27
AK	119000.00				119000.00
Total	119000.00	80393.67	6062.90	84478.48	289935.05

INDICATOR 35: Area and percent of forest land managed for general recreation and tourism, in relation to the total area of forest land.

Data Summary

The total Federally-owned acreage available for public recreation in the United States is over 640.2 million acres. The total forested State land area available for recreation is over 7.1 million acres, or 24 percent of all State lands (Table 7-2). These data clearly show that a significant proportion (>30 percent) of recreation on State lands is dependent on forest land areas.

Private lands are by far the largest of the three ownership categories, totaling approximately 1.26 billion acres. Of these, approximately 95 percent is private, non-industrial lands, and approximately five percent is private industrial.

Because we do not know what percent of these private lands available for recreation is forested, the areas are weighted with the forest percentage used in above. The survey shows that only 176.5 million acres (14 percent) of the private non-industrial lands are available for recreation; most private lands are closed. Of these available lands, only an estimated 84.5 million acres are forested.

By taking the weighted totals of forest land from each of the three ownership categories, Federal, State, and private, adding Alaska (and subtracting Alaska data from the other three), the total acres of forested lands available for general recreation and tourism is calculated. This estimate

represents total forest land in the U.S. available for recreation, and it serves as the best available approximation for Indicator 35.

Interpretation

Outdoor recreation and tourism are becoming increasingly important aspects of forest lands in America and around the world. This indicator is intended to help determine if forests are being managed for long-term sustainability. A trend of stable to increasing area managed for general recreation and tourism may indicate that society recognizes non-commodity values of the forest, and may be more likely to manage it on a sustainable basis. In the United States, available data show that the overall trend in forest land available for recreation is generally downward--with government lands about stable, and private land access down significantly.

Analysis for this indicator illustrates that much rural, non-developed recreation and tourism takes place in natural environments that include meadows, grasslands, national and State parks.

Available data do not allow determination of actual acres of forest land managed for recreation. Therefore, land available for recreation is used, weighted by total forest area. The assumption that the proportion of forested area is the same for all three main ownership categories has been made. This is a questionable assumption that may, if false, greatly skew the data. Currently, there are no data for private industrial lands. The question of duplication of data on State lands makes quantification of this category uncertain.

INDICATOR 36: Number and type of facilities available for general recreation and tourism in relation to population and forest area.

This indicator is intended to help determine if the number of facilities available for general recreation and tourism is decreasing or increasing, with respect to the total area of forest land and the population; thereby to determine if forests are being managed for long-term sustainability or not. A trend towards increasing numbers of facilities per capita or per unit area may indicate that society recognizes the non-commodity values of the forest, is willing to make the investments to make the forest enjoyable, and is maybe more likely to manage the forest on a sustainable basis. It can also be an indicator of recreational jobs.

Data Summary

Forest-based recreation and tourism facilities range from high-service types, such as resorts, to low-service types, such as trail heads. An inventory of almost all such facilities, across the spectrum--from high-service development, to low-service access--has been completed for all counties in the nation, and across public and private ownerships, except for municipal and county government holdings. It seems appropriate, given the climate of funding for planning and

Table 7-3. Index of outdoor recreation facilities available, present, in relation to population and forest area, by Ecoregion.

Ecoregion	Number of Counties	Mean % of Forest Area	Mean % of All 26 Facilities present	Mean % of Facilities Weighted by Forest	Mean 1995 Population per county	Facility Index	Relative Facility Index (highest =100)
210	178	65.0	30.7	20.7	47441	43.6	100.0
220	933	39.9	18.7	7.9	115109	6.9	15.8
230	758	54.6	13.9	7.3	76106	9.6	22.0
240	43	65.5	43.9	28.2	166727	16.9	38.8
250	449	7.7	14.4	1.1	53705	2.0	4.6
260	41	29.7	44.3	14.0	644721	2.2	5.0
310	178	2.0	12.5	0.6	44446	1.4	3.2
320	39	1.3	27.5	0.6	231327	0.3	0.5
330	405	8.4	16.5	2.6	21379	12.4	28.4
340	93	8.5	31.1	3.3	44416	7.4	17.0
U.S. Total	3117	32.8	18.1	6.5	83723	7.8	17.9

Note: Data not available for Alaska

assessing outdoor recreation, to build an index that employs a more limited spectrum of indicator facility types which are more likely to be available in future years from ongoing databases. The broad categories of facility types are campgrounds, visitor centers, scenic roadways, ski areas, and trails.

The Facility Index was constructed on a per capita basis and weighted by the proportion of total forested area in the county where the facility is located. The Facility Index denotes the mean number of facilities in forested areas per 100,000 people in each ecoregion (calculated at the county-level) (Table 7-3). The Relative Facility Index ranks the ecoregions by facility index. The percent of total possible facilities (26=100 percent) was determined for each county and ecoregion. For each ecoregion, the mean percentage of facilities weighted by forest was divided by population to derive the Facility Index.

Interpretation

Data have shown that certain areas of the country have more facilities available on forest land per capita for recreation and tourism; these can be re-measured as often as the sources produce new data. These indices are sensitive to various recreational opportunities, changes in forest land and population--this is a baseline for future studies.

Data is not available for the number of facilities or the number of services that the facilities provide (e.g., beds, ski lift capacity, etc.). These data can be acquired with much time and effort;

however, a comprehensive inventory is not yet available. The indices provided herein are likely a reliable measure for this indicator, even though increases or decreases in facilities are identified instead of the actual numbers of each type of facility available.

INDICATOR 37: Number of days of recreation and tourism participation in relation to population and forest area.

As a first approximation, the following estimates are reported as millions of persons 16 years and older, who participated in activities one or more times between January 1994 and January 1995:

- Dispersed nature-based outdoor activities
- Nature-based developed site activities
- Nature appreciation and study activities
- Water-based activities
- Snow and ice-based activities

These data are available from the Census Division, and can be weighted by percentage of total area that is forested in each Division to show days of participation in relation to forest area. However, this analysis still would not give the correct number of days spent in activities on forest lands, since it is difficult for people interviewed to remember how many times they participated in each activity, or which activities were spent in forested areas. The NSRE is the only national database available to use in approximating this indicator.

Data Summary

Data for this indicator shows that the U.S. population devotes the greatest number of days participating in order of importance: walking, bird-watching, visiting a beach or waterside, swimming in a pool, wildlife viewing, biking, sightseeing, studying nature near water, swimming in non-pools, and family gatherings (Table 7-4). The average number of days of activity are not shown, only the final data for total days of participation.

Over 50 percent of the U.S. population is participating in "walking" and "sightseeing." These are not the fastest growing activities; however, the activities with a greater than 50 percent increase between 1983 and 1995 were those done on forest lands, and include: hiking, bird watching, downhill skiing, camping in a primitive area, backpacking, and attending an outdoor concert or play.

Table 7.4. National estimated recreation days of participation by activity (by persons 16+ in age).

Activity	Percent of U.S. pop.	Number (in millions)	Days in Participation (in millions)
Fitness Activities: Biking, walking	68.32	136.9	16,618.4
Viewing Activities: Cultural sites, wildlife, beach/water viewing	76.18	152.6	14,737.5
Snow and Ice Activities: Skiing, snowmobiling	18.12	36.3	241.3
Camping (overall)	26.35	52.8	701.0
Hunting	9.29	18.6	654.6
Fishing	28.89	57.9	2,145.9
Boating	28.99	58.1	1,252.8
Swimming Activities	54.22	108.6	3,864.9
Outdoor Adventure Activities: Hiking, backpacking, mtn climbing, caving, horseback riding, etc.	36.76	73.6	2,084.5
Social Activities: Picknicking, family gatherings	67.82	135.9	1,946.4

Source: The National Survey on Recreation and the Environment (NSRE), 1994. Partially analyzed and fully described in Cordell, H.K., B.L. McDonald, B. Lewis, M. Miles, J. Martin, and J. Bason, 1996 "United States of America," Chapter 13 In: World Leisure Participation: Free Time in the Global Village. Cushman, G., A.J. Veal, and J. Zuzanek, Eds., pp. 215-235.

Interpretation

Data show that the U.S. population values a wide range of outdoor recreational activities in and around forested areas. This indicator also demonstrates that the public is using forests for outdoor recreational uses at an increased rate of 50 percent or more over the previous twelve years. Currently there are no data that can distinguish those days of participation that occurred in forests.

C. Investment in the Forest Sector

INDICATOR 38: Value of investment, including investment in forest growing, forest health and management, planted forests, wood processing, recreation and tourism.

This indicator measures resources dedicated to future forest production, providing direct insights into the physical sustainability of resource management. Measures of investment were developed

for three categories: (1) forests, (2) wood processing, and (3) recreation and tourism. Each category is discussed separately below:

Forest investment. Direct investment in forest establishment and regeneration is measured. In addition, we measure changes in the total stock of forests to estimate net investment. This measures the contribution of direct investment and growth, net of activities that reduce forest stocks such as land use conversions and timber harvests.

(a) Investment in forest establishment is tracked and reported by the Forest Service in annual tree planting reports. The agency reports the area of tree planting in the U.S. between 1930 and 1995.

(b) Net investment. The net value of investment is indicated by change in the total stock of forests. One crude approximation of net investment is simply the change in the quantity of forest inventories over time. However, volumetric measures of inventory do not capture the effects that changes in forest composition and location have on forest productivity and value. To capture these effects, i.e., changes in forest quality as well as quantity, a value-weighted index of total forest inventory was constructed for each of the four large regions (North, South, Pacific Coast, and Rocky Mountains as described in the Forest Service RPA Assessment) and for the U.S. as a whole. We call this a forest capital index.

The value index of forest inventory weights the contribution of hardwood and softwood, sawtimber and non-sawtimber components, of inventory using their respective stumpage prices (sawlog prices are applied to sawtimber, and pulpwood prices are applied to non-sawtimber). Components are aggregated using a standard Divisia (Tornqvist) index approach to measuring capital stocks of different types and vintages (for details, see Wear 1997).

Price and volume data are required for each component of the inventory for each year evaluated. Volume data were taken from Powell et al. 1993. Prices were taken from Haynes et al. 1995. Data are not maintained on an annual basis but are available for the RPA benchmark years. The Forest Service reports volumes of growing stock and forest capital indices by region and for the U.S. as a whole for the years 1952, 1962, 1977, 1987, and 1992. Increases in the forest capital index indicate that net investment has been positive, i.e., that the effects of direct investment and growth have exceeded the effects of forest land conversions and timber harvesting. If this value is stable over time, then investment is maintaining the stock of forests--although composition could be changing. A declining value index would indicate net disinvestment in the forest sector.

Investment in wood processing sectors is measured as gross investment in equipment and structures for the lumber and wood products industry (Standard Industry Code 24), and for the paper and allied products industry (SIC 26). Annual data for 1960-1994 were taken from the

"Detailed Investment by Industry" data base maintained by the Department of Commerce, Bureau of Economic Analysis, and reported in real terms.

Investments in recreation and tourism are available for expenditures by Government agencies for improvements, construction, and maintenance of recreation facilities, and these are reported here. The agency reports (1) total expenditures by Government for natural resource infrastructure for 1975-1992, (2) expenditures by the National Park Service for improvement, maintenance, and construction of facilities, and (3) expenditures by the Forest Service for maintenance and construction of facilities.

Data Summary

Forest Investment. The area of forest planting has grown substantially since the 1930's, with peaks occurring in conjunction with special Federal programs (Table 7-5). Total U.S. softwood inventories have been relatively stable over this 40-year period. However, stability masks strong decreases in softwood inventories in the Pacific Coast Region and countervailing increases in the East, and especially in the South. Hardwood inventories have expanded strongly in the North, South, and for the U.S. as a whole. Total inventory has grown accordingly, reflecting a strong shift towards hardwood composition (Table 7-6).

The forest capital index, which accounts for changes in both the quantity and quality of the inventory, shows value growth between 1952 and 1977, but a leveling off between 1977 and 1992. Strong declines in forest capital in the Pacific Coast region have been largely offset by capital accumulation in the South and the North. However, forest capital also declined slightly between 1977 and 1992.

Table 7.5 Tree planting in the United States (1930-1995).

Fiscal Year	Acres	Fiscal Year	Acres	Fiscal Year	Acres
1930	138,970	1976	1,892,309	1986	2,753,176
1935	292,033	1977	1,978,170	1987	3,033,159
1940	519,051	1978	2,088,568	1988	3,394,478
1945	138,944	1979	2,061,373	1989	3,021,948
1950	497,507	1980	2,266,956	1990	2,862,207
1955	812,588	1981	2,351,389	1991	2,558,025
1960	2,137,460	1982	2,374,794	1992	2,544,862
1965	1,325,063	1983	2,453,386	1993	2,419,691
1970	1,599,819	1984	2,553,029	1994	2,477,479
1975	1,930,468	1985	2,695,423	1995	2,421,861

Table 7.6 Volume and aggregate value index of forest inventories in the United States, by region: 1952, 1962, 1977, 1987, and 1992.

Volume of Softwood Growing Stock (billion cf)						Volume of Hardwood Growing Stock (billion cf)					
	North	South	Rockies	Pacific	Total		North	South	Rockies	Pacific	Total
1952	27.1	60.5	87.5	256.7	431.8	1952	76.7	88	5.1	14.3	184.1
1962	33.7	75.1	93.2	247.8	449.8	1962	94.6	99	5.6	16.6	215.8
1977	43.9	101.2	95.1	226.8	467.0	1977	119.2	122.2	6.1	18.6	266.1
1987	47.6	105.6	100.3	199.4	452.9	1987	142.4	139	7.7	23.5	312.6
1992	51.0	102.9	101.5	194.5	449.9	1992	156.1	147.7	8.7	23.2	335.7

Total Volume of Growing Stock (billion cu. feet)						Forest Capital (1952=1.00)					
	North	South	Rockies	Pacific	Total		North	South	Rockies	Pacific	Total
1952	103.8	148.5	92.6	271	615.9	1952	1.00	1.00	1.00	1.00	1.00
1962	128.3	174.1	98.8	264.4	665.6	1962	1.10	1.08	1.07	1.00	1.05
1977	163.1	223.4	101.2	245.4	733.1	1977	1.21	1.20	1.11	0.97	1.10
1987	190	244.6	108	222.9	765.5	1987	1.26	1.24	1.16	0.94	1.11
1992	207.1	250.6	110.2	217.7	785.6	1992	1.29	1.23	1.18	0.93	1.11

Average annual rates of change in forest capital between benchmark years (percent)

	North	South	Rockies	Pacific	U.S. Total
1952-62	0.96%	0.79%	0.68%	0.04%	0.53%
1962-77	0.63%	0.70%	0.27%	-0.19%	0.29%
1977-87	0.39%	0.28%	0.44%	-0.40%	0.06%
1987-92	0.54%	-0.06%	0.34%	-0.20%	0.06%

Wood Processing. Since 1960, expenditures for equipment and structures have trended upward in the Paper and Allied Products industry. In this sector, expenditures in the 1990's are roughly 3 to 4 times their quantity in the 1960's (Table 7-7). Expenditures in Lumber and Wood Products trended upward between 1960 and the late 1970's, though at a much more moderate rate. Since the 1970's, expenditures have leveled off at values observed early in that decade. These measures of gross investment, while not providing a complete picture of investment, indicate an expanding paper sector and a relatively stable lumber and wood products sector in the U.S., consistent with production patterns.

Recreation and tourism. Government spending for natural resource infrastructure fell by about 33 percent between the late 1970's and the early 1990's (Table 7-8). The Federal Government accounted for all of this decline, with spending by State and local governments remaining essentially constant over this period. Total expenditures for infrastructure were \$9 to 10 billion/year (1987=100), during the late 1970's. They were about \$6.3 billion/year for 1990-1992. Although this index gives a general indication of total expenditures for natural resource infrastructure, it is not specifically linked to the recreation component. Public expenditures related to ski resorts and eco-tourism, among others, would provide a more complete understanding of investments for recreation.

Table 7.7 Expenditures for equipment and structures 1960-1994 (million dollars, 1987=100).

Year	Lumber and Wood Products SIC 24	Paper and Allied Products SIC 26	Year	Lumber and Wood Products SIC 24	Paper and Allied Products SIC 26
1960	1338	2373	1980	3287	7399
1961	1019	2456	1981	2758	6288
1962	1183	2660	1982	1864	6483
1963	1298	2746	1983	1593	5672
1964	1404	3173	1984	2118	6022
1965	1838	4092	1985	1903	6987
1966	1820	4762	1986	1825	6692
1967	1525	4350	1987	2014	6220
1968	1688	3767	1988	1885	7396
1969	1985	4141	1989	1999	10173
1970	1772	3915	1990	1916	10674
1971	2222	3173	1991	1419	8052
1972	2655	3438	1992	1312	6747
1973	2559	3692	1993	2106	7002
1974	3408	5033	1994	2375	8385
1975	2793	5665			
1976	2522	5793			
1977	3360	5945			
1978	3637	6551			
1979	3821	7318			

Source: Department of Commerce, Bureau of Economic Analysis. Total investment summed over all asset classes. Prices deflated by the GDP price deflator (1987=100).

Table 7.8 Infrastructure spending for natural resources by Federal and by State and Local governments, millions of 1987 dollars. (Source: Statistical Abstract of the United States, 1986, 1987, 1994, Table no. 476).

Fiscal Year	Federal	State & Local	Total	Fiscal Year	Federal	State Local	Total
1975	6943	2262	9205	1985	4335	1839	6174
1976	7518	2050	9568	1986	3768	1861	5629
1977	9013	1376	10389	1987	4058	2157	6215
1978	9289	1066	10355	1988	3447	1823	5270
1979	9139	1099	10238	1989	3489	1861	5350
1980	5643	1467	7110	1990	4147	2246	6393
1981	6460	1289	7749	1991	4014	2104	6118
1982	5922	1279	7201	1992	4521	1874	6395
1983	5161	1503	6664				
1984	4874	1554	6428				

Spending for improvements, maintenance, and construction of facilities in national parks was relatively stable between 1975 and 1991 (about \$250 million/year). It increased to nearly \$350 million/year from 1992-1994 (Table 7-9).

Table 7.9 National Park Service spending on improvements and maintenance, and on construction, millions of 1987 dollars. (Source: Statistical Abstract of the United States, 1979, 1986, 1994).

Fiscal Year	Improvements & Maintenance	Construction	Total	Fiscal Year	Improvements & Maintenance	Construction	Total
1975	82	174	256	1985	135	90	225
1976	84	202	286	1986	123	130	253
1977	87	147	234	1987	144	103	247
1978	106	168	274	1988	149	83	232
1979	104	117	221	1989	182	79	261
1980	108	177	285	1990	141	96	237
1981	104	156	260	1991	153	114	267
1982	117	87	204	1992	176	161	337
1983	117	400	517	1993	182	184	366
1984	150	103	253	1994	176	163	339

Table 7.10 National Forest System infrastructure spending, millions of 1987 dollars.
 (Source: Report of the Forest Service, various years).

Fiscal Year	Facilities		Roads		Trails	
	Maint.	Constr.	Maint.	Constr.	Maint.	Constr.
1981	18.8	27.9	98.5	257.8	18.3	5.2
1982	14.1	21.3	77.9	281.9	13.5	4.8
1983	24.9	58.5	84.5	218.2	16.0	5.7
1984	15.5	25.8	71.0	244.7	10.2	5.7
1985	15.7	27.8	69.3	242.5	9.8	7.5
1986	14.6	27.0	63.8	186.7	9.8	7.1
1987	15.1	25.7	63.1	233.3	11.4	7.6
1988	15.9	11.6	80.6	165.3	19.3	14.1
1989	16.2	29.8	74.4	161.9	24.6	18.3
1990	18.7	31.9	85.1	145.1	21.6	16.4
1991	21.1	54.6	77.6	147.2	24.0	18.3
1992	21.7	64.1	71.0	139.8	25.3	17.9
1993	21.5	67.9	66.3	113.8	25.4	22.1
1994	21.0	74.9	62.8	77.2	27.4	25.6

Investment in the infrastructure of the National Forests (Table 7-10) has also changed over the last 15 years. Spending for maintenance of facilities has increased slightly, while spending for facility construction has increased nearly three-fold. As a result, total spending on facilities increased from \$47 million in 1981 to \$96 million in 1994 (1989=100). Spending on trails has also increased substantially, from \$24 million in 1981 to \$53 million in 1994. Spending for roads, in contrast, fell from \$357 to \$140 million between 1981 and 1994.

Interpretation

Taken together, these data indicate that investment efforts in the forest sector have been and remain strong in the U.S. (evidenced by a planting rate of about 2.5 million acres per year). However, net infrastructure investment measures indicate that investment over the last 15-20 years has largely been replacement investment. As a result, the value of forest inventories has generally leveled off and is neither expanding nor contracting.

These measures of gross investment, while not a complete picture of investment, indicate an expanding paper sector and a relatively stable lumber and wood products sector in the United States--consistent with production patterns.

While total government expenditures for natural resource infrastructure has declined over the recent past, important recreation components (i.e., for National Parks and National Forests) have increased. While far from a complete picture of investment in recreation and tourism, these trends indicate continued, perhaps increasing, commitment of resources to provide forest-based recreation in the United States.

INDICATOR 39: Level of expenditure on research and development, and education.

This indicator measures how society is investing in the generation of new knowledge and technology related to the function and management of forest systems. Increased productivity of forest goods and services has been a key aim underpinning the maintenance of long-term multiple benefits.

Data were compiled on the funding of research by the USDA Forest Service and at public forestry schools in the United States. Data sources were CSREES and USDA Forest Service reports. Additional data for private investment in forestry research and for forest-related research in other University departments outside of forestry schools (e.g., botany, biology, and economics departments, etc.) are needed. Moreover, tabular information that follows pertains to all forest related research, not just research aimed specifically at social and economic questions.

Data Summary

The total of funding for forestry research at universities increased by approximately 20 percent in constant dollars between 1978 and 1994 from \$80 million (1987=100) to \$128 million between 1978 and 1994 (Table 7-11). Only about 40 percent of this funding comes from Federal sources.

Table 7.11 Funding for forestry research in the United States.

Fiscal Year	McIntire Stennis	RRF + Hatch	Other CSRS	Total CSRS	USDA CGCA	Other Federal	Non Federal	Total Univ.
millions of dollars (real, 1987=100)								
1978	15.59	2.32	0.00	17.91	5.14	9.95	46.60	79.60
1979	14.20	2.29	0.00	16.49	6.26	8.85	48.24	79.85
1980	13.25	2.37	0.00	15.62	9.76	8.09	55.09	88.56
1981	12.80	2.28	0.00	15.08	8.49	9.89	53.99	87.45
1982	13.13	2.15	0.00	15.27	7.04	8.95	52.86	84.13
1983	13.07	2.06	0.00	15.14	7.57	7.57	53.56	83.83
1984	12.97	0.11	0.00	13.08	6.37	6.26	54.40	80.11
1985	12.50	1.80	0.00	14.30	6.04	6.67	58.69	85.70
1986	11.76	1.55	2.17	15.48	6.40	7.33	61.82	91.02
1987	11.40	1.60	2.30	15.30	6.20	7.10	65.90	94.50
1988	14.73	1.73	2.31	18.77	9.05	7.22	67.66	102.69
1989	14.94	1.66	2.58	19.19	8.03	7.75	72.05	107.01
1990	13.99	1.68	2.13	17.80	8.33	9.12	77.06	112.31
1991	13.95	1.62	2.64	18.20	7.48	8.84	74.83	109.35
1992	13.90	1.49	2.98	18.36	9.84	11.41	76.18	115.80
1993	13.60	1.38	3.24	18.22	11.82	14.25	83.48	127.77
1994	14.91	1.51	3.09	19.51	12.61	12.69	83.66	128.47

Between 1978 and 1996 appropriated funding for Forest Service research averaged \$136.4 million (real, 1987=100) per year (Table 7-12). On average, extramural funding added another \$15 million. Appropriated funding for Forest Service research is characterized by three distinct

Table 7.12 Funding for USDA Forest Service Research. (Source: personal communication, USDA Forest Service, Office of Deputy Chief for Research).

Fiscal Year	Appropriated Funding	Extramural Funding	Total Forest Service	Fiscal Year	Appropriated Funding	Extramural Funding	Total Forest Service
1978	146.60	18.24	164.84	1988	130.41	13.96	144.37
1979	143.36	15.27	158.63	1989	127.21	14.76	141.97
1980	133.75	14.78	148.54	1990	133.66	11.69	145.35
1981	137.52	18.00	155.51	1991	142.52	15.99	158.50
1982	133.77	12.89	146.66	1992	149.30	24.48	173.78
1983	123.51	10.67	134.17	1993	147.94	21.86	169.80
1984	120.22	8.46	128.68	1994	152.82	17.02	169.84
1985	128.92	7.94	136.86	1995	149.44	20.00	169.44
1986	123.94	10.73	134.67	1996	134.96	11.07	146.03
1987	132.70	14.60	147.30				

phases: (1) decline between 1978 and 1984 at an average annual rate of \$4.3 million per year, (2) increase between 1984 and 1994 at a rate of \$3.3 million per year, and (3) decline again between 1994 and 1996, at a rate of \$8.9 million per year. The current level of funding, in constant dollars, is significantly less than funding in 1978.

If appropriated Forest Service Research funding of social and economic research is evaluated, one finds these areas to comprise, historically, a smaller percentage of allocation within the Research budget. For example, economics research in constant 1984 dollars was funded at \$6.67 million in 1984 (or 4 percent of the 1984 FS Research appropriation) as compared to \$7.2 million in 1994 (or 3.7 percent of the 1994 appropriation). Recreation research, in constant 1984 dollars, was funded at \$2.9 million in 1984 (or 2 percent of the 1984 appropriation) and at \$4.4 million in 1994 (or 2.3 percent of the 1994 appropriation). These data demonstrates a modest level of investment in the areas of social and economic research that has not changed over time.

INDICATOR 40: Extension and use of new and improved technology.

This indicator measures investment in new technologies as major sources of productivity growth in forestry and forest industries.

The U.S. Bureau of Labor Statistics, Division of Productivity Research, Office of Productivity and Technology calculates productivity indices for the lumber and wood products industry (Standard Industrial Code 24) and the paper and allied products industry (SIC 26). Total factor productivity indices measure the contribution of technological change.

Total factor productivity indices are difficult to develop for timber production, e.g., because ambiguity regarding the intended use of forest resources and changes in environmental factors also influence productivity. Timber productivity depends on a variety of factors, most importantly the application of new timber management technologies and biological technologies, such as genetic improvements in the quality and productivity of trees. One study (Wear 1994) provides estimates of total factor productivity for industrial forests in the South.

Data Summary

Productivity growth in the lumber and wood products industry (Table 7-13) was nonexistent in the 1970's, grew fairly steadily throughout the 1980's, and has leveled off since the late 1980's, raising concern about the adequacy of investment in new technologies in the industry. This recent downturn may be due to the significant decline in forest products research in both the public and private sectors. Productivity growth in paper and allied products was sluggish between 1970 and 1992. When compared with companies operating in non-wood-based markets, private firms' investments in forestry and forest products research are often less, both in absolute magnitude and in proportion to various economic measures, especially in terms of per-scientist investment rates as a percent of sales and profits.

Table 7.13 Total factor productivity indexes for the lumber and wood products industry (SIC 24) and the paper and allied products industry (SIC 26), 1987 = 100 (Source: unpublished data, Division of Productivity Research, Office of Productivity and Technology, U.S. Bureau of Labor Statistics).

Year	Lumber	Paper	Year	Lumber	Paper
1970	81.5	87.2	1982	84.2	93.2
1971	80.9	90.2	1983	86.2	96.3
1972	82.0	94.3	1984	90.6	96.5
1973	79.1	98.4	1985	91.4	96.6
1974	79.3	94.0	1986	94.8	99.4
1975	83.3	87.8	1987	100.0	100.0
1976	82.9	91.2	1988	99.8	99.6
1977	81.6	92.8	1989	99.5	97.7
1978	78.8	94.6	1990	94.7	96.3
1979	78.6	93.2	1991	93.6	99.2
1980	80.9	90.3	1992	88.1	101.0
1981	80.3	90.2			

The total factor productivity index for industry land in the South indicates a moderate growth in productivity between 1962 and 1985. Productivity grew at an average compound rate of about 0.5 percent per year but was level between the mid-1970's and 1985. These findings, based on an economic model of productivity, are very similar to the results of a biophysical analysis of productivity growth

Interpretation.

While modest, increases in total factor productivity indicate that forest productivity has increased on industry lands in the South. However, this growth reflects the effects of technological change, e.g., advances in tree improvement and forest management research, not of changes in other relevant factors such as the environment. If, for example, environmental conditions had changed in a way that reduced the productivity, then total factor productivity measures would be biased downward.

INDICATOR 41: Rates of return on investment.

Examining rates of return on investment provides a means of comparing forestry investment returns with other sectors of the economy.

Estimating rates of return requires measures of total revenues from, as well as measures of the resources dedicated to forest production. Resources dedicated to timber production can be estimated by summing up the asset values of all forests within a region. The rental method of calculating asset values requires estimates of the quantity and asset prices of forests of various

types. The preferred method for valuing forest capital is to use estimates of harvest age, anticipated revenues, and the value of subsequent rotations to calculate rents for forests of different types. However, data required for this approach are available only for the South. An alternative approach, the inventory method, uses stumpage prices and inventory volumes to provide a rough estimate of forest asset value. This method is applied to the four major regions of the U.S. For both methods, it is important to note that rotations are closely linked with market forces and impact productivity and diversity, which eventually influence the rate of return.

(a) Inventory Method. Asset values were calculated by multiplying forest inventory volumes by stumpage prices for four components of the inventory (hardwood sawtimber and non-sawtimber, and softwood sawtimber and non-sawtimber). Measuring the revenue derived from forests required detailed estimates of the timber produced and its stumpage prices. Because stumpage prices are the value of delivered logs less relevant harvesting and hauling costs, these values define net revenues to forest owners. A measure of the rate of return to forest production was then estimated as the ratio of net revenue to asset value. These estimates were made for individual regions and for the U.S. as a whole.

Price and volume data are required for each component of the inventory by region and year. Volume data were taken from Powell et al. (1993). Prices were taken from Haynes et al. (1995). Data were not available on an annual basis, but were available for the RPA benchmark years. Forest asset values, timber revenues, and rates of return by region and for the U.S. as a whole for the years 1962, 1977, 1987, and are reported. The quantities of timber products by species group and region for benchmark years were taken from various Forest Service reports. Values for sawlogs, veneer, pulpwood, fuelwood, and miscellaneous products were tracked. Sawtimber prices were used to value sawlogs and veneer. Pulpwood prices were applied to all other products.

(b) Rental Method. Forest asset values can be calculated using rental values that account for differences in forest type and age. This approach requires data on timberland by age class (rather than timber volumes used in the inventory method), and rental values derived from a management simulation model. This method accounts for the vintage of the forest inventory and, therefore, anticipated revenues can be accounted for in the calculation of asset values. Asset values are developed in this fashion for the South. Net revenues are those described under the inventory method, and the implied rate of return is calculated as the ratio of net revenue to asset value.

The rate of return index provides a rough approximation of returns to investment, to the extent that the value of standing timber represents accumulated investment in timber growing. It provides a useful index for making comparison between regions and time, but it may be limited for making comparisons with other sectors of the economy.

Data Summary

Rates of return (Table 7-14) show higher rates in the eastern States compared to the western regions. Two factors likely contribute to this difference. One is that eastern forests are largely in private ownership, while a large share of western forests are on public lands. A higher financial rate of return is anticipated on private lands. Additionally, a larger share of forests in the West may be inaccessible from an economic perspective, thereby overstating asset values and lowering the rates of return.

Table 7-14 Asset value of standing forests, total net revenue from timber production and rate of return index for forests in the United States, by region: 1962, 1977, 1987, and 1992.

Total Asset Value of Standing Forests

	North	South	Rockies	Pacific	U.S. Total
	million dollars (1987=100)				
1962	77803	89405	21088	120183	308479
1977	98060	129877	40380	216688	485005
1987	108512	129671	31279	139638	409101
1992	120646	132850	50578	310118	614192

Total net revenue from timber production

	North	South	Rockies	Pacific	U.S. Total
	million dollars (1987=100)				
1962	1231	2389	88	1426	5134
1976	1220	3793	243	3304	8560
1986	2718	4681	221	2702	10322
1991	2746	5347	386	5202	13681

Rate of Return Index (net revenue / asset value)

	North	South	Rockies	Pacific	U.S. Total
	percent				
1962	1.58%	2.67%	0.41%	1.19%	1.66%
1976	1.24%	2.92%	0.60%	1.52%	1.76%
1986	2.50%	3.61%	0.71%	1.94%	2.52%
1991	2.28%	4.02%	0.76%	1.68%	2.23%

Rates of return have increased over time in the South, North, and Rocky Mountains, indicating increased utilization of forest assets. Rates of return increased in the Pacific region from 1962 to 1986, but then fell between 1986 and 1991. This is coincident with decreased timber harvesting from public lands effected by the northern spotted owl. The rate of return for the entire country followed a similar pattern. Across regions, the rate of return averages about 2 percent, and

reaches no higher than about 4 percent. This is a fairly moderate rate of production and indicates that forest assets in the U.S. are not being over-exploited from a timber production perspective.

Rates of return for the South calculated using the rental price method are somewhat higher, ranging from 4.02 percent in 1976 to 5.84 percent in 1991. These higher rates are likely explained by allowing for capital gains from real price increases in forest products over time. Nevertheless, these rates of return also fail to indicate over exploitation of timber resources in the U.S.

D. Cultural, Social, and Spiritual Needs and Values

While our society is changing and becoming much more diverse in ethnic makeup and cultural backgrounds, mass media and proliferating electronic information sources, as well as homogenized retailing across the country, continue to illustrate similarities in the values and needs of our social and ethnic strata, rather than the differences. It therefore seems reasonable to assume that indexing protected lands and associated human artifacts can provide a measure of the cultural, social, and spiritual needs and values associated with forests and other natural resources. Although cultural values are maintained to some degree across a variety of ownerships, National protected areas are used to establish a beginning point for baseline data. Such data are available from:

- Wilderness Areas
- National Monuments in Rural Counties
- National Historic Sites
- National Recreation Areas
- National Parks
- National Wildlife Refuges
- National Wild and Scenic Rivers and Scenic Byways
- National Recreation, Scenic and Historic Trails

Area and number in these designated land classifications--at the national level--will be weighted by the percentage of total forested area where the protected resources are found.

INDICATOR 42: Area and percent of forest land managed, in relation to the total area of forest land, to protect the range of cultural, social, and spiritual needs and values.

Data were collected at the State level only, because no data are available at the county or ecoregion level. State data for national recreation areas (NRA's) is also available. These data are divided into Census Divisions, and State acres are summed for each division, then weighted by the amount of forest in each State, to obtain the number of NRA acres that are forested (using the percentage for the State). Acres available in each wilderness area, similarly weighted by the percent of forested area per State, has been calculated to achieve a total for each Census Division and a U.S. Total.

Data Summary

Protected areas are described by two variables -- acres and miles, and each was weighted, i.e., total acres weighted by forest, and total miles weighted by forest (Tables 7-15 and 7-16). The total area of forest land in the United States has stabilized, and is likely to remain at approximately the current level into the foreseeable future. At the same time, the number and area of protected sites have been increasing. There is a physical limit to how much area can be converted to protected status.

Table 7-15. Total acres of National Recreation Areas (NRA), National Wilderness Preservation System lands (NWPS), National Historic Sites, National Parks, National Monuments and National Wildlife Refuges, by Census Division, weighted by percent forest area.

Census Division	NRA acres	NWPS acres	National Historic Sites	National Parks	National Monuments	National Wildlife Refuges	Total acres of Forest Land Available
New England	27050	147325	1503	39844	0	58229	273,951
Middle Atlantic	67226	11706	11736	0	24	62834	153,526
South Atlantic	148916	1173522	44171	1001825	638	1121566	3,490,638
East South Central	0	67825	11685	140966	212	211048	431,736
West South Central	20082	78133	11680	57350	420	412523	580,188
East North Central	15728	146291	1284	283491	0	138728	585,522
West North Central	15145	249095	577	64845	474	83543	413,679
Mountain	482457	2228104	4813	426456	75320	431459	3,648,609
Pacific	2026365	25495129	6288	1488400	953125	550717	30,520,024
U.S. Total	2802969	29597130	93738	3503176	1030213	3070647	40,097,873

The 9,397-mile and 40,097,873-acre totals provide a baseline data set for area of forest land available to protect the range of cultural, social, and spiritual needs and values. Of the listed protected areas, some include forest land; although some cultural, social, and spiritual needs and values are independent of forest land. Some areas are set aside for reasons other than protection of cultural, social, and spiritual values; but, nonetheless, some needs and values are coincidentally protected. We assume that these protected areas contribute to or are a result of the public's cultural, social, and spiritual needs and values.

Cultural, social, and spiritual needs and values in this context have not been adequately defined. Therefore, no data has been collected to directly measure this indicator. Before collecting data, it will be necessary to agree on definitions and methodology for measurement.

Table 7-16. Total miles of Scenic Byways, Wild and Scenic Rivers (WSR) and National Recreation Trails (NRT), by Census Division, weighted by percentage of Forest Area.

Census Division	Scenic Byway miles	WSR miles	NRT miles	Total Miles Available
New England	23	140	151	314
Middle Atlantic	17	234	723	974
South Atlantic	242	60	535	837
East South Central	60	84	453	597
West South Central	113	120	244	477
East North Central	63	382	248	693
West North Central	56	86	58	200
Mountain	432	168	247	847
Pacific	1410	2361	684	4,455
U.S. Total	2417	3635	3345	9,397

Census Division

New England Division: ME, NH, VT, MA, RI, CT

Middle Atlantic Division: NY, NJ, PA

South Atlantic Division: DE, MD, DC, VA, WV, NC, SC, GA, FL

East South Central Division: KY, TN, AL, MS

West South Central Division: AR, LA, OK, TX

East North Central Division: OH, IN, IL, MI, WI

West North Central Division: MN, IA, MO, ND, SD, NE, KS

Mountain Division: MT, ID, WY, CO, NM, AZ, UT, NV

Pacific Division: WA, OR, CA, AK, HI

INDICATOR 43: Non-consumptive forest values.

Some values associated with forests are neither economic nor production-oriented. In fact, everyone who benefits from America's wildland and urban forests assigns a unique value to their resources. To determine the value of those forests, we discounted recreational activities constituting the removal of forest resources, such as coldwater fishing and big game hunting. The list of activities and their dollar surplus, or net economic value, are then provided (Table).

For the purposes of this report, the only known, readily available measures of non-consumptive values of America's forests are sets of recreational-use values associated with type of recreational pursuits for each of 10 ecoregions. These values were estimated using travel cost methodology and using a Forest Service "CUSTOMER" data base. National-level values have also been estimated for the same sets of activities. In some ecoregions, data was for demand model estimation for some activity categories and, therefore, estimation of consumer surplus net economic value.

National-level estimates of net economic values (not including hunting and fishing) for recreational use of natural resources will be reported. Reporting in future years may be problematic because there is no assurance that a data base of the magnitude and geographic scope of the CUSTOMER data base will be available. Work to estimate a new set of national valuation models for the Forest Service RPA Program for the year 2000 is ongoing.

Water and other primary elements of the natural environment have always held attractions for people, an attraction that has grown exponentially in recent years. World tourism is currently providing one out of every 15 jobs worldwide, and an estimated 50 percent of travelers seek an experience of nature in their touring. The implications of these trends require further study.

Data Summary

Water and land-based activities in America were used in the individual travel cost method (ITCM) to estimate demand. The data range from \$14.98 per person, per day (wildlife observation) to \$154.65 per person, per day (outdoor swimming) (Table 7-17). Most of the net economic value of these activities range from \$20 to \$30 per person, per day.

Table 7-17. Results of Reduced Models for Aggregate Activities

Activities (no. of observations in parentheses)	Surplus (day)	Model (without Nonlocal dummy) in dollars	
		Land Bound	Upper Bound
Developed and Primitive Camping (10410)	\$22.85	\$22.11	\$23.60
Day Hiking and Walking (2401)	32.74	31.64	33.84
Whitewater Rafting (240)	34.41	31.20	37.62
Bicycling and Mountain Biking (179)	30.33	25.96	34.11
Nature Study and Photography (420)	26.13	22.49	29.78
Picnicking (1211)	56.32	50.20	62.44
Outdoor Swimming (2311)	154.65	150.25	158.95
Wildlife Observation (787)	14.98	13.86	16.08
Visiting Prehistorical Sites (1274)	43.66	36.36	50.97
Relaxing and No Main Activities (3557)	32.19	30.78	33.62

In the database report, these data are disaggregated into ecoregions. This may be useful in comparing characteristics of recreation sites, and in postulating how net economic values differ; that is, to compare dollars per activity across ecoregions.

Interpretation

Data regarding the value of many elements of the natural world, e.g., the intrinsic value of wildlife, are not available. Moreover, such values may not lend themselves to economic consideration. An exception includes the measure of *willingness-to-pay*.

E. Employment and Community Needs

INDICATOR 44: Direct and indirect employment in forest-dependent sectors and forest-dependent sector employment as a proportion of total employment.

Stable employment levels may be an indicator that a sector is a viable part of the domestic economy, provides value to society, and may be managed on a sustainable basis. However, employment may change because of changes in technology or for other reasons, so there can be other interpretations when fluctuations are observed.

The impact of economic activity is not restricted to an individual firm or group of firms (an industry). Gains or losses in business affect both industry suppliers and the buying power of employees within the industry and supplier firms. For this reason, it is of interest to track both the employment levels in forest-based industries, and in associated economic sectors. Input-output (I-O) analysis accomplishes exactly that. I-O models take a "general equilibrium" view of an economy and track the income, employment, and trade interactions between sectors.

For this indicator, direct employment is defined as employment in those industries dependent on forest resources. This would include not only those involved in commodity extraction, such as timber, range, and hunting, but also non-consumptive uses such as recreation. Indirect employment is that employment which is stimulated by economic activity in the directly forest-dependent industries.

Indirect employment per unit of direct employment is estimated through the use of multipliers. For example, if an employment multiplier of 5.8 is estimated for a particular industry, then for every job generated (or lost) by that industry, 4.8 jobs are supported (or lost) in the economy as a whole. This includes the economy-wide stimulus of employees, in the direct- and backwards-linked industries, spending their income. This relationship holds true only as long as there are no significant structural changes in the economy for which the multiplier is estimated. Significant changes would require a re-estimation of the multipliers. In general, the larger the geographic area included in the model, the larger the employment effect will be, given the higher number of interacting industries.

The Forest Services I-O model IMPLAN was used to generate the data presented below. IMPLAN is not the only source of such information. Data on direct employment are available from several sources; State labor departments and the U.S. Department of Labor, the U.S. Department of Commerce, the U.S. Census Bureau, and others. Multipliers that are used to estimate indirect employment per unit of direct employment are available from many sources as well, a principal one being the U.S. Department of Commerce RIMSII system. These sources may be accessed free of charge, whereas the IMPLANs databases cannot. IMPLAN was used here, however, as a matter of convenience. Both employment figures and multipliers are available from one source at both a county and national scale. With IMPLAN, as with any I-O model, estimates of indirect employment are derived by building a model of an area of interest and estimating employment multipliers. Data for direct and indirect employment within the U.S., for example, may be represented. Databases are available for 1977, 1980, 1982, 1985, and 1990-1993.

Data Summary

Employment level and multipliers are reported here for several forest-dependent sectors for the U.S. as a whole. Note that employment is reported in terms of full-time-equivalents, not actual numbers of jobs (Table 7-18).

Interpretation

Given more time, we may have further developed these data to include several regions in the U.S. to give a better idea of local linkages. GIS coverage would assist in the identification of physical links between and among ecoregions, and the political boundaries for which economic data exist. Nevertheless, the national data demonstrate the utility of this type of analysis.

For the years modeled, employment has been relatively stable in the forest products sector. Interestingly, though, forest sector employment itself represents a very small proportion of total U.S. employment--associated economic stimulus creates a much larger number of jobs throughout the rest of the economy. This type of information not only indicates that the forest resource continues to exist, it intimates that the quality and health of the resource have not been degraded in the short term. It is difficult to assert, however, that this indicator gives any idea of long-term sustainability. Changes in individual sectors over time would not necessarily indicate an impact on the sustainability of forest resources. It would be difficult to discern whether employment changes would be due to resource degradation, changes in markets, changes in societal values, or changes in technology.

Table 7-18. Direct and Indirect Forest Sector Employment

Industry	Year	Employment Multiplier	Direct Employment	Indirect Employment
Forest Nurseries	1990	2.7	21,776	37,019
	1991	5.5	10,270	46,215
	1992	4.5	3,273	11,456
	1993	2.9	6,368	12,099
Commercial Forests	1990	11.7	34,138	365,277
	1991	15.2	27,250	386,950
	1992	10.8	27,810	272,538
	1993	12.8	28,026	330,707
Logging	1990	5.8	99,407	477,154
	1991	6.2	91,897	477,864
	1992	7.1	96,109	586,265
	1993	7.8	94,945	645,626
Sawmills	1990	5.2	185,233	777,979
	1991	5.7	170,339	800,593
	1992	6.1	171,856	876,466
	1993	6.6	169,969	951,826
Veneer & Plywood	1990	5.6	64,584	297,086
	1991	5.9	58,293	285,636
	1992	6.1	59,376	302,818
	1993	6.3	60,877	322,648
Pulp Mills	1990	12.1	13,960	154,956
	1991	9.5	14,356	122,026
	1992	12.2	13,797	154,526
	1993	9.6	13,149	113,081
Total Forest Sector Employment (% US tot)				
	1990	137,153,200	419,098(.3%)	2,109,471(1.5%)
	1991	139,586,600	372,405(.3%)	2,119,284(1.5%)
	1992	139,678,200	372,221(.3%)	2,204,069(1.6%)
	1993	141,981,500	373,334(.3%)	2,375,987(1.7%)

An explicit link between economic activity and the state of the biophysical resource would give a better idea of the long-term prognosis. This information could be developed from an integrated economic-ecologic I-O model, which then could be used to estimate the ties between levels of direct and indirect economic activity and the state of the resource base. This, of course, would be far more data-intensive.

INDICATOR 45: Average wage rates and injury rates in major employment categories within the forest sector.

Stable-to-increasing wages in the forest sector may indicate that employment provided by forestry and forest products enterprises are competitive and in demand by the labor force, providing stable sources of income for communities. Low and decreasing injury rates may indicate high standards of safety in the forest sector workplace and quality employment for forest sector labor forces.

Data Summary

Average wage in Table 7-19 are in current dollars. Injury rates in Table 7-20 are job-related injury and illness rates per 100 workers. Data are available from the U.S. Bureau of Labor Statistics.

Table 7-19. Average hourly wage rates for selected forest sector jobs.

Year	Wages in current \$					Wages in constant 1982 \$			
	Logging	Plyw & Sawmill	Wage Veneer	Paper	Index	Plyw & Logging	Sawmill	Veneer	Paper
1950	1.21	1.48			28.30	4.28	5.23		
1955	1.50	1.85			32.10	4.67	5.76		
1960	1.71	2.30			31.30	5.46	7.35		
1965	2.03	2.70			36.60	5.55	7.38		
1970	2.84	3.55			46.90	6.06	7.57		
1975	5.28	4.34	5.05	5.26	61.80	8.54	7.02	8.17	8.51
1980	8.64	6.70	7.94	8.27	105.50	8.19	6.35	7.53	7.84
1985	10.90	8.52	9.84		138.10	7.89	6.17	7.13	
1990	11.22	9.22	10.34		156.10	7.19	5.91	6.62	
1995	11.66	10.31	12.21		183.00	6.37	5.63	6.67	
1996	11.80	10.59	12.72		189.70	6.22	5.58	6.71	

Table 7-20. Job related Injury and Illness rates (per 100 workers)

Year	Logging	Sawmill	Veneer & Plyw	Pulp Mills	Paper Mills	Forestry	Fish, Hunt, Trapping
1989	19.5	18.6	12.9	13.8	11.9	11.4	n/a
1990	17.5	18.1	13.5	8.5	11.3	13.3	6.0
1991	15.9	17.3	12.2	10.1	10.5	13.5	6.7
1992	14.6	16.4	11.5	10.0	9.7	11.6	n/a
1993	13.8	14.9	9.6	8.6	8.7	9.7	7.6
1994	11.0	13.2	9.7	7.7	8.7	9.5	6.6
1995	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1996	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Interpretation

The data clearly show that forest product jobs have gotten steadily safer since 1990. The U.S. Bureau of Labor reports injury and illness rates for forestry, and fishing, hunting, and trapping. However, it is unclear how these sectors are defined, because they are not included in definitions by the Bureau of Labor.

If the premise is that increasing wages and safety would make forest-dependent jobs attractive to adjacent communities, the data presented above are a mixed bag. It is clear that these jobs are getting safer, but wages are decreasing in all sectors for which data are reported. If data were available on wages and injury rates for such areas as forest-based recreation, non-timber commodity production, etc., a more realistic picture of pressures on the forest resource could be developed.

INDICATOR 46: Viability and adaptability to changing economic conditions, of forest dependent communities, including indigenous communities.

Analysis for this indicator is based on the premise that the more diverse the economy, the more viable and adaptable it is, and the less likely that the forest resource will be over cut to provide jobs and income. As an index of economic diversity increases, it is assumed to be more likely that the forest will be managed on a sustainable basis. Data is lacking for indigenous communities, in particular.

If economic diversity is defined as the presence in an area of a great number of different types of industries, or the extent to which the economic activity of a region is distributed among a number of categories, then a regional summary statistic could help describe an area's comparative economic diversity. The Shannon-Weaver entropy function (Shannon and Weaver 1949) has been used to calculate indices of economic diversity. Perfect diversity occurs when all industries contribute equally to the region's employment.

Data Summary

Economic diversity indices have been computed for all U.S. counties, labor market areas, and States, and for some Tribal governments, using IMPLAN employment data for the years 1977, 1982, 1985, and 1990 to 1993. Also, indices have been computed for three levels of industry aggregation: 1-, 2-, and 4-digit SIC groups. These data are available in various spreadsheet and database formats. There is no explicit correlation among the indices and the physical geography of the areas for which they were calculated, so there is no way to illustrate a tie between forest preservation and economic diversity. This would be an important link to consider because rural economies dependent on the extraction of wood fiber from the forest tend to be less diverse. It would be of interest to study whether there is any trend in forest management practices between areas of different economic diversity, and in areas where diversity has changed over time.

Interpretation

Data show, economic diversity has increased over time throughout the U.S.

INDICATOR 47: Area and percent of forest land used for subsistence purposes.

People who depend on forests for their daily survival and livelihood will likely support sustainable forest management for multiple values. A *stable-to-increasing* area of forest that is used for subsistence purposes may indicate that subsistence rights are being honored, and that society values the forest for reasons other than its direct economic benefit.

It is difficult to identify a single, useful definition of subsistence. In the search for data for this indicator, it was assumed that subsistence was any activity dependent on use of the land's resources that does not require land-use conversion. Slash and burn subsistence agriculture was not included, for example. Subsistence activities include hunting, gathering, and timber or firewood extraction, if done for individual/family income, and if the forest resources at issue are left in such a condition as to remain viable over time.

Interpretation

It was difficult to gather meaningful data for measurement of this indicator. Although we carried out an exhaustive search of pertinent literature and various data bases, only apocryphal anecdotes or descriptive analyses germane to subsistence uses of forest resources were found. These were generally very useful and insightful studies, but because they yielded only non-numerical data, the information was not useful in defining this indicator.

iii. SUMMARY FOR THE CRITERION

The maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies from U.S. forests has been measured by nineteen indicators of production and consumption of wood and non-wood products; recreation and tourism resources; investment in the forestry sector; cultural, social and spiritual needs and values from forest resources; and, employment and community needs met by the forestry sector. The following highlights reflect the significant trends and indications of this criterion in relation to the sustainability of U.S. forests.

Highlights

- To evaluate sustainability of a certain trend in harvest for products, we need to determine if the expected future level can allow continual acceptable ecosystem function with a different level of harvest. Whether we can sustain a future higher level of harvest depends critically on the detailed character of the harvest - what species and sizes are harvested, how intensive is the growth and harvest area, what species and sizes of tree remains after harvest. Also, the role of substitute materials impact our ability to sustain production and consumption of wood and non-wood products. Our flexibility in alternating sources of raw material will make a critical difference in whether or not a future level of harvest is sustainable. The trend in flexibility can be measured by the increase in range of species and sizes of wood and recycled wood/paper that can be used for products.
- Estimates of the value of non-wood products in the United States are most likely grossly underestimated based on a sample of available data. The potential value of individual products such as mushrooms or honey have significant values of production, although only a fraction of the value of major wood products.
- Outdoor recreation and tourism are becoming increasingly more important to the management of forest lands in the USA and worldwide. In comparison with previous national assessments of forest and range lands, the trend in area of forest land managed for recreation and tourism is generally stable on government lands and significantly decreasing on private land access.
- A variety of protected land and water areas exist which represent both historic and contemporary expressions of the cultural, social and spiritual values of the United States society. The total forest land appears to have stabilized while the number and area of protected sites has been increasing.

Gaps

- The level of sustainability for wood products industries, relative to growing populations, raw materials, labor, energy and capital, cannot be determined with a high degree of certainty.
- Whether the trend in contributions of wood products to national income will continue to decline is not apparent with the current indicator; moreover, the level at which economic activity is sustainable has not been determined.
- The actual acres of forest land managed for recreation cannot be determined; rather, the land available for recreation (weighted by forest area) is used.
- The extent and level of consumer willingness to use recycled materials cannot be determined.
- It is difficult to discern how employment changes relate to resource degradation, changes in markets, changes in societal values, or changes in technology.

Chapter 8

Criterion 7 LEGAL, INSTITUTIONAL AND ECONOMIC FRAMEWORK FOR FOREST CONSERVATION AND SUSTAINABLE MANAGEMENT

i. INTRODUCTION

Criterion 7 and associated indicators relate to the overall policy framework of a country that can facilitate the conservation and sustainable management of forests. Included are the broader societal conditions and processes often external to the forest itself but which may support efforts to conserve, maintain, or enhance one or more of the conditions, attributes, functions, and benefits captured in criteria 1-6. No priority or order is implied in the listing of the indicators.

ii. INDICATOR REPORTS

A. Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests, including the extent to which it addresses a variety of issues.

A nation's legal framework can mandate sustainable forest management on federally-controlled lands, maintain a fair system of property rights, foster good management on private lands through incentive systems, and value and protect the unique knowledge, methods of forest management, cultural interpretation of forests by indigenous people and traditional communities.

The legal framework in the United States

In the U.S., the national, state, and local levels all impact the state of the environment through the actions of the legislative, executive and judicial branches at each levels. Federal and state governments regulate the public's rights to use federal and state lands. Some of the important pieces of federal legislation for protecting natural resources with unique cultural, social environmental or scientific values include:

Wilderness Act of 1964. P.L. 88-577. 78 Stat. 890
 National Historic Preservation Act of 1968. P.L. 89-665. 80 Stat. 915
 Wild and Scenic Rivers Act of 1968. P.L. 90-542. 82 Stat. 906.
 Wild Horses and Burros Protection Act of 1971. P.L. 92-195. 85 Stat. 649.
 Endangered Species Act of 1973. P.L. 93-205. 87 Stat. 884.
 Archaeological Resources Protection Act of 1979. P.L. 96-95. 93 Stat. 721
 Federal Cave Resources Protection Act of 1988. P.L. 100-691. 102 Stat. 4546.

Native American Graves Protection and Repatriation Act of 1990. P.L. 101-601. 104 Stat. 3048.

National Indian Forest Resources Management Act of 1990. P.L. 101-630. 104 Stat. 4532.

Federal Land Policy and Management Act of 1994. P.L. 94-579.

Other important legislation mandates public involvement in the decision-making process and management of natural resources on federal lands. The Multiple Use Sustained Yield Act of 1960, the National Environmental Policy Act of 1969 (NEPA), the Forest Rangeland Renewable Resources Planning Act of 1974 (RPA), the Federal Land Policy and Management Act of 1976, and the National Forest Management Act of 1976 (NFMA) are the principle laws mandating public participation in forest management. NFMA requires each forest to develop an integrated 10-year forest plan. The public assists in identifying issues and concerns and comments on the plan's management proposals developed in the plan. Advisory committees, established under the guidelines of the Federal Advisory Committee Act of 1972 (FACA), are another vehicle for public input on such issues as wild and scenic rivers, national trails, and urban forestry.

The Federal government does not directly regulate activities on state and private land. However, federal agencies often participate in resource management decisions at all levels and, in some cases provide incentives through technical and financial assistance to encourage and facilitate better practices.

State regulation: The role of state and local governments include regulating property rights for privately-owned lands and administering federal laws that affect private property rights. State laws that govern forest practices on private lands in various manners include coastal zone management acts, clean air acts, hazardous waste removal laws, pesticide and insecticide laws, worker safety laws, and endangered species laws. These laws may apply directly or indirectly to state, federal, or other government lands. Public lands also have a host of other unique legislation and regulations that govern their forest practices and management.

More specifically, as of 1992, 644 individual forest regulatory rules had been enacted in the United States. Of these, 117 were enacted at the state level, 170 were enacted at the county or parish level, and 357 were enacted at the municipal or township level. Examples of county ordinances include those to control erosion and stream sedimentation, and to protect county roads and bridges from damage by logging trucks. Urban or municipal ordinances include those to protect shade trees and greenbelts, to prescribe silvicultural practices, and to limit hours of operation for heavy equipment.

By 1996, 38 states had at least one program that regulates the application of forest practices on private forest land. Ten states--Alaska, California, Connecticut, Idaho, Maine, Massachusetts, Nevada, New Mexico, Oregon, and Washington--have comprehensive forest practice regulatory programs. The legislative intent of these laws is to protect forest soils, fisheries, wildlife, water quality and quantity, recreation, and scenic beauty, and at the same time maintain an economic

atmosphere that promotes a healthy wood-based industry. The forest practice rules in state forest practice laws include general administrative procedures required for landowners to perform forestry operations; standards for timber harvesting, transportation, reforestation, sensitive resources protection; and enforcement procedures.

Other regulatory trends include increasing numbers of states with laws to mitigate long term impacts. This contrasts with prior regulations set forth by administrative agencies. Incorporation of long-term environmental effects have been considered and laws addressing them have been implemented in some states, especially in the west. Increases in regulations add a considerable cost for state agencies; and for private land owners in their forest management. The regulations are also expected to reduce available timber supplies and increase timber prices over the long term.

Areas for further research: There is data on the U.S. laws, regulations and incentive programs regarding management practices on forests, though it may be inconsistent and incomplete. Further, there is data on property rights, planning, public participation, and the preservation of unique cultural or historic values of forest lands. Earlier sections of the First approximation report deal with the data on the biophysical conditions of the land base of the U.S. However, a synthesis of these data sets is necessary to determine a) how the legal framework has thus far impacted, hindered or fostered sustainable forest management on federal, state and private forest lands; b) the most effective way to adapt or revise that framework to ensure sustainable forest management now and in the future. It is expected that some combination of regulatory actions, cost sharing arrangements laws, and incentive programs will prove most effective. But without a thorough analysis of the effects of the existing systems on the biophysical conditions, it is difficult to describe the optimal mix of these actions.

While research has identified ways to increase and improving public participation in the planning of natural resource management, there is a great need for assessing the quality of that input in terms of representativeness (i.e., is the range of the public participating broad and inclusive or narrow?) And the impact of participation on practices and ultimately, the long term health of the resource base. The type of public input as well as methods for eliciting it are crucial areas for further inquiry. It is possible that the process of public input may have mixed results on the long term natural resource management. Critics argue that efforts to include the public in forest management are overly bureaucratic and time-consuming. Further, they argue that informing the public contrasts greatly with involving the public in decision-making. Many believe that without involvement of local communities in the design, implementation and evaluation of forest plans, sustainable management of the forests is impossible.

INDICATOR 48: Extent to which the legal framework clarifies property rights, provides for appropriate land tenure arrangements, recognizes customary and traditional rights of indigenous people, and provides means of resolving property disputes by due process.

Present land and property use patterns in the U.S. are result from the American legal system, the nation's cultural values and the free market economy. Thus, analysis of the impact of the U.S. laws, economic conditions and its heterogenous cultural traditions on forest management are important to understanding Indicator 48.

Underlying the four components of this indicator is a set of assumptions:

- that stable property rights are essential for sustainable forest management,
- that property rights reflect a society's values,
- that property rights are evolutionary, and
- that property rights are determined by means of due process.

The property rights relevant to the sustainability of forests and other natural resources include: the ability to exclude or control access; dispose, alienate, or transfer; manage or manipulate; use, withdraw, consume, transform; and enjoy. Property rights in the United States are protected by due process (the administration of law in the courts of justice) and restricted by police powers of the state. In addition, each level of government maintains powers of taxation, eminent domain, and escheat.

The most important sources of definition and clarification on property rights are contained in the judicial case law and its interpretations. Legislation on and regulation of property rights has generally been directed toward the administration of public lands and resources (Table 8-1). Increasingly, legislation and regulation have applied to cases which formerly might have been considered common pool or open access resources.

Data Summary

In general, data gathering has been less consistent and comprehensive for the property rights and distribution of forest land than that for agricultural land. However, there are periodic surveys and censuses which provide quantitative data on the trends in forest land ownership. Most of the data are found in government documents, legal casebooks and databases, and from private sources. Although considerable data is available in raw form, analysis of it has not always been uniform. For example, state foresters do not maintain comparable records on public and private forest land holdings. Another example is that the periodic Forest Inventory Analysis conducted by the USDA Forest Service does not specifically address ownership patterns. In general, there is more data on large scale private forest and farm land holdings than for small holdings.

Table 8-1: Rights, responsibilities, and rules in five property regimes

	Private property	Common property	Public/state property	Common pool (fugitive) resources	Open access resources (non-property)
Resource rights	Exclusion, disposal, use, enjoyment	Exclusion, disposal, use, enjoyment	Exclusion, disposal, use, enjoyment	Capture and subsequent use; enjoyment	No well-defined rights
Right holder(s)	Individual or Corporation	Identifiable, interdependent group or community	State (government on behalf of the citizens)	None until capture	None; all have access
Responsibilities (liabilities) of right holder	Refrain from socially unacceptable uses	<i>Group:</i> Refrain from socially unacceptable uses; <i>Member:</i> Respect intra-group rules	Maintain social objectives; determine rules	Determine socially acceptable capture rules	Not applicable
Expectations of right regarded	Expect socially acceptable uses	Expect socially acceptable uses	Expect socially acceptable uses	Expect socially acceptable capture rules	Not applicable
Responsibilities (liabilities) of right regarded	Observe right-holder's rules; refrain from preventing use	Observe right-holders' rules; refrain from preventing use	Observe rules; refrain from preventing use	Observe capture rules	Not applicable
Rules, regulations	Determined by individual or corporation	Determined by the identifiable, interdependent group or community	Determined by legislation, regulation, courts	Determined by legislation, regulation, courts	None
Enforcement / Protection	State	<i>Intra-group:</i> by the group and the state <i>External:</i> State	State	State	None

One category of property rights which deserves special attention is land held in trust for Native American people. The United States has a trust responsibility to protect, conserve, utilize, manage, and enhance Indian forest land, including its economic and other benefits in perpetuity. This responsibility includes the provision of essential primary and secondary forest roads. Despite this federal responsibility, Indian tribal lands are considered private lands. In 1990, Indian forest lands totaled more than 15,990,000 acres, 36 percent of which consisted of commercial forest land and 54 percent of which is woodland.

Interpretation

There are four overarching trends in the evolution of property rights in the U.S.

1) There is an **increase in the regulatory, legislative, and judicial actions** that diminish or expand the property rights of forest rights advocates. Although the United States has one of the most highly developed property rights systems, the number of federal, state, and local policies and regulations that affect the actions of property holders concerning forests and other natural resources has rapidly multiplied in the postwar era. As a result, property owners are uncertain of restrictions on certain activities, increased transaction costs, risks of civil and criminal penalties, and overlapping governmental jurisdictions. Such uncertainties can be perceived as deterrents to sustainable forest management practices when the confusion results in unsustainable investment decisions. On the other hand, as uncertainties decrease through the development of consistent case law, long-term forest management may improve. Voluntary adoption of Best Management Practices across diverse property regimes is providing alternatives to increased regulation of property rights and responsibilities.

2) There is significant **change in patterns of ownership and use** on forest lands. Ownership and use patterns on forest land are changing in response to environmental and ecological concerns, economic conditions, inheritance and other transfer patterns, and alternative possessory titling systems. Tenure and related legal arrangements that support the long-term conservation and preservation of critical habitats are diversifying. Such arrangements include conservation easements, placement of lands in private and public land trusts, co-management of forest industry lands for conservation and research purposes, marketing of rights traditionally associated with property (e.g., development rights or pollution rights), and debt-for-nature or other types of land swaps. During the 1980s, nearly 500 land trusts were created, which produced a land trust population of about 1000. During the period 1972 through 1994, three nonprofit organizations alone transferred about 3.2 million acres to federal, state, or local governments or to other

organizations or individuals through sales, donations, or exchanges for protection and management of their environmental values.

Institutional ownership of commercial timberlands is expanding because of regulatory changes, concurrent with the forest industry's reexamination of the benefits of totally-integrated raw material and production facilities. Some believe that land concentration in the hands of industry may reinforce sustainable forest management practices.

Inheritance taxes are being revised in some states in order to reduce forest land fragmentation, enable family retention of nonindustrial private forest land, and to encourage application of sustainable forest management practices. This and other financial changes, combined with better legal services to disadvantaged forest landowners, may slow the process of land loss among certain minority and economically disadvantaged groups. Maintaining diversity of sustainable forest management practices among a mosaic of forest land owners may enhance cultural and social sustainability in rural forested communities.

3) There is a trend of **increasing transformations in the valuation of goods and services** from private, common, and public property, which provide incentives or disincentives for sustainable forest management. Recent changes in the valuation of goods and services derived from forests, as well as from common pool and formerly open-access resources, provide incentives for sustainable management practices in a variety of property regimes. Certain of these transformations affect annual, mid-term, and long-term income streams, thus influencing forest land ownership retention, alienation, and transfer patterns. Some examples include hunting leases, non-timber forest product collection, and tax or subsidy opportunities for protecting threatened and endangered species. Some of these are discussed in more detail under Criterion 6.

As common pool and open-access resources including air and water quality gain economic value and enter the marketplace, they evolve into common, private, or public properties, changing the duties and liabilities of right holders, right regarders, and right protectors. Trends in this area and more importantly, the effect of the forest health are too new to measure definitively as yet. However, many claim that when new types of resources enter the property domain with a set of long-term goals, more sustainable management of the forests may result.

4) **Increasing autonomy of decision-making on Native American tribal lands** over the last 26 years has the potential to influence forest ownership and management practices. Beginning with the Alaska Native Claims Settlement Act in 1971, the trend in management of Native American forest land has moved steadily toward tribal autonomy and tribal determination of forest management practices. In 1990, the National Indian Forest Resources Management Act reinforced cooperative federal and tribal management and protection of Indian forest resources. Although it acknowledged a trust responsibility for Indian forest resources, it reinforced the claim that Indian forest lands were analogous to private forest lands, not to public domain lands. On the assumption that clear property rights in both forest land and the trees upon it foster

sustainable management, then clarifying tribal property rights may encourage more sustainable forest land management

INDICATOR 49: Extent to which the legal framework provides for periodic forest-related planning, assessment, and policy review that recognizes the range of forest values, including coordination with relevant sectors.

This indicator examines how a society plans for the use of forest resources, founded upon the specific value assigned to alternative uses. Without planning and assessment, sustainable management is less likely feasible.

Planning is a central component of land and forest management. Each statute and administrative strategy governing land management incorporates planning. The planning guides individual discretionary decisions guided by explicit plan goals. All statutory schemes that govern any aspect of a forest, such as habitat and species protection, restrictions on use and silvicultural schemes, best management practices, and water protection laws, are plans to some extent. The schemes include analysis of forest health and use and prescribe actions to promote sustainable practices. Because the schemes govern a dynamic system, affecting federal, state and local governments, regions and private citizens, they are subject to periodic review and revision in the political and agency arenas.

Interpretation

Federal Planning, Assessment, and Policy Review: Historically, federal land management agencies planned a general strategy for their programs. Now, however, federal laws mandate and govern federal land use planning, resulting in more formal planning which is more extensive in process and substance than at any time in history. Individual managers have less discretion in deciding whether and how to plan.

Today, statutes require the Bureau of Land Management (BLM) and the Forest Service to plan for their lands, though in different ways. Congress ordered that management decisions must be "consistent" or "in accordance" with formal plans for both agencies. However, the Forest Service is required to comply with relatively specific procedures in its planning while the BLM has only very general provisions guiding its work. Details about requirements for these planning processes are discussed under Indicator 54.

By contrast, the National Park Service (NPS) has a partial statutory planning requirement, and the Fish and Wildlife Service (FWS), has none. Both agencies do prepare land use plans for a variety of uses though. These plans are similar to discretionary regulations, in that they guide officials but rarely dictate the specified result. They do, however, provide reviewing courts with standards against which to judge subsequent management actions for arbitrariness or capriciousness.

The Department of Defense also has a statutory requirement to prepare integrated natural resources management plans for military lands. This is spelled out in the Sikes Act (16 USC 670).

Planning at the State and Local Level: Over the past 10 years, 48 states have developed and implemented statewide forest resource plans, prompted by the Federal Cooperative Forestry Assistance Act of 1978. The forest resource plans are intended to be a state forestry organization's principal guiding document, providing long range direction, operation objectives or targets, and a budget framework that will assure coordinated and balanced implementation.

Programs designed to address the use and management of forest and range resources on the country's 800 million plus acres of non-federal land have several goals. They are to: encourage the efficient transfer of new technology and forest resource information to private forestry interests and state forestry organizations; increase the management efficiency of state forestry programs; and to assure that information from non-federal forest and range lands is effectively represented in federal and state natural resource planning. To achieve these goals, the Secretary of Agriculture is authorized to provide federal technical and financial assistance to the states. As a result, significant federal and state investments have been made in the programs.

Most states also provide for periodic forest-related assessments and policy reviews through their monitoring processes. States monitor their forest regulatory programs to determine whether the programs are producing the desired result. Information gathered from monitoring can serve numerous purposes. For example, results of the monitoring can clarify which forest practice standards accomplish program goals and objectives best. It can help determine whether enforcement procedures should be intensified or modified.

Beginning in the early 1970s and accelerating since the mid-1980s, nine states adopted programs to assert state control over land development policies. These programs attempt to reconcile the goal of environmental protection with that of economic development. The growth management regulations guide and direct the pattern and pace of development. Often, the programs are geared toward preventing or slowing the conversion of agricultural or forest land to other uses. This is accomplished by a shift from low-density urban sprawl to compact development with higher densities and a sharper transition from urban areas to surrounding greenbelts. By limiting urban sprawl, existing open spaces, including undeveloped wetlands, forests and mountains can be preserved.

In summary, numerous statutory and regulatory schemes are in place that require forest-related planning and assessment at the federal, state and local level. The statutes require that governmental agencies meet needs with appropriate programs and legislation. However, there are no systematic evaluations of the quality or effectiveness of these plans and assessments. Future implementation and revision of the statutes depends on the outcome of current litigation involving the various planning regimes.

INDICATOR 50: Extent to which the legal framework provides opportunities for public participation in public policy and decision making related to forests and public access to information.

Public involvement is a democratic, dynamic, interactive process of bargaining, negotiating, and mediation among and between constituents and managers. All steps in the management decision process--problem identification, data collection, analysis, alternative formulation, and choice--are open to participation. Forests may be managed more sustainably if people have a chance to influence and support plans for forest management actively. Public participation can foster political support for sustainable management.

Interpretation

Public participation is today a routine and integral part of land management and other agency activities. Requirements for public participation have, to an extent, changed the work of many natural resource professionals. Managers must not only understand the current scientific and technical issues in their fields but also understand the role of public interests in resource management. Furthermore, managers find ways to encourage and facilitate public involvement which involve a different set of skills than those taught in most natural resource management training.

Research has identified some of the more successful means of integrating public participation into the planning process. Two areas, in particular, have been examined: 1) effective administration of the public involvement process, and 2) adequate preparation of federal public servants to conduct the process. Guidelines have been proposed by various researchers.

One notable means for eliciting public participation is federal incentive programs. The Federal government does not regulate activities on state and private land, but the incentive programs which encourage and facilitate technical and financial assistance increased are one effective means for increasing participation.

INDICATOR 51: Extent to which the legal framework encourages best practice codes for forest management.

Best management codes set standards for sustainable management of forests to foster appropriate management practices which are ultimately the key factor in forest sustainability. They are written guidelines which prescribe specific forest management actions. Whether they are regulatory, quasi-regulatory, or voluntary, best practice codes strive to ensure forest sustainability. The condition of forests at the stand, landscape, local, regional, national, and global level depend entirely on the management (or lack of management) on the ground. Sound forest management practices and operations ensure sustained forest productivity for market

goods, protection of ecological values, and protection of the various social, cultural and spiritual values of the forest.

By contrast, best management practices (BMPs) are methods, measures or practices selected by an agency to meet its nonpoint source control needs. They should reflect a balance among the many benefits, uses and values of forests. BMPs include but are not limited to structural and nonstructural controls and operation and maintenance procedures. The U.S. Environmental Protection Agency initially designed BMPs to protect water quality. They can be applied before, during and after pollution-producing activities to reduce or eliminate their introduction of pollutants into receiving waters. BMPs also may be designed to protect other outputs and resources associated with forests.

Best management practices for forestry and for agriculture have been developed in almost every state in the U.S. Some of these BMPs for forest management activities are required under various state, local, or federal laws. Others are implemented through various voluntary or quasi-voluntary programs. Implementation of BMPs is monitored periodically in all states and localities, whether the programs are regulatory or voluntary. In several eastern states, wildlife BMPs have been adopted.

Interpretation

In 1995, the American Forest and Paper Association instituted the Sustainable Forestry Initiative (SFI), which sets forth a detailed set of forest practices standards or best management practices. These standards cover practices including protecting water quality, ensuring prompt reforestation, enhancing wildlife habitat, minimizing the visual impact of harvesting, protecting special sites, and contributing to biodiversity.

These standards are not codified, but member companies of the AF&PA are required to implement the standards on their lands. Further, members provide advice to private forest landowners from whom they buy timber on implementing the practices on their lands. This is a substantial commitment for member companies, and is intended to prove their commitment to the world's sustainable forestry principles, on their lands and on NIPF lands. Several forest products firms have chosen not to participate in this program, and resigned as members of AF&PA. The first SFI annual report, produced through internal review, documented excellent progress in achieving the purposes of this program. It is unclear how external or independent reviewers would rate the improvement of practices.

In addition to the AF&PA efforts, various organizations have attempted to develop programs of green certification or wood labeling, such as the Forest Stewardship Council. These have been applied in a limited degree to a few large forest landowners in the United States. The National Woodland Owners Association has also developed a landowner rights and responsibility code,

and began a program in 1997 to have consulting foresters certify that forest management has occurred in sustainable manner on inspected NIPF lands.

Alternatives to outright regulation are becoming more popular. These include the nonregulatory or voluntary BMP programs, with either explicit or implicit contingent back-up of regulatory enforcement action; green certification or stewardship programs; and the industry-sponsored Sustainable Forestry Initiative. Other non-regulatory mechanisms include: cost-share payments under the Forestry Incentives Program; Agricultural Conservation Program; Conservation Reserve Program; Wildlife Habitat Incentives Program; preferential property or income tax treatment; technical assistance and extension education programs; environmental education and urban forestry programs; and conservation easements also can help achieve the purpose of best practice codes or BMPs. These non-regulatory approaches offer the promise of eliciting excellent compliance rates with socially-desired forest practice standards, at a lower cost. While the same practice standards may be expected by all forest landowners, more flexibility to adapt to unique forest or stand conditions should allow more management discretion and reduced costs to achieve sustainable forest management.

There is reasonably accurate and reliable state-level data analyzing the impact of BMPs on water quality and the compliance by forest landowners. Much less data is collected on the effects of forest practices on most other forest-related outcomes such as wildlife, soil productivity, or biodiversity. Data on individual forest tracts or small forest areas is also lacking.

INDICATOR 52: Extent to which the legal framework provides for the management of forests to conserve special environmental, cultural, social, and/or scientific values.

Both law and administrative regulations provide for areas to be set aside for protection based on their social, cultural, ecological and environmental values. The U.S. legal framework enables Federal, State, Tribal governments, local government agencies and private landowners to designate and conserve special areas. Further, non-governmental organizations, including the Nature Conservancy, can and do purchase land for the purpose of conserving it.

Interpretation

The United States has passed numerous Federal laws to protect an increasing number and variety of special areas. Over time, the rate of forest lands designated for protection will slow as the inventory of special areas without designation as such declines. The discussion of the U.S. legal framework lists some of the major pieces of legislation which protect unique natural resources, including forest lands, for their unique social, cultural, environmental or scientific features. These laws collectively demonstrate concern for management of forests for a wide range of values on Federal lands. There is a great need for assessment of the impact of the legal framework on the quality of both the special areas set aside for protection and the quality of their management.

B. Extent to which the institutional framework supports the conservation and sustainable management of forests, including the capacity to accomplish various objectives.

INDICATOR 53: Capacity to provide for public involvement activities and public education, awareness, and extension programs, and make available forest related information.

Support for sustainable forest management and public participation in forestry planning and decision-making requires citizens who are well informed and knowledgeable about forestry issues and activities. Indicator 53 discusses the institutional framework which provides for education and public participation. This includes thousands of environmental groups, governmental agencies and services, not-for-profit educational foundations, facilitation organizations, and forest products consortia.

Public Participation Activities

Without public support and active involvement, an "unwanted" sustainable plan will ultimately fail. However, public involvement involves a complex, two-way dialogue where all affected stakeholders should have an opportunity to influence decisions on public lands. This means that institutional partnerships are usually necessary in planning activities. These institutions include county governments, not-for-profit facilitation groups, not-for-profit environmental groups, tribal governments, state governments, the forest industry, and scientists.

Another mechanism for participation is the Seventh American Forest Congress. It has been an important grass roots mechanism for networking, community-building, and public involvement on the full range of forest related issues. In 1996, the Seventh American Forest Congress was held to develop a collective vision for the next twenty years of forest conservation and management, a list of principles that would achieve that vision, and the next steps needed. Follow-up activities are currently underway across the country. The Forest Congress focused on building community by involving people from all backgrounds as one group which committed and participated in a final product.

Public participation is important in the forest planning process for federal lands, but must be more effective than it has in the past in order to serve its constituents more reliably and without undue contention. Barriers to successful communication and participation have included use of incorrect models of public involvement, professional resistance to public ideas, and inflexible conditions for managers. In over two-thirds of the 121 national forests, regional issues need more attention to strike a better balance among local, regional, and national concerns. In addition, the public has traditionally been involved once a problem arises or a plan is needed. Instead, participation should be involved in defining the problem.

Engaging the public does not ensure sustainability in itself. It does, however, inform participants about the issues involved, including often conflicting laws, lack of funds, and what other people and groups want. Field trips, outdoor events, and other gatherings may also break down barriers between people and foster better knowledge of their shared lands. In this area, however, no large-scale national trends in sustainability and conservation can be seen and are difficult to measure, although local successes can be seen in a wide variety of examples.

Environmental Education

Many states have not developed environmental education programs. Even states which do have functioning programs have not evaluated the impact of the programs on student behaviors and practices. Some of the notable programs include Project Learning Tree and Project Wild but their reach is limited to less than three percent of the U.S. teacher population. Funding is the major constraint for most programs.

Natural Resources Conservation Education Program: The NRCEP is a joint effort between the USDA Forest Service and National Association of State Foresters. The goal of the NRCEP is to help people of all ages understand and appreciate our country's natural resources, and how to conserve those resources for future generations. Although the NRCEP is a national program, it is implemented locally. The program funds environmental education projects, strengthens partnerships between funded organizations, and collaborates on local projects. Other sponsors and partners include the EPA, the National Environmental Education Training Foundation, the National Forest Foundation, the American Forest Foundation, several agencies within the Department of Interior agencies, the Natural Resource Conservation Service, and a host of local and state organizations.

EPA Environmental Education Office: The Environmental Education Act of 1990 created this office to administer a grant program for environmental education and national teacher training and programming activities. The \$7.8 million in funds is split between grants (38 percent), training programs (25 percent), public-private foundations (10 percent), and other broader categories. Advisory groups provide feedback and evaluation programs are required.

National environmental education advancement project (NEEAP): This program helps state leaders to implement and shape their environmental education programs by serving as a conduit between environmental education leaders and their counterparts in other states and between state and national organizations and expertise. Partnerships in this program include the EPA, National Fish and Wildlife Foundation, North American Association for EE, National Association of Conservation Districts, and National Wildlife Federation. NEEAP provides leadership clinics, workshops, seed funding, informational services, and networking opportunities for each of the nine participating states. Eleven more states will be added to the program in the next three years.

Other institutions: The North American Association for Environmental Education (NAAEE) manages a \$1.95 million consortium project funded through EPA and coordinated with a wide range of institutions in addition to those above. The NAAEE focuses on information dissemination, education reform and innovation through training, and expansion of partnerships.

The National Forum on Education About the Environment, linked to the President's Council on Sustainable Development, oversees integration of education about sustainable development into environmental programs.

As a whole, the above institutions comprise the framework for environmental education at a national scale through which local programs are funded, programmed, or otherwise assisted. The framework itself appears well developed, although its level of funding is low and evaluation of program impacts is crucial.

Local and State K-12 Programs: Project Learning Tree (PLT) is national not-for-profit environmental education program funded by state boards of education, private companies, professional associations, individual donations, and state and federal agencies. In the long-term, this form of environmental education is designed to educate the public to improve decision-making concerning natural resource issues and to increase involvement in these decision-making processes. PLT currently trains 50,000 teachers each year based on national guidelines in a training partnership with the Environmental Protection Agency (EPA) and the National EE Advancement Project (NEEAP). Project WILD has trained 550,000 educators and has worked with more than 35 million students since its inception in 1980. Project WILD teaches wildlife conservation and the ecology, values, social systems, and responsibilities that come with it. All three programs--Project Learning Tree, Project WILD, and the most recent Project WET--are designed to be concept-oriented, balanced and fair, and neither pro nor con on value-sensitive issues. Although all three projects relate to natural resource issues, PLT more directly focuses upon forests.

Lifelong Environmental Education: The quality and quantity of environmental education varies dramatically by state. Some have strong, well-established programs, but many are just getting started and are helped through NEEAP and other national programs. Courses in ecology, environmental studies, forestry, and many other topics vary between schools in their quality and quantity depending on the focus of each institution and the faculty they attract. One noticeable trend has been an evolution towards environmental curricula in traditional forestry schools, espousing a more holistic and less traditional approach.

The National Wildlife Federation (NWF) educates children about the environment through publication of two magazines. The Foundation encourages intelligent management of the life-sustaining resources of the earth and promotes a greater appreciation of these resources, their community relationship, and wise use.

The National Audubon Society educates both children and college students. Through their Audubon Expedition Institute, hundreds of college and graduate students are prepared for environmental careers through first-hand learning. Audubon Adventures teaches ecology to 600,000 children in grades three through six.

Extension Forestry

Cooperative Extension provides 9.9 million owners of 393 million acres of forest with management related information and educational programs. Owners are increasingly better educated and are more likely to prioritize ecological or aesthetic values over commodity production. Several trends which affect education of landowners are evident:

- The number of citizens owning fewer than ten acres increased 300,000 to 5.8 million, and 90 percent of forest ownership is fragmented into tracts less than 100 acres. On this land, fragmentation and high landowner turnover become challenges to educators. For example, the rate of turnover may reach approximately 15% of the properties for a state, translating into 20,000 new landowners each year in Pennsylvania.
- Regulations such as the Endangered Species Act are inflexible and force compliance, making them less effective than instilling a land ethic to landowners through education.
- Inadequate funding, personnel, and technical training in federal, state, and local educators hinders outreach.

For these reasons, extension services may reach only five percent of landowners with technical assistance through the Stewardship Program of the 1990 Farm Bill and other educational outreach. Since larger-land owners are disproportionately reached, the acreage with multiple resource management plans may approach 15 to 20 percent of non-industrial private forest land. In North Carolina, a state with many non-industrial private forest owners, 210,000 acres out of 12.3 million acres have management plans. Throughout the management plan process, education concerning multiple and often conflicting management objectives is a major focus of CES extension programs.

Extension foresters also educate loggers about BMP compliance, safety, and other issues. In this case, 95 percent of loggers may be reached and BMP compliance may be over 90 percent based on independent inspections of state forestry departments. Since both the BMP compliance rate and regulations dictated vary by state as delegated in the Clean Water Act, results are difficult to quantify, but nevertheless impressive.

Extension foresters work in collaboration with state forestry agencies, the Forest Service, the Forest Landowners Association (in the South), consulting foresters, the American Forest and Paper Association (AF&PA), and a variety of other interested parties. AF&PA, with its

Sustainable Forestry Initiative, provides funds for logger education about BMPs with penny a ton taxes funding pilot projects in Georgia, Mississippi, and Virginia.

A close partnership and joint staffing exists between the extension services and state foresters. The National Association of State Foresters may even include extension agents as members. In the Northeast, state foresters are usually part of the state's department of environmental protection; in the west, part of trust agencies and land departments; in the south, part of governor-appointed commissions to promote the forest products industry. Funding, therefore comes from many sources. Once again the variation between states is broad and difficult to interpret.

Funds for extension activities are provided through the Renewable Resources Extension Act (RREA), Smith-Leaver federal funds as allocated by states, and through state matching funds and local funds. Since it was first funded in 1982, RREA has increased the number of extension agents involved in forestry from 180 to 280 and in all natural resource fields from 330 to 700.

Since private property rights figure prominently in the U.S., a land ethic which espouses sustainable management must be gained through individual commitment. The extension services can only help based on their success rates at education combined with incentives for good stewardship. The magnitude of their success will be further quantified and qualified when the Chief Financial Officer reports to Congress on the results of the Government Performance and Results Act. This and other evaluations to determine the most effective means to encourage sustainable forest management and is necessary.

INDICATOR 54: Capacity to undertake and implement periodic forest-related planning, assessment and policy review processes including cross-sectoral planning and co-ordination.

This Indicator examines the legal requirements for assessment and planning on forest lands in the U.S. This indicator considers the institutional framework supporting the capacity to implement these laws.

Federal Forest lands: The federal forest lands are primarily managed by the National Park Service, Forest Service, Fish and Wildlife Service and Bureau of Land Management. It is possible to determine decision and rule making processes and assess whether adequate information for decision making is used, cooperation between agencies is present and public input is solicited and then used.

Information from the Forest Service includes costs for different program activities. From these reports it is also possible to assess performance goals as they relate to the RPA program, to the management of National Forests and to assisting state, private and other federal landowners.

State Forest Areas: Apart from the management of state-owned forest lands. States also have a substantial role in regulation of private forest practices, forestry extension and support of private land owners. In collaboration with federal agencies, state governments have established a variety of cooperative incentive programs designed to protect forests and ensure forest productivity for all uses. This technical support is provided under the Cooperative Forestry Assistance Act of 1978.

Extension services include transfer of technical assistance and distribution of information about best management practices that can be voluntarily applied. States also produce financial incentives in the assumption that private landowners are financially unable to carry out socially responsible forestry practices. States can also implement regulatory measures to force uniform application of socially acceptable forest practices on all private lands within a state.

In 1992 of the many state programs, 28 percent were technical assistance, 27 percent were primarily educational. These types of programs existed in 84 to 94 percent of all states. Fiscal incentive programs were 15 percent of all programs and were said to exist in 26 and 78 percent of all states (depending on how definition of program objectives). Voluntary guidelines account for 13 percent of program applications and regulatory programs account for 11 percent of state program applications.

The acreage of state forests can be assessed and the type of management plans can be investigated. Generally, state foresters reports contain many of the quantifiable variables relating to management of state forests.

It is possible to assess the state government programs focused on major private forestry activities. This would focus on the activity, the region and the type of program. The categories of program in such an assessment would include educational programs; technical assistance; voluntary guidelines; tax incentives; regulatory programs.

Private Forests

Ownership of the nation's non-industrial private forests is dispersed across 10 million individuals. Many of the private land-owners activities are encouraged, facilitated, or advised by other types of institutions such as federal and state forestry agencies, and associations including the American Tree Farms System. This association is a forestry industry program to encourage good forest management on private land. There are over 72,000 tree farms in 50 states which cover 88 million acres. To become a member of this system, the land must be inspected by one of the 10,000 foresters who donate their time to this system. The lands are then inspected every five years.

Various parameters can be used to assess private forest management including:

- Owner objectives for various uses, land investment, recreation, timber production, farm and domestic use, part of a farm, aesthetic enjoyment, part of residence;
- Timber harvesting behavior which reflects harvest experience and harvest intentions;
- Percentage of management plans and acres covered by plans. However, this does not provide information regarding the content of the management plan or its effect on the ground.

While there is information available from the various private associations including the AF&PA Sustainable Forestry Initiative on harvest levels, public opinions, and land assistance programs, analysis of the institutional effectiveness in fostering good planning for sustainable forest management is lacking.

Regional Planning

Recently, comprehensive assessments have been undertaken in the Sierra Nevada, Upper Columbia Basin, the Northern Forests and other areas. Problems in accomplishing large scale regional plans include the difficulty in eliciting adequate public participation and no requirements for different institutions to collaborate. While there are various methods to assess the success of regional plans, none is comprehensive. For example with the Sierra Nevada Ecosystem Project, there were public meetings with the steering committee. In the Upper Columbia Basin, the correspondences of the county commissioners from Oregon, Washington and Idaho could be used in the same way. The written public comment record from the public meetings illustrates public opinion and reaction to the planning process. Pairing these qualitative data sources and other quantitative data with the resulting forest management remains an important area for future research.

INDICATOR 55: Extent to which the institutional framework includes the capacity to develop and maintain human resource skills across relevant disciplines.

The management practices which determine the sustainability of the nation's forests depend largely upon human skill and ingenuity. A broad range of disciplines and skills is necessary to achieve the goals of sustainable forest management including not only the traditional scientific disciplines of forestry, botany, wildlife biology, ecology, but also the social sciences of economics, anthropology and conflict resolution.

Skills in the many disciplines are developed through formal education and on-the-job-training, and are maintained through direct experience working in the discipline as well as through professional certification/licensing requirements, professional societies, continuing education programs, extension landowner outreach programs, and technical/trade training and assistance programs.

Data Summary

The institutional framework in the U.S. supporting the development and maintenance of human resource skills in forestry has been well developed for many decades. Periodic assessments of the relevance and changing needs of forestry education have guided the evolution of forestry programs in the United States. Recent developments such as the SAF's Certified Forester program represents a strengthening of the institutional framework needed to maintain human resource skills.

Data on skill maintenance are available from several sources, including professional societies, individual corporations and government agencies, trade associations, and extension programs. These data are, however, are not uniform in substance or maintenance. More importantly, in their raw form, they provide no analysis of the impact of the programs upon forest management.

The data from academic institutions with programs in natural resource management show that enrollment in agriculture, natural resource, and forestry schools is on the rise. The Food and Agricultural Education Information System (FAEIS) noted five year trends in the combined national enrollment (2 year, BS, MS, and PhD) showed a 27% increase between 1991 and 1995. National enrollment in natural resources experienced a 31% increase between 1991 and 1995, while forestry enrollment increased 18% for the same time period.

Two professional societies in the natural sciences, the Society of American Foresters and the Southeastern Section of the Wildlife Society, offer accreditation to schools that meet their criteria for professional education. Further, the National Association of Professional Forestry Schools and Colleges (NAPFSC) has a committee that focuses on forestry education for its 60 member schools. The committee has served as a catalyst for issue examination by cosponsoring a series of meetings on forestry education in the United States. The committee has also cosponsored symposia examining the role and changing needs for forestry education.

Data pertinent to the other relevant disciplines exist, but are of limited immediate use as they are compiled and held by individual schools. Qualitative data regarding the academic emphasis within each department as well as the scope and detail of the courses could be collected. This information, combined with quantitative data about the number of students enrolled in these programs, would give a clearer picture of the status of the U.S. institutional capacity to further human resources necessary for sustainable forest management.

Trade associations such as the American Forest and Paper Association (AF&PA) work closely with individual state programs to provide education and training to loggers, procurement foresters, and sawmillers. Programs vary by state; for example, Missouri currently has no logger education program, while other states are in the process of developing continuing education criteria for persons who have completed training. AF&PA also offers education and training for

member companies as part of its Sustainable Forestry Initiative (SFI). Data on these programs varies in quality and availability.

Professional societies representing the relevant disciplines (with the exception of the Botanical Society of America) offer certification programs for their members and require some type of continuing education for certification maintenance. Most societies open their continuing education programs to non-certified members as well. Accreditation programs reflect organization priorities: in the case of the SAF, interdisciplinary efforts in four main education areas (communications, science and mathematics, social sciences and humanities, and electives) are stressed. Faculty experience and program scope and rigor are heavily weighted in the Southeastern Section's program.

Many private corporations and government agencies involved with forest management offer or require some type of professional development or in-service training program for their employees. The extent of this practice is unknown, and data documenting requirements have not been collected.

Trade associations such as the AF&PA are currently working with individual state technical training programs to develop continuing education requirements for loggers, sawmillers, and procurement forester who have participated in workshops. The AF&PA also commits time to working with member companies to provide them with new information that will help them meet the requirements of SFI.

State extension agencies offer landowner assistance and education programs. The real challenge lies in keeping extension agents up to date with changes in technology so that they can offer the highest-quality assistance to interested landowners. Moreover, some states require foresters to be licensed and/or registered, which helps ensure high professional standards for private forestry practices. Currently only 11 states require foresters to be licensed, and 13 states require foresters to be registered. No states currently require licensing or registration for the other disciplines.

Interpretation

There are a number of data sources on the capacity of the institutional framework in the U.S. to foster and maintain the human resource skills relevant to sustainable forest management in the U.S. The major need for future inquiry is comprehensive analysis of the impact of various institutions and programs on forest health.

INDICATOR 56: Extent to which the institutional framework has the capacity to develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and support forest management.

In many cases, access to the forest is needed for sustainable management. To the extent that adequate infrastructure is provided in appropriate situations, the greater the likelihood that forest will be managed on a sustainable basis.

Management objectives determine what is the efficient physical infrastructure for sustainable forest management. In the U.S., the profit motive of industrial timberland owners provides an analytical framework for determining how much infrastructure to develop and maintain on their lands. Management of publicly-owned forest ecosystems, however, faces multiple, shifting, often poorly defined and contradictory objectives which vastly complicates the determination of efficient levels of physical infrastructure. This discussion is focused on publicly-owned land because most data available on this indicator pertain to them.

As physical infrastructure, we are including structures and facilities that are essential for the sustainable production of benefits from forests to society. Unroaded areas and permanent installations such as trails, roads, campgrounds, and ski lifts are included.

Benefits to society cover a wide array, including 1) inputs to the economy (such as wood and minerals); 2) amenities (opportunities for recreation, viewing wildlife, enjoying scenery, and services that are not related to any direct use of the environment); 3) life-support services (clean air and clean water); and 4) dispersing, transforming, or storing residuals that are by-products of human and economic activity. Efficiency with respect to physical infrastructure means allocating resources, without waste, to produce desired levels of all kinds of outputs--including areas with no permanent installations if that is what society desires.

Direct measures of infrastructure--such as miles of road or numbers of campgrounds--are scattered and uneven. Data included in the National Outdoor Recreation Supply Information System (NORSIS) is derived from a variety of references and databases.

If infrastructure is restricted to permanent installations alone the analysis becomes biased by the implicit assumption that areas without permanent installations have no positive value. In fact such areas have considerable value when measured in terms of willingness to pay even though, because of market failure, it is difficult to capture that value monetarily. A broader, more inclusive definition of infrastructure would include various combinations of unroaded areas, trails, roads, campgrounds, and ski lifts. Appropriate levels of infrastructure thus are unique to each ecosystem depending on both its biophysical properties and its socio-economic context. Appropriate amounts of roads, unroaded areas, trails, and ski lifts for a temperate, mountainous, moist ecosystem are not the same as for an arid, flat ecosystem. Likewise appropriate amounts of infrastructure for two identical ecosystems, one near fast-growing population centers with transportation networks and the other remote and isolated, are different .

Interpretation

The relationship between physical infrastructure and sustainable forest management for public lands is not at all clear for several reasons. At a given time some outputs from forest ecosystems (timber or camping) are positively related to the presence of roads and campgrounds, while other outputs (wilderness or hiking trips) are diminished by more infrastructure. The question of efficient infrastructure becomes more complicated if viewed through time. As the population grows and all demands on forested ecosystems increase, infrastructure requirements will change.

Preferences can change with the population structure, for example, recreation demands as the population ages. Preferences can also change as alternatives to timber or outdoor recreation become available, but these are difficult to predict. While infrastructure data can be collected and trends can be displayed, they cannot be interpreted without placing them within the broader policy context.

Data showing normalized trends in miles of trails and roads and acres of wilderness for the Forest Service illustrate the difficulties of interpretation. Since 1983 all of these variables have had an upward trend: a land base of finite size has been yielding simultaneously more acres of designated Wilderness and more miles of roads and trails. One has to assume road and trail density has been increasing during this period. Is this sustainable infrastructure? At what trail and road density does another unit of physical infrastructure provide fewer benefits from forests than its cost to build and maintain?

If we analyze the per capita trends the conclusions are no more clear. Acres of designated wilderness, for example, have fluctuated around a mean of 0.13 acres per person in the last decade. In some years Wilderness designation has not kept pace with population growth, in other years it has exceeded it. The implication is that sustaining the provision of wilderness areas to each person requires continual additions to the wilderness system, an absurd conclusion at the extreme. A more sensible policy is to set the ratio of roaded to wilderness areas where society is indifferent between one more unit of roaded area and one more unit of wilderness. At present we lack methods to know what this ratio is, much less how it may change through time.

The Forest Service has provided roads and trails on a per capita basis. But for both, the percentage of the infrastructure not being maintained to standard has been increasing. Assuming we know what levels of roads and trails are efficient, these trends raise doubt that current institutions can sustain them. Resources for maintaining roads and trails have declined in recent years. This suggests the need to reexamine the policy for funding road and trail maintenance. Many users of Forest Service roads and trails pay no fee at present: firewood cutters, mushroom and huckleberry harvesters, hunters, and all sorts of recreationists. Analysis of efficient allocation of the costs of road and trail construction and maintenance is required, as well as an assessment of mechanisms for collecting revenues.

With respect to roads, determining the efficient level of infrastructure is complex because roads facilitate hauling timber, provide access for recreation, and facilitate forest management activities such as firefighting, thinning, and monitoring. Roads thus are associated with multiple outputs and enter at different stages of the production process for different outputs. Evaluating these benefits and the attendant impacts of fire risk, erosion, spread of diseases, etc., presents challenges that have not yet been satisfactorily resolved.

Expenditure data are not reliable indicators of the state of the physical infrastructure. It is conceivable that efficient physical infrastructure can be provided with no expenditures, or conversely efficient infrastructure is not provided despite substantial expenditures. More direct measurement of the infrastructure is preferable. Ideally some indication of the quality of the infrastructure would be available too.

INDICATOR 57: Extent to which the institutional framework has the capacity to enforce laws, regulations, and guidelines.

Without adequate enforcement efforts, the effectiveness of laws and regulations intended to promote forest conservation and sustainable management will be greatly reduced. Therefore, the greater the extent of enforcement, the more likely that forests will be managed on a sustainable basis.

Building on the principle that sustainability in forest resources management is based on balancing private and public interests and the uses and benefits of present and future generations, legislative policies concerning the management of renewable resources must be developed to be comprehensive, understandable, and, yet, concise. More importantly, these policies must reflect the consensus of a public that realizes the importance of these balances and the benefits of the enforcement of such legislation. In terms of policy enforcement, this consensus is reached when nearly everyone expects the rules to be enforced (regardless of whether they agree with the specifics of those rules or not) and this expectation deters actions of non-compliance.

In the arena of enforcement, laws, regulations, and guidelines have varied applicability and are enforced within a complex jurisdictional structure. Jurisdiction describes the enforceable reach of a law and who has the responsibility of enforcing that law. Mapping jurisdictions can be quite confusing as some resources (e.g., wildlife) are the responsibility of state government, while others (e.g., endangered species) can be said to belong to the federal government. Some resources (timber or habitat, for example) actually belong to the land owner, whether private or public, though non-owners may have a say in how that resource is used. In addition, jurisdictions may overlap as agencies practice cooperative law enforcement techniques.

Guidelines are treated here as non-authoritative standards of practice developed by governmental or non-governmental organizations and enforced by moral persuasion. Regulations express authoritative standards of operational procedures established to govern behavior and actions of

agencies and enforced by superiors in the organization. Laws are legislatively-binding authoritative standards enacted by the government to codify and regulate behavior and practices among the members of a society and enforced by agencies directed to execute policy. Several categories of laws are included.

Best Management Practices (BMPs) are usually voluntary guidelines designed to help educate landowners about conservation-minded management practices. Some states monitor for compliance with BMPs, and may issue fines for deviations, but in general this is a nonregulatory approach. Forest Practices Acts (FPAs) establish in broad terms the objectives of regulation; activities to be regulated; manner in which forest practices are to be regulated; responsible administering agencies; and penalties for noncompliance. Right to Harvest Laws are being adopted by several states to ensure legal protection of timber harvesting in a perceived atmosphere of constricting environmental legislation. Bad Actor Laws are often used by states to back-up pre-existing guidelines that don't prescribe penalties for noncompliance. Generally, these laws provide a method of enforcing guidelines by invoking the penalty of a functional forest law with similar resource conservation intentions (such as a water quality standard) that has also been broken.

Attempts to measure the effectiveness of law enforcement for promoting sustainable forest management are subjective by nature. While data on natural resource related law enforcement expenditures are compiled at the federal level, there is presently no system in place to track this type of spending at the state or local levels. Another useful method of tracking state forestry regulations is through the National Woodland Owners Association which annually recognizes outstanding forestry legislation. However, the goals of these Associations are not necessarily the promotion of sustainable forest management, as defined in the Montreal Process, at the national or global level; and neither of these Associations tracks the enforceability of the laws reported.

Interpretation

The collected data and information present findings on the types of laws enacted to regulate natural resource management, the distribution of these types of laws, and trends in legislation and enforcement. The types of laws that directly or indirectly regulate natural resource management generally belong to one of the following categories: environmental protection (air quality, water quality, species preservation, soil conservation), timber harvesting, public property protection, tree protection, and special features protection (sensitive or fragile areas containing unique environmental attributes or resources). Distribution of natural resource management laws may be gleaned from the literature and data compilations. Federal natural resource laws tend to be well publicized and are frequently critiqued in numerous publications. The National Association of State Foresters tabulates data on which states have adopted common forestry ordinances, and the National Woodland Owners Association reviews other state forestry legislation and publicly commends states for outstanding laws.

Trends in legislation and enforcement may be tracked through the historical record of legislation (addition and repeal), the annual expenditures by enforcement agencies, the annual number of reported law enforcement incidents, and the number of law enforcement officers in reference to area of jurisdiction. Information used to map these trends is considerably more available at the federal level than at the state or local levels. Federal documents, such as the *Annual Report of the Forest Service*, report the total number of incidents administered by that agency as well as expenditures for agency and cooperative law enforcement on an annual basis.

The most striking element that cannot be determined from the data is a reliable measure of the effect that law enforcement has on the promotion of sustainable forest management. As the absence of data exhibits, it is quite difficult to accurately track costs of law enforcement at the state level. Often, state forestry agencies don't have the power of enforcement and must refer cases to police or other environmental agencies that do have the power of enforcement. Present legislation on conserving and developing forest resources does not sufficiently reflect the principle of sustainability. Indeed, many laws and regulations are inconsistent and often contradictory to long-term forest management.

C. Extent to which the economic framework (economic policies and measures) supports the conservation and sustainable management of forests through a variety of mechanisms.

INDICATOR 58: Investment and taxation policies and regulatory environment which recognize the long-term nature of investments and permit the flow of capital in and out of the forest sector in response to market signals, non-market economic valuations, and public policy decisions in order to meet long-term demands for forest products and services.

If capital is kept out of the forest sector, sustainable management may not be possible. If capital is prevented from leaving, inefficiencies can occur in both the forest sector and the economy at large and overexploitation may occur in the forest sector.

Evaluations of investment and taxation policies and the regulatory environment are very judgmental, going from the extremes of no regulation to full regulation. Various approaches to capital gains and estate taxes or other incentive programs tend to generate controversy. Direct regulation of private land is done only by state and local jurisdictions. A comprehensive discussion of state regulations can be found in Ellefson, et. al. Twelve states have a total of 13 timber severance tax programs that generally have the intent of encouraging better forest management.

An important part of the relevant economic framework is the provision of secure property rights which allow for investment in natural resources and intertemporal efficiency.

Interpretation

There is a trend toward increased regulation of forestry practices on private lands. There are mixed opinions about the effects of these regulations on timber supply. The regulatory environment evolves over time. For example, the implications of the Endangered Species Act for management of private lands are evolving through the court system.

Public lands are generally managed for a variety of values and the long term nature of investments is recognized. There is competitive bidding for most timber sales with the rights to harvest timber going to the highest bidder. Sales may last a year or more and the purchaser has some discretion over the timing of harvest in response to market signals.

Timber processing industries are subject to the same federal and state laws as are other industries. The Clean Water Act and other federal and state legislation may affect how processing occurs.

Although conclusive evidence is often elusive, many of these states can point to a number of tangible benefits that have resulted from their investments in state regulatory programs. Water quality is often better, reforestation rates are higher, wildlife habitat is more extensive, and amenity values are more pleasing.

Counting the number of regulations does not get at the flow of capital in and out of the forest sector. Although regulations may produce a variety of benefits, they can be a negative factor in timber supply.

INDICATOR 59: Non-discriminatory trade policies for forest products.

Over the past several decades, the U.S. timber processing industries have supported open trade in manufactured products. This support was reflected in the U.S. government's positions in both the Tokyo and Uruguay rounds of GATT negotiations. At the conclusion of the Uruguay Round, U.S. tariffs on imports of logs, lumber, plywood, and pulp and paper products were zero or near zero.

The terms of the U.S.-Canadian Free Trade Agreement and later, the North American Free Trade Agreement, are further evidence for U.S. support of non-discriminatory free trade policies.

Exceptions are the terms of the Forest Resources Conservation and Shortage Relief Act of 1990, as amended (FRCSRA), the final rule of the USDA Animal and Plant Health Inspection Service on the importation of logs, lumber, and other unmanufactured wood articles (APHIS restriction), and the terms of the 1996 softwood lumber agreement between the government of the United States of America and the government of Canada (softwood lumber agreement).

In general, the FRCSRA prohibits the export of unprocessed logs from publicly owned lands in the contiguous States west of the 100th meridian. One of its purposes is to continue and refine

the existing Federal policy of restricting the export of unprocessed timber harvested from Federal lands in the western United States. Definitions of processed material, exceptions, etc. can be found in the language of the legislation.

The general intent of the APHIS restriction is to protect the U.S. domestic timber resource from the introduction of unwanted pests that could damage the resource. The implementing rules and regulations detail acceptable treatments and handling procedures. Current rules exempt Canada and Mexican States bordering on the United States from the terms of the restriction.

The softwood lumber agreement caps Canadian tax-free exports to the United States at 14.7 billion board feet annually, 9 percent below the record 16.2 billion board feet in 1995. The agreement contains a provision for an export tax of \$50 per 1,000 board feet for the first 650 million board feet above the 14.7 billion board foot level and \$100 per thousand board feet for amounts beyond 15.35 billion board feet. Exports from the Maritime provinces, Manitoba, and Saskatchewan are exempt from the terms of the agreement.

As trade in timber products increases, there will likely be growing concerns over the introduction of exotic pests, and history indicates that there are legitimate reasons for concern. For example, introduction of the chestnut blight into the United States forever changed the nature of forested ecosystems in the Eastern United States.

There is increasing interest around the World in use of timber products from forests certified as sustainable, especially regarding tropical timber products. There may be increasing interest in this area on the part of U.S. consumers that would be reflected at State and local levels rather than the Federal level.

The trend in international negotiations for the United States to take a zero position on tariffs for forest products indicates non-discriminatory trade policies for forest products. Trade policies evolve over time, and there may be situations develop such as the softwood lumber agreement where trade policies might be open to discussion.

D. Extent to which the economic framework provides the capacity to measure and monitor changes in the conservation and sustainable management of forests.

INDICATOR 60: Availability and extent of up-to-date data, statistics and other information important to measuring or describing indicators associated with criteria 1-7.

The more widespread and current is the information related to criteria for sustainable forest management, the more likely forests will be managed on a sustainable basis. Greater knowledge enables decision makers and forest managers to make wise decisions.

The availability, and extent of up-to-date data, statistics, and other information important to measuring or describing indicators associated with criteria 1-7 vary by criterion.

- For criterion 1--ecosystem diversity--, information on forest types is available only for timber land. The concepts of fragmentation and scale are not well developed. For species and genetic diversity, the number of species is not known and the concept of viability is not well developed.
- For criterion 2, there is sufficient information for indicators 10 and 11; information for indicator 12 is spotty; for indicator 13, the sustainable volume for private lands remains to be determined and we are forced to use net annual growth as a proxy. For indicator 14, the concept of sustainability is loosely integrated into game management, but not for other non-timber forest products.
- For criteria 3 and 4, available information is localized and tends to come from case studies and regional assessment and monitoring efforts.
- For criterion 5, information is well developed, but subject to limitations of inventory coverage in some areas such as Alaska. There is also uncertainty about the level of carbon in forest soils.
- For criterion 6, there are reasonable and timely data for most indicators dealing with timber production, but little for non-wood products.
- For criterion 7, comprehensive information has not been accumulated in a single source. What is known is piecemeal and inconsistent.

There is increasing interest in monitoring the environment, but funding for this activity is difficult to maintain.

Trends in timber production and consumption, timber growth, mortality and inventory can readily be assessed on two-thirds of the forest land. In addition, the variety of programs pertinent to the indicators can readily be assessed, especially at the Federal level.

Availability is improving with access to systems through the WorldWideWeb. Consistency and comprehensiveness are becoming more critical.

There is little information on timber growth, mortality and inventory for the one-third of the forest land that is not classified as timberland. Especially for criteria 3 and 4, we have little consistent information for the various indicators, especially on private lands. Information on indicators associated with non-wood goods and services is also unavailable at this time.

INDICATOR 61: Scope, frequency and statistical reliability of forest inventories, assessments, monitoring and other relevant information.

This indicator assumes that better quality forest information makes it more likely that the forest will be managed on a sustainable basis. Trends cannot be detected nor impacts estimated without adequate data.

Early interest in forest inventories was primarily focused on availability of timber for commercial harvesting. Over time, there has developed increased focus on forest values besides timber. Because of the length of the inventory cycle, it may take over a decade to collect any new information for a national report. New remote sensing and sampling technologies offer promise in reducing the time needed to implement new variables for national reporting.

The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) has provisions for monitoring of the effects of forest management on the productivity of the land. Increasing concerns about forest health led in 1990 to the establishment of a forest health monitoring program. The program is active in 18 states and it monitors many of the indicators in the Santiago declaration.

In the United States, forest inventories are conducted under the terms of the Forest and Rangeland Renewable Resources Research Act of 1978 which directs the Secretary of Agriculture to make and keep current a comprehensive survey and analysis of the present and prospective conditions of and requirements for renewable resources of the forests and rangelands of the United States. These forest inventories are carried out by USDA Forest Service Research on all lands in the United States except for National Forests in the West where forest inventories are maintained by Regional Offices of USDA National Forest Systems. All inventories are done with annual appropriations, augmented in some instances by cooperator funding.

The forest inventory is based on a systematic grid of over 100,000 inventory plots across the country. The average time between inventories varies, depending on budget, but is currently about 12 years. State-wide inventory information has been collected continuously for over 60 years. In most regions of the country, the third inventory cycle has been completed and some areas have been inventoried as many as six times. Each year, over 18 million hectares of forest land are inventoried. The statistical reliability of the inventories is targeted at the State level with forest area being estimated plus or minus 2 percent per million hectares.

The Renewable Resources Planning Act of 1974 provides for a national renewable resource assessment and a program based on that assessment. Assessments were done in 1975, 1979, and 1989. Assessment updates were done in 1984 and 1993. Programs were done in 1975, 1980, 1985, 1990, and 1995. Planning is underway for an assessment to be completed in 1999. These Assessments have tended to focus primarily on supply and demand issues rather than the condition of the resources. However, including use of the criteria and indicators for sustainable

forest management will enhance the ability of the 1999 Assessment to address resource condition issues.

Limited forest inventories are also done by the Natural Resources Conservation Service on private lands. These inventories are less comprehensive than inventories done by the Forest Service and focus on soil and water protection aspects of forest lands. There are on-going efforts to coordinate methodologies used in this National Resources Inventory with the inventories conducted by the USDA Forest Service.

Monitoring and assessment activity occur at the State and local government levels, as well as on Tribal and private lands.

There has been a proliferation of ecoregion assessments around the country. These assessments have a variety of objectives and more are expected. They may generate information useful for evaluation of indicators at a regional level.

The Forest Health Monitoring and Forest Inventory and Analysis programs of the USDA Forest Service are being integrated to create efficiencies in data collection. Research is underway to annualize inventories to decrease the time between observations on sample plots.

A Forest Inventory and Monitoring Institute has been established within the USDA Forest Service in part with the intent of coordinating development of protocols for measurement of selected indicators in the Santiago Declaration.

Interpretation

The United States has maintained inventory, assessment, and monitoring capabilities for years at the Federal level. The need for additional and more timely information is reflected in current research activities. There also is a great need to coordinate and integrate assessment and monitoring work being done by other public agencies, corporations, and individuals.

INDICATOR 62: Compatibility with other countries in measuring, monitoring and reporting on indicators.

Consensus criteria and indicators reflect a global sense of the meaning of sustainable management. The greater the ability to fit within this context, the more likely that there will be a successful interpretation of the degree of sustainability.

Determination of compatibility must wait until countries' FAR reports are available. However, inferences about probable compatibility can be derived by examination of the situation within the United States. As illustrated in the analyses of the various indicators of sustainable forest

management in the United States, there is great variability within the United States in terms of the capability to measure, monitor, and report on indicators.

For criterion 1, much of the available information is for characteristics of forests on productive lands (timberlands). Timberland accounts for about two-thirds of total forest land. Data in the United States for inventory and land use are not organized according to the IUCN categories.

For criterion 2, the concept of sustainability is generally well developed on public lands and they are managed with the general intention of sustainability with some variation as to what sustainability means. The recent Sustainable Forestry Initiative of the American Forest and Paper Association is intended to enhance sustainable forest management of forest commercial forest lands.

For criteria 3 and 4, available information tends to be from case studies and development of a national report would be difficult and expensive.

Criterion 5 is generally compatible with other countries, and for some ecosystem components, standards exceed the draft international guidelines and protocols established by the IPCC. This criterion is well developed through assumptions about unit carbon values, but there is much uncertainty about the amount of carbon in forest soils.

Criterion 6 is well developed at the national level for various measures related to timber production. There are various measures of use for non-wood products on public lands, but little information is available for use on private lands.

Criterion 7 is well developed for public lands in terms of planning, public involvement, etc. For private lands, the legal, institutional, and economic framework tends to vary by State.

Given this variation within the United States, there is likely to be considerable variation among countries in terms of the ability to measure, monitor and report on indicators. The newly established Inventory and Monitoring Institute within the USDA Forest Service will provide the capability to develop protocols for some of the indicators in the Santiago Declaration.

E. Capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services.

INDICATOR 63: Development of the scientific understanding of forest ecosystem characteristics and functions.

The more scientific resources that are effectively applied, the more likely that forests will be managed on a sustainable basis. This indicator suggests the need to know the quality of our scientific understanding of forest ecosystem characteristics and function.

At this time, the best way to assess this indicator is to track the amount of money spent on research on forest ecosystems and functions. The following discussion points out the problems in trying to estimate this funding.

The United States has made significant investments in development of scientific understanding of forest ecosystem characteristics and functions. Research on forest ecosystem characteristics, functions and processes has been carried out in universities, Forest Service Research, and other federal agencies for many years. But the importance of this research has been increasingly recognized in recent years. Whether or not this increased recognition will translate into increased research investments and increased research capacity remains to be seen.

Recognition of the importance of increasing our understanding of forest ecosystems has grown dramatically in the United States in recent years. One indication of this is the National Research Council's report on forestry research, in which it was recommended that forest ecosystem research be "drastically" expanded. Another indication is the USDA Forest Service's strategic research plan, in which research on "understanding ecosystems" was identified as the first of three major program components for future research, with the expectation that this type of research will provide the scientific basis for addressing the health and productivity of natural and managed systems and natural resource issues related to environmental concerns. It will help us understand how forest and range ecosystems affect and are affected by natural and human-made environmental changes.

Despite increased recognition and funding for forest ecosystem research, quantifying the research capacity related to this area of research is problematic. Until very recently, research on forest ecosystems was not identified as a separate budget line item or research classification category. For example, forest ecology is not identified as a separate category of research in the recently updated Current Research Information System. Forest ecosystem research was not identified as a separate budget line item in USDA Forest Service Research until 1994. Research on forest ecosystem characteristics and functions has long been carried out in universities and Forest Service Research, but the funding history is essentially not retrievable due to the research classification systems used in the past.

An important point related to research capacity on forest ecosystems is that a significant amount of research on this topic takes place outside university forestry departments and Forest Service Research. Research on the structure and function of forest ecosystems has provided much of the information that is provoking major changes in our view of forests and how they work and has provided many concepts that are helping to resolve conflicts among resource values, such as timber and wildlife. Much of this research has been carried out by scientists outside of the field of forestry with funding from the National Science Foundation, private foundations, and non-government organizations.

Private sector organizations have not been extensively involved in basic research on ecosystem structure and function in the United States. The wood-based industry's research and development investments are focus heavily toward development, with very little emphasis on research areas such as developing increased scientific understanding of forest ecosystems.

INDICATOR 64: Capacity to develop methodologies to measure and integrate environmental and social costs and benefits into markets and public policies, and to reflect forest related resource depletion or replenishment in national accounting systems.

With more appropriate methodologies available, it is assumed to be more likely that forests will be managed on a sustainable basis. The U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis (BEA) has conducted an analysis to implement the United Nations System of Environmental and Economic Accounting. In its initial work, BEA focused on mineral resources, but it has also looked at forests as national income accounts. The analysis was released in May, 1994.

The analysis was controversial to the point that Congress eliminated funding for the work pending the results of a study currently underway by the National Academy of Sciences. This study will focus on analytical methods.

There is increasing interest in including the environment in national income accounts. To do this in a meaningful way, significant advances will be required in the underlying environmental and economic data. If the United States is to embrace methodologies for green national accounting, it will be done by the Bureau of Economic Analysis. Available information indicates that any move in this direction will be controversial and problematic. We cannot determine the outcome of the study by the National Academy of Sciences and government reaction to it.

INDICATOR 65: Capacity to develop new technologies and to assess the socioeconomic consequences associated with the introduction of new technologies.

The more powerful are our knowledge tools, the more effectively we can apply them to the management of forests on a sustainable basis.

Technologies have evolved over time in all aspects of timber products production and use. New harvesting equipment and logging practices, new processing technologies, and new products and their application are constantly changing the ways that wood fiber is produced and consumed in the United States. In the past decade, engineered wood products have enabled the replacement of large softwood trees with smaller trees of less commercially desirable species in the production of products. Over time, there has been a pattern of substitution of new wood-based products for existing wood-based products.

The origins of new technologies include academia, Federal agencies and the timber products industries. Some innovative technologies have been imported, especially from Scandinavia.

Research aimed at assessing the socioeconomic consequences of new technologies in forestry has been carried out on a small scale for a number of years, both in forestry departments in several universities and in USDA Forest Service Research. Currently, the only Forest Service program conducting research related to this area is the Timber Demand and Technology Assessment Research Work Unit. This unit conducts both case studies of individual technologies and assessments of the impacts of technologies at an aggregate level. In addition to evaluating the economic (efficiency and demand) impacts of wood products and paper technologies, this unit is also evaluating impacts on supply, employment, trade, carbon cycling, and to some degree air and water emissions. Seven scientist-years plus professional and technical support are currently devoted to this research effort, which was initiated in the early 1970s.

Several economists in forestry schools around the country also have expertise in analyzing the economic consequences of new technologies. These university scientists depend mainly on funding from the Forest Service to conduct research in this area, which has significantly declined in recent years. Limitations of past research on the impacts of new technologies in forestry are that wood products technologies have been the main focus, with very little attention given to forest management technologies, outdoor recreation technologies, etc., and that the focus has been on economic efficiency impacts rather than impacts on social and ecosystem sustainability.

Funding and the number of scientist-years devoted to research on assessing the socioeconomic consequences of new technologies in forestry has declined significantly since the late 1980s and early 1990s.

INDICATOR 66: Capacity to enhance the ability to predict impacts of human intervention on forests.

It is increasingly recognized that the main driving force behind all of today's critical natural resource and environmental issues (e.g., sustainable development, global environmental change, loss of biodiversity, ecosystem health, etc.) is the impacts of human intervention. Research on the impacts of human intervention on forests is an extremely broad area, cutting across many lines of research. Research areas that relate include global environmental change, loss of biodiversity, acid deposition, loss of wetlands, loss and alteration of wildlife habitat, exotic species introduced by humans, toxic contaminants and other types of pollution, land-use and management practices, and all other research dealing with the impacts of anthropogenic disturbances. Research on these and related topics includes everything from social science research (e.g., research on the economic impacts of alternative silvicultural systems) to research in the biological and physical sciences.

There is a significant, crosscutting research effort in place to predict impacts of human intervention on forests. Research capacity is spread out across many organizations, including Federal and state governments, university forestry departments, and many other university departments, ranging from sociology to ecology. Funding comes from full range of research funding sources, from state governments to the National Science Foundation and private foundations.

Assessing research capacity related to the impacts of human intervention on forests is greatly complicated by the large number and diversity of research areas, organizations, and funding sources that are involved. For example, research on the impacts of human intervention is not identified as a separate category of research in the recently updated Current Research Information System, or CRIS. Consequently, the annual Inventory of Agricultural Research, based on the CRIS classifications, is of little help in assessing funding or scientist years devoted to this area of research. Research on the impacts of human intervention is not identified as a separate budget line item in USDA Forest Service Research, but is carried out in many Forest Service Research Work Units.

Trends related to the capacity for research on the impacts of human intervention on forests are difficult to assess, because the funding history -- except for individual programs such as global environmental change -- is essentially not retrievable.

INDICATOR 67: Capacity to predict impacts on forests of possible climate change.

A greater the ability to predict impacts provides the capability to take mitigating actions earlier, thus improving the likelihood that forests will be managed on a sustainable basis. Capacity to conduct and apply research and development to the problem of predicting climate change effects involves the development of a good understanding of the impacts of climate change on forests and their disturbances such as pests and fire, the ability to quantify those effects on forest productivity and changes in stand structure, and the ability to integrate these effects across the atmospheric, ecological, and economic systems.

One of the deficits at the global scale, recognized by the IPCC Working Group 2 report, is the need for uniform reporting and assembly of national forest inventory data sets. Within the United States, our capability far exceeds that of many countries in our ability to inventory private forest lands, and to a lesser degree, publicly managed forest lands. This capacity enables the development of forest sector models to quantify the production, removal and consumption of forest products within the United States.

The United States has had a global change research Program since 1990. Participating agencies include the Environmental Protection Agency, Department of Energy, NOAA, and the USDA Forest Service. Research in the USDA Forest Service relates to the potential effects of climate

change on forests and their management. As our knowledge base grows, so will our ability to predict impacts on forests of possible climate change.

Forest production studies have been enhanced by ecological research examining the nature of forest ecosystem processes as affected by climate and nutrient cycling. This increased understanding has facilitated the development of models to quantify the impacts of climate change on forest productivity. We now have the capability to interpolate large scale climate scenarios and examine the potential impacts on forest production with these ecological models. This understanding is limited, however, particularly in the area of empirical data demonstrating the direct effects of atmospheric carbon dioxide on tree growth and the long-term effects on ecosystem productivity.

Recent work has linked the atmospheric, the ecological and the economic systems in assessing the impacts on forest of climate change. This work has suggested the importance of incorporating the feedbacks between the ecological and the economic systems in any examination of climate change effects on forestry. Our current ability to predict the impacts on forests of possible climate change rests on our current understanding and tentative assumptions within each of these systems. Within atmospheric sciences, the global circulation models resolve the climate at large spatial scales only, and there is the need to predict the potential changes at finer geographic scales.

Our ecological understanding is limited in the area of quantifying the transient (lagged) responses of forests to rapid climate change, understanding the ability of species to migrate with climate or adapt in place, and the nature of the feedbacks between land use change (land clearing or harvest) and local climate.

Potential species shifts and changes in productivity imply potential shifts in forest product use and depend on new technology. The nature of change within the infrastructure of the forest sector, particular at time scales of 50 years, the period over which climate changes are being analyzed, is an area of little understanding. Improving forest management and the delivery of forest goods and services will depend on future research and development in these areas.

iii. SUMMARY FOR THE CRITERION

The legal, institutional and economic framework for forest conservation and sustainable management in the U.S. has been measured by twenty indicators of legal, institutional and economic framework, monitoring and measuring capacities and research and development support. The following highlights reflect the significant trends and indications of this criterion in relation to the sustainability of U.S. forests.

Highlights

- Although the United States has one of the most highly developed property rights systems, the number of federal, state, and local policies and regulations that affect the actions of property holders concerning forests and other natural resources has rapidly multiplied in the postwar era.
- Tenure and legal use arrangements that support the long-term conservation and preservation of critical habitats are diversifying in response to environmental and ecological concerns, variations in financial and market conditions, inheritance and other transfer patterns, and alternative possessory titling systems.
- Institutional ownership of commercial timberlands is expanding because of regulatory changes, concurrently with forest industry reexamination of the benefits of totally integrated raw material and production facilities.
- Beginning with the Alaska Native Claims Settlement Act in 1971, the trend in management of Native American forest land has moved steadily toward tribal autonomy and tribal determination of forest management practices.
- All federal land management agencies have proceeded according to some general strategy since their earliest dates. Now, however, federal law mandates and governs federal land use planning. Formal planning is now more extensive, procedurally and substantively. Managers have less discretion in deciding whether and how to plan.
- The National Environmental Policy Act of 1969 (NEPA), the Forest Rangeland Renewable Resources Planning Act of 1974 (RPA), the Federal Land Policy and Management Act of 1976, and the National Forest Management Act of 1976 (NFMA) are the principle laws mandating public participation in forest management.
- The legal, administrative, and voluntary programs that prescribe, measure, and monitor forest practice codes and best management practices in the United States have expanded rapidly in the last few years. Modern BMPs were developed as the principal implementing mechanism to protect water quality from nonpoint source pollution. The use of BMPs has expanded to include a variety of water quality protection measures and broader forest management, regeneration, and environmental protection measures.
- Alternatives to outright regulation of forest practices are becoming more popular, including nonregulatory or voluntary BMP programs, cost-share payments, preferential property or income tax treatment, technical assistance and extension education programs, environmental education and urban forestry programs, and conservation easements.

- Federal statutes demonstrate concern for management of forests for a wide range of special environmental, cultural, social, and/or scientific values on Federal lands.
- Cooperative Extension serves 9.9 million people who own 393 million acres of forest by providing landowners with forest-related information and educational programs. In the west, 610,000 people own 46 million acres, whereas, in the south and north, 3.9 million owners with 173 million acres and 3.3 million owners with 114 million acres exist, respectively.
- Several trends affect landowners' need for and ability to obtain continuing education on forestry: increased fragmentation of forest landowners, regulations which focus on compliance rather than the ultimate goal of sustainable forest management, and inadequate funding, personnel, and technical training in federal, state, and local educators.
- The Environmental Education Act of 1990 created the office of Environmental Education to administer the grant program for environmental education and national teacher training and programming activities.
- The quality and quantity of state environmental education varies by state and is dependent on the political climate.
- An institutional framework supporting the development and maintenance of human resource skills in forestry has been in place for many decades and is relatively well developed. Trends in the combined national enrollment for forestry, natural resource and agriculture degrees showed a 27 percent increase between 1991 and 1995.
- Evaluations of investment and taxation policies and the regulatory indicate the extremes of no regulation to full regulation. Direct regulation of private land is done only by state and local jurisdictions. An important part of the relevant economic framework is the provision of secure property rights which allow for investment in natural resources and intertemporal efficiency.
- Over the past several decades, the U.S. timber processing industries have supported open trade in manufactured products, reflected in the U.S. government's positions in GATT negotiations. U.S. tariffs on imports of logs, lumber, plywood, and pulp and paper products are at or near zero. The terms of the U.S.-Canadian Free Trade Agreement and later, the North American Free Trade Agreement, are further evidence for U.S. support of non-discriminatory free trade policies.
- Restrictions to trade usually reflect protection of domestic timber supplies from diseases and pests, and other conditions which are potentially divesting in an economic sense.

- The United States has maintained inventory, assessment, and monitoring capabilities for years at the Federal level. The need for additional and more timely information is reflected in current research activities. There is great variability within the United States in terms of the capability to measure, monitor, and report on indicators.
- Research on forest ecosystem characteristics, functions and processes has been carried out in universities, Forest Service Research, and other federal agencies for many years.
- There is increasing interest in including the environment in national income accounts. To do this in a meaningful way, significant advances will be required in the underlying environmental and economic data.
- Funding and the number of scientist-years devoted to research on assessing the socioeconomic consequences of new technologies in forestry has declined significantly since the late 1980s and early 1990s, even while we voice commitments to integrate the human dimension in ecosystem planning and management.
- Research capacity related to the impacts of human intervention on natural resources and the environment is spread out across many organizations. Funding comes from full range of research funding sources, from state governments to the National Science Foundation and private foundations.

Gaps

We cannot determine the extent of and outcome of litigation involving the various planning regimes discussed above. We are also unable to measure the quality or quantity of planning.

What is currently not known may be summarized as follows: 1) the role of public participation in the sustainable management of non-federal (i.e., state and private) forest lands, 2) the most appropriate methods for resolving disputes between opposing parties, and 3) the specific goals of sustainable forestry which will be incorporated into the public involvement process. With regard to the latter point, the appropriate public participants have not yet been identified, the relevant land management agencies have not been identified, nor the means by which to incorporate public involvement into the land management process.

The number of laws, area and number of places to provide for management of forests to conserve special environmental, cultural, social and/or scientific values do not address the quality of places nor the quality of their management.

Data on management practices and best management practice codes on individual forest tracts or small forest areas is lacking. We will have more difficulty in assessing other forest outputs or conditions.

Essentially quantifying or even qualifying the extent to which behavior can be changed through these activities is time consuming and may not be altogether accurate.

The current data cannot tell us whether the accredited curricula are relevant to the task of sustainable forest management. The quality of the education is assumed to be high, but no mechanisms exist to measure it beyond periodic review by the SAF and Southeastern Wildlife Society. Also unknown is the quality of the students currently enrolled in forestry and other disciplines. Despite the emphasis on interdisciplinary education, the numbers of baccalaureate and graduate students focusing their studies in economics, computers, policy, public administration, decision analysis, dispute resolution, and other social science specialties are not readily available.

Missing from all sources is information about the education offered at small, non-accredited schools, trade schools, and schools not surveyed by FAEIS. Also absent is information about the scope of the programs and content of courses offered at all institutions and in all disciplines. Social science skills such as dispute resolution, economics, computer science, policy, communication, etc. will be essential to implementing sustainable forest management. Determining the depth of skill development across the relevant disciplines will be difficult.

The data cannot tell us the scope, quality, and rigor of the continuing education and training programs, nor their ability to facilitate implementation of sustainable forest management. Also unknown is the level of attendance for the various continuing education programs, which offerings generate the highest attendance rates, and in what areas woods workers and professionals are not getting adequate training and exposure.

Expenditure data on existing physical infrastructures are not reliable indicators of the state of the physical infrastructure. It is conceivable that efficient physical infrastructure can be provided with no expenditures, or conversely efficient infrastructure is not provided despite substantial expenditures. More direct measurement of the infrastructure is preferable. Ideally some indication of the quality of the infrastructure would be available too.

There is a lack of information detailing cost-benefit ratios to measure the degree to which the increased cost of doing business under regulations balances with the social gains derived from what the regulations exist to protect. It is apparent that most regulations increase forest management costs, but the extent at which regulations become an insurmountable obstacle to forest practices, or cause backlashes or other perverse effects, is obscure.

The amount of regulation does not address the flow of capital in and out of the forest sector. Although regulations may produce a variety of benefits, they can be a negative factor in timber supply.

Little information is available on timber growth, mortality and inventory for the roughly one-third of the forest land that is not classified as timberland. Especially for criteria 3 and 4, we have little consistent information for the various indicators, especially on private lands. We have little information on indicators associated with non-wood goods and services.

The United States has made significant investments in development of scientific understanding of forest ecosystem characteristics and functions. However, comprehensive information on trends in funding and the quality of the results is not available at this time.

If the United States is to embrace methodologies for green national accounting, it will be done by BEA. Available information indicates that any move in this direction will be controversial and problematic.

Within the United States, there is a small and declining effort for developing the capacity to assess the socioeconomic consequences associated with the introduction of new technologies. We cannot determine the quality of the existing work nor the need for additional work. However, there is a significant, crosscutting research effort in place to predict impacts of human intervention on forests.

The United States has an active climate change research program with the capability to predict impacts on forests of possible climate change. The accuracy of the models cannot be validated.

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