Idaho Forest, Wildlife and Range Policy Analysis Group

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Toward Sustainable Forest Management:

Part II—The Role and Effects of Timber Harvesting in Idaho

by

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About the Policy Analysis Group (PAG)

Role and Mission. The Idaho Legislature created the Policy Analysis Group (or "PAG") in 1989 as a way for the University of Idaho to respond quickly to requests for information and analysis about current natural resource issues. The PAG's formal mission is to provide timely, scientific and objective data and analysis, and analytical and information services, on resource and land use questions of general interest to the people of Idaho.

PAG Reports. This is the nineteenth report of the Policy Analysis Group (see inside cover). The PAG is required by law to report the findings of all its work, whether tentative or conclusive, and make them freely available. PAG reports are primarily policy education documents, as one would expect from a state university program funded by legislative appropriation. The PAG identifies and analyzes scientific and institutional problems associated with natural resource policy issues. In keeping with the PAG's mandate, several alternative policy options are developed and their potential benefits and detrimental effects are analyzed. As an operational policy the PAG does not recommend an alternative.

Advisory Committee. A standing Advisory Committee (see inside cover) has specific functions assigned by the PAG's enabling legislation. The committee's main charge is to review current issues and suggest topics for analysis. Based on those suggestions, the dean of the College of Natural Resources works closely with the PAG director to design analysis projects. The Advisory Committee has a responsibility to suggest the appropriate focus of the analysis. This is done iteratively, until an outline for the project is mutually agreed upon by the committee and the PAG. The outline is usually organized as a series of focus questions, and the PAG's analytical tasks are to develop replies to the questions. The PAG uses the resources of the university and other public and private organizations as needed. When the PAG becomes active on a project, the committee receives periodic oral progress reports. This process defines the scope of PAG report content and provides freedom for the PAG to conduct unbiased analysis.

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ABSTRACT

"Sustainability" has, in the last decade, become an increasingly popular term in discussions about environmental and resource management. The scientific literature and popular debates are filled with discussions about what sustainability is, what activities might be sustainable, and how particular resources can be managed sustainably.

Sustainable forest management is one goal of a growing list of human activities that impact the environment. This report places timber harvesting in Idaho in that context. As in other Policy Analysis Group reports, each chapter addresses a different focus question that helps guide the analysis.

1. What is sustainable forest management? Chapter 1 provides a framework for understanding sustainable forest management and a foundation for interpreting the information in the remainder of the report. Sustainable forest management is ecologically sound, economically viable, and socially desirable.

2. How important is the timber harvesting issue in Idaho? One of the main points of Chapter 1 is that evaluation of the sustainability of forest management depends on human values. Chapter 2 looks at the values associated with forests in Idaho from both social and economic perspectives. Timber is one of many forest values.

3. What is the timber situation in Idaho's forests? To get a handle on the sustainability of timber harvesting, information about the state or condition of resources is needed. Chapter 3 provides some basic statistics about Idaho's timberlands. Unfortunately, more timely and accurate estimates of timber inventories and conditions in Idaho are lacking. Nevertheless, some conclusions about forest conditions in Idaho can be drawn from existing timber resource data.

4. What policies affect timber harvesting in Idaho? Each owner of forest land operates under a different set of policies, although they have many elements in common. These policies determine what activities different owners undertake. Chapter 4 examines laws, rules, regulations, and management objectives of both public and private forest landowners.

5. What are the effects of timber harvesting on other resources? Forests are complex systems, and management actions aimed at one element of the system have repercussions for other elements. In Chapter 5, we examine some of the linkages between elements by looking at timber harvesting's potential effects on other forest resources. Timber harvesting's effects are highly variable depending on where and how it is done and what is being measured. We look at timber, water, wildlife, and scenery and what is known about how these four forest resources are impacted by timber harvesting. We do not try to determine what levels of impacts should be considered sustainable.

6. Alternative Approaches to Watershed Analysis. Analysis of ecosystems at the watershed scale, or "watershed analysis," is one tool for attempting to assure that forest management activities are sustainable. Chapter 6 analyzes the federal and two state (Idaho and Washington) approaches to watershed analysis, and we look at a process developed for private lands that extends the usefulness of watershed analysis.

7. Conclusions. Is timber harvesting in Idaho's forests sustainable? Sustainable forest management depends on three dimensions—ecological soundness, economic viability, and social desirability. The reply to the question is "yes" for some of Idaho's forests, "no" for others, and "we don't know" for others. Many dynamic factors affect judgments of sustainable forest management. Timber harvesting may be either "more" or "less" sustainable in a particular forest than it would be somewhere else at a particular time. Sustainable forest management can be a goal, and progress toward the goal can be measured.

This report provides information to Idaho citizens and policymakers so that they can develop informed opinions and make prudent decisions about forest management. Conflicting values within our state, the nation, and the world, plus a high degree of uncertainty, make decisions difficult. The best way to know for sure that forest are managed sustainably is to manage a particular way for two hundred years and see what happens. Even then it would not be possible to know what might happen in the third century.

Nothing in this report is intended to be prescriptive. We are not trying to tell people what to do. We describe what is, and what may be, possible. Questions about the sustainability of forest management do not have technical answers. Nevertheless, we hope the technical information in this report will enhance peoples' understanding of forest management issues, especially timber harvesting. The balancing of social values through democratic processes determines what should and does happen in our forests.

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EXECUTIVE SUMMARY

Peoples' interests and concerns about the condition and management of Idaho's forests are expressed in many ways, including the following questions:

- How well are Idaho's forests being managed?
- Is Idaho's timber harvest level sustainable?
- Are Idaho's forests being overcut?
- Can Idaho's forests produce more?
- What kind of place will Idaho's forests be for our children's children?

People want some assurance that the benefits they receive from the forest will continue to be available to them and to future generations. Although Idaho has a strong tradition of natural beauty and wildness, the extraction of marketable wood products from Idaho's forests is also part of the state's history. People want Idaho's forests managed ***sustainably,*** but what does "sustainably" mean? And how do we know if we are managing forests sustainably? Neither question has an easy answer.

Sustainability, by some definitions, has been a part of modern forest management from its beginnings. In North America, modern forestry evolved because of concerns about "timber famine" and the "unsustainability" of timber harvesting practices of the 1800s. However, like forestry, the concept of sustainability has evolved. Today, sustainability is about something much more than timber harvesting.

The purpose of this report is to examine timber harvesting in Idaho in the context of sustainable forest management. Timber harvesting is only one activity within the broad realm of natural resource management. It is impossible not to connect and relate timber harvesting to other forest management activities. People are not just concerned about timber; they are concerned about the forest. To understand timber harvesting in the context of sustainability, we provide a framework for discussion through a series of focus questions related to different forest resources. A summary of the reply to each focus question follows.

Chapter 1. What is sustainable forest management?

Sustainable forest management is

- ❖ **ecologically sound**,
- ❖ **economically viable**, and
- ❖ **socially desirable**.

Although there are dozens of definitions of sustainable forest management in the literature, we have adopted the concise, common definition above (from Aplet et al. 1993). This definition follows the broader idea of sustainability, a concept that is gaining visibility, acceptance, and use as a goal for societies, economies, governments, businesses, resource management activities, and a variety of other human organizations and undertakings. For example, sustainable development seeks to ensure that development meets "the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987).

The sustainability concept expresses human values, is built on concerns about equity for this and future generations, and requires that issues of spatial and temporal scales be addressed. Moving towards more sustainable actions will not be an easy task for many reasons, including:

- a lack of agreement on how to define and measure sustainability;
- conflicting societal values;
- differing beliefs about the substitutability of different types of capital—natural, human, human-created, and social;
- the dynamic nature of ecosystems, economies, and societies;
- the need for institutional change; and
- determining acceptable risk in the face of uncertainty.

Historically, forestry sought sustainability in the concept of sustained yield, especially in terms of timber. Sustained yield means that timber is harvested at no greater rate than it is growing. However, sustained yield of timber is too narrowly focused to serve as a proxy for sustainable forest management. Timber harvesting is a part of sustainable forest management for some forests, but it is not the only attribute or activity of importance. Sustainable forest management addresses the wider ecological, economic, and social functions of forests.

Chapter 2. How important is the timber harvesting issue in Idaho?

People value forests for many reasons, and the importance they attach to those values determines, in part, whether forest management is sustainable. We summarize research that identifies and quantifies a few forest values, including timber, that are socially and economically important to the people of Idaho.

Social Values

People's views about forest management and appropriate uses of forests vary widely. Some view forests as storehouses of timber existing primarily for human use—an anthropocentric perspective. Others place less emphasis on timber for human use and more emphasis on other forest ecosystem components—a bicentric perspective. Fundamental differences in perspectives on forests and their appropriate use conflict and drive forest management issues and debates.

Idahoans, like most Americans, express positive opinions about the environment. For example, when asked what the three most important factors concerning the future of public lands in the interior Columbia River basin (including Idaho) were, a sample of basin residents reported resources for future generations, ecological health, and the quality of the place they live as the most important. However, basin residents were more likely to report timber production, livestock grazing, and economic opportunity as their top choice than were members of a national sample (McCool et al. 1997). Several studies (e.g., Shindler et al. 1993, Brunson et al. 1994) also produced results showing that Idahoans tend to express more anthropocentric values about forests than does the U.S. public overall. Such differences contribute to the debate about national forest management in Idaho because national forests are public lands belonging to all the people of the U.S., but many of the consequences from their management are felt most heavily at the local level.

This does not mean that Idahoans do not care about forest values other than timber; other survey results show they do. For example, in 1997, the Idaho Forest Products Commission surveyed Idahoans about the importance of various uses of Idaho's public forests. A source of clean water was rated most important followed by fish and wildlife habitat, jobs, recreation, source of wood products, and monies for schools and roads (IFPC 1997). The survey results also indicate that Idahoans find timber harvesting to be an appropriate activity in Idaho's forests, and most residents think the timber industry is important (IFPC 1997).

The usefulness of public opinion as a force for changing public policies is subject to question (Yankelovich 1991). How forest values, or opinions about them, can be translated into sustainable forest management ends and means remains a void for which processes allowing the "public judgment" Yankelovich (1991) desires have yet to be designed.

Economic Values

Forests provide many things people value, including wood products, non-timber forest products, and a variety of recreation opportunities. The mixture of these forest outputs and how they affect economic growth and development are key policy considerations.

Wood products. The forest products industry is a substantial component of Idaho's economic structure, particularly in northern Idaho. In 1995, there were 149 primary forest products manufacturing facilities (i.e., lumber, plywood, and paper mills) operating in 29 of Idaho's 44 counties (Keegan et al. 1997). Total sales in the Idaho primary forest products industry were about $1.55 billion in 1995. Since 1954 lumber production in Idaho has ranged between 1.5 and 2.0 million board feet per year, except for three brief downturn periods. Idaho has consistently produced 5 to 6% of all softwood lumber produced in the U.S. (WWPA annual, 1963-1996).

In 1996, the forests product industry accounted for about 20,200 jobs in Idaho, or about 10% of all basic industry employment in Idaho (Keegan et al. 1997). Employment in the forest products industry in Idaho has varied over the last 25 years, with a peak at about 22,700 jobs in 1979 and lows of about 15,400 in 1970 and 16,000 in 1982. The types of jobs in Idaho's forest products industry have been changing. Primary wood processing has decreased while the conversion of lumber, plywood, and paper into other products through secondary manufacturing has increased (Keegan et al. 1997).

Non-Timber Products. People consume products from forests other than wood including non-timber forest "products" such as cones, boughs, wildflowers, herbs, berries, mosses, mushrooms, nuts, burls, bark, and other parts of the flora of the forest. Very little information exists on the value of non-timber forest product industries in Idaho, but it appears to be increasing (Schlosser et al. 1995).

Recreation. Recreation is another forest "product" that receives much attention. Determining the economic value of forest-based recreation is not an easy task. Unlike timber, which is sold in the market place and its value reflected by its price, much forest-based recreation, particularly on public lands, is provided without a direct cost to the consumer. Estimates of the economic value of recreation in Idaho generally range in the hundreds of millions of dollars, but vary considerably depending on how value is measured (e.g., see USFWS & USBOC 1993, Haynes and Horne 1997).

Growth and Development. In addition to questions about the value of various products from forests, broader questions exist about how these values fit into the overall economic and social structure of Idaho. Much of the discussion about sustainable management of Idaho's forests centers around sustaining Idaho's communities. For communities in Idaho where wood products manufacturing facilities are located, the policies of the U.S. Forest Service have been important because national forests comprise much of the land base and timber inventory near these communities. The PAG has underway at this writing another project for analyzing the role of natural resources in economic development.

Importance of Place

It is easy to talk in generalities about people valuing forests for timber, recreation, scenery, and other attributes, but often what people really value are specific forests or areas within forests, i.e., "places." Research on "place," "place attachment," and "sense of place" has expanded considerably in the last decade (e.g., see Galliano and Loeffler 1999). Idaho has many special places, and resource managers are now recognizing the impact and importance of place attachment in forest planning and management. Perhaps by better understanding what people value about particular forests we will improve our understanding of the social and economic realms of sustainable forest management.

Chapter 3. What is the timber situation in Idaho's forests?

One prerequisite for an analysis of the sustainability of forest management is an accurate and comprehensive inventory of the forest resources of concern. Because the focus of this report is timber harvesting, we focus on the timber resources of Idaho and have found that there are shortcomings in the timber inventory information. Three-quarters of the forested land in Idaho is managed by the U.S. Forest Service, and the inventory information currently available for many of Idaho's national forests is 10 years old or older. The lack of timely information and questions about accuracy have led some observers to question the usefulness of national forest inventory data (e.g., AFSEEE 1994, Jackson 1994). Although it has shortcomings, the Forest Inventory and Analysis (FIA) unit of the Forest Service provides the only statewide forest inventory data for all ownerships in Idaho (Brown and Chojnacky 1996). We use the FIA data here, but urge caution in their interpretation. Some key highlights follow.

Idaho Timber Statistics

The state of Idaho consists of 53.5 million acres of land. Approximately 22.3 million acres (42%) are classified as forest land—at least 10% stocked with trees. About 21.4 million acres of the forest land in Idaho are classified as timberland—forest land where tree species traditionally used for industrial wood products make up 10% of stocking (Brown and Chojnacky 1996). Almost 4 million acres of timberland (18%) are "reserved." This means withdrawn from tree utilization by statute or administrative designation, and almost all these lands are national forest areas in the National Wilderness Preservation System. Management for tree utilization is not prevented by law on the remaining 17.6 million acres of timberland (82%). The statistics that follow relate only to this non-reserved timberland.

More than 14 million acres (81%) of timberland in Idaho is in public ownership (Figure ES-1). Almost 13 million acres (73%) of timberland is in national forests, managed by the U.S. Forest Service. Other public entities, including the state of Idaho, own about 9% of the timberlands. Forest industry owns 7%, and other private entities, including American Indian tribes, own about 12%.

Although timberland acreage has remained relatively constant since 1952, the trends in growing stock volume and the tree species that comprise it reveal major changes in Idaho's forests. Overall, growing stock volume has increased by 35% since 1952, but species composition has changed. Species decreasing since 1952 are western white pine (−86%) and ponderosa pine (−35%). Species increasing are true firs (grand fir and subalpine fir, +112%), Douglas-fir (+64%), lodgepole pine (+45%) and various other species (+50%). Changes are the result of timber harvesting history, impacts of disease and insects, and fire management policies. High value species such as western white pine and ponderosa pine are sought after and harvesting has reduced the areas they once occupied. Outbreaks of white pine blister rust and mountain pine beetle have also reduced inventories of valuable pines. Wildfire control policies and programs have encouraged Douglas-fir and spruce-fir forests to expand, as the ecological role of fire has been precluded and suppressed.

Idaho's timberlands contain almost 40 billion cubic feet of timber growing stock volume, or wood. National forests contain 76% of this volume; forest

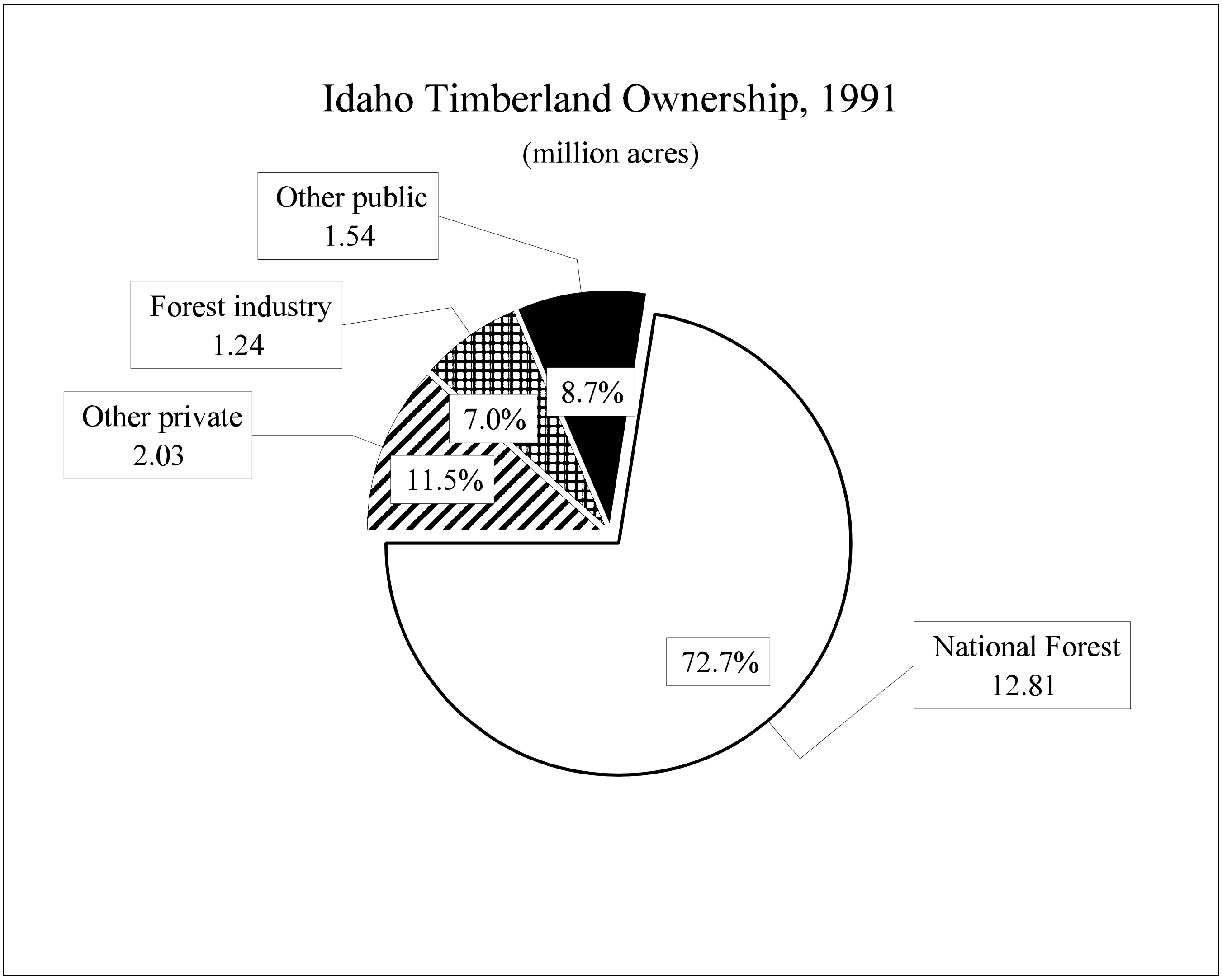

Figure ES-1. Idaho timberland area by ownership, 1991.

Source: Brown and Chojnacky (1996).

industry has about 6%; and other public and other private owners have about 9% each (Figure ES-2). Almost one-third of the wood volume is Douglas-fir (Table ES-1). Grand fir and lodgepole pine each make up 14% of the volume. Subalpine fir, ponderosa pine, Engelmann spruce, and western redcedar each make up between 5% and 10% of the volume. No other species makes up more than 5% of the timber growing stock volume. All of these species are softwoods. Hardwoods such as aspen and cottonwood are 2% of the timber inventory (Table ES-1).

In 1996, the most recent compilation of statewide inventory (USFS 1999*a*), Idaho forests classified as timberlands added an annual increment of approximately 1.1 billion cubic feet to the timber inventory growing stock volume. From this gross annual growth, mortality factors reduced the actual increment by 288 million cubic feet to a net growth of 806 million cubic feet. The annual timber harvest at that time was 252 million cubic feet. In sum, Idaho forests added approximately 554 million cubic feet of timber to the inventory in 1996 after timber harvests and morality from insects, diseases, and wildfire were accounted for. One conventional definition for a sustainable yield of timber is that net annual growth of timber must at least equal harvest. That was the situation in 1996 when the ratio of net growth to removals was 3.2:1. Timber harvests have declined since then.

Although there are problems with the reliability of timber growth data trends, we present what can be gleaned from FIA reports from 1952 to 1996. In

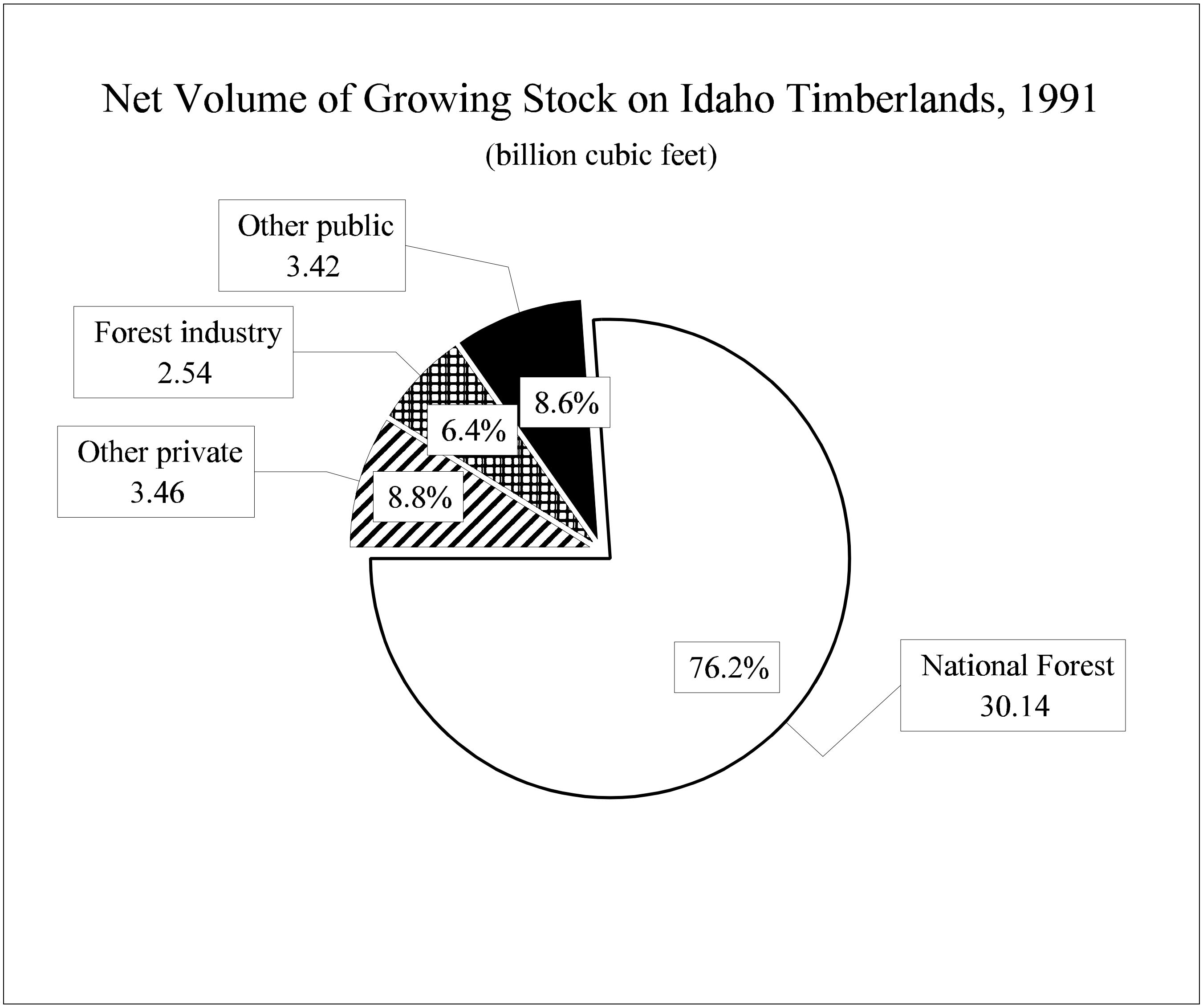

Figure ES-2. Net volume of growing stock on Idaho timberland by ownership, 1991.

Source: Brown and Chojnacky (1996).

each inventory period, the net growth to removals ratio exceeded one, meaning the traditional but simplistic sustained yield criterion was met (Figure ES-3).

Softwood sawtimber is a subcategory of timber growing stock volume. Sawtimber is commonly measured in board feet. Softwood sawtimber harvest levels fell from a peak of 1.85 billion board feet in 1979 to 1.31 billion in 1999 (Keegan et al. 2000). There also has been a shift in the contribution of each ownership group to the timber harvest volume. Between 1979 and 1990, national forests accounted for between 40 and 47% of Idaho's annual softwood timber harvest volume. In 1999, this share decreased to 11%. Each of the other three ownership groups have increased their share of harvest, but overall the harvest level declined 23% between 1990 and 1999.

A survey sponsored by the PAG revealed that Idaho's 1996 sawtimber harvest was 1.56 billion board feet (Wagner et al.1997). Assuming that 1996 net annual growth was the same as in 1990—a questionable assumption due to changing conditions in Idaho's forests—the 1996 timber harvest level was 1.9 billion board feet less than net annual growth. In other words, timber harvest was 45% of net annual growth. This varied by ownership. On national forests the 1996 harvest was 14.6% of net annual growth. On other public lands 62% of net annual growth was harvested. On forest industry lands timber harvest exceeded growth by 82%, which is in

Table ES-1. Net volume of growing stock on Idaho timberland by species, 1991.

Species	Growing stock volume	
	million cu.ft.	%
Douglas-fir	12,406.8	31.4
Grand fir	5,749.1	14.5
Lodgepole pine	5,529.1	14.0
Subalpine fir	3,727.2	9.4
Ponderosa pine	2,734.0	6.9
Englemann spruce	2,487.8	6.3
Western redcedar	2,273.4	5.7
Western larch	1,476.4	3.7
Western hemlock	895.0	2.3
Mountain hemlock	757.8	1.9
Western white pine	436.8	1.1
Other pines	284.8	0.7
Aspen	509.7	1.3
Cottonwood	292.5	0.7
Total	39,560.4	100.0

Source: Brown and Chojnacky (1996).

part of reflection of 27% of its stands being in the seedling and sapling stand-size class. On other private lands harvest exceeded net annual growth by 7%. In 1996, the level of harvests on private lands, did not meet the traditional sustained yield criterion.

In 1999, timber harvested from Idaho national forests fell to 111 million board feet, the lowest level since the 1940s. In the last decade, Idaho's overall timber harvest declined by about 30%, due almost entirely to an 85% reduction on national forests, from 746 million board feet in 1989 to current levels.

Sustaining Healthy Forests

Forest health is a multidisciplinary concept that integrates a variety of resource management concerns and relates them to something familiar to people—human health. Like sustainability, forest health is a value-based concept (SAF 1997) and explicitly includes social considerations as to what people want from forests (Atkins et al. 1999). The Society of American Foresters concluded that forest health is "an informal and technically inexact term" (SAF 1997:8), yet forest health has become a common metaphor in the forestry literature.

Assessment of forest health requires an understanding of both the condition of the forest and forest management objectives (Jenkins 1997, SAF 1997). In the past, forest condition assessment has focused on trees, particularly timber species. Some researchers have been critical of this focus (e.g., Schowalter 1994, DellaSala et al. 1995, Kolb et al. 1995), and scientists are beginning to develop a broader set of indicators to measure forest condition (see Atkins et al. 1999, USFS 2000*b*).

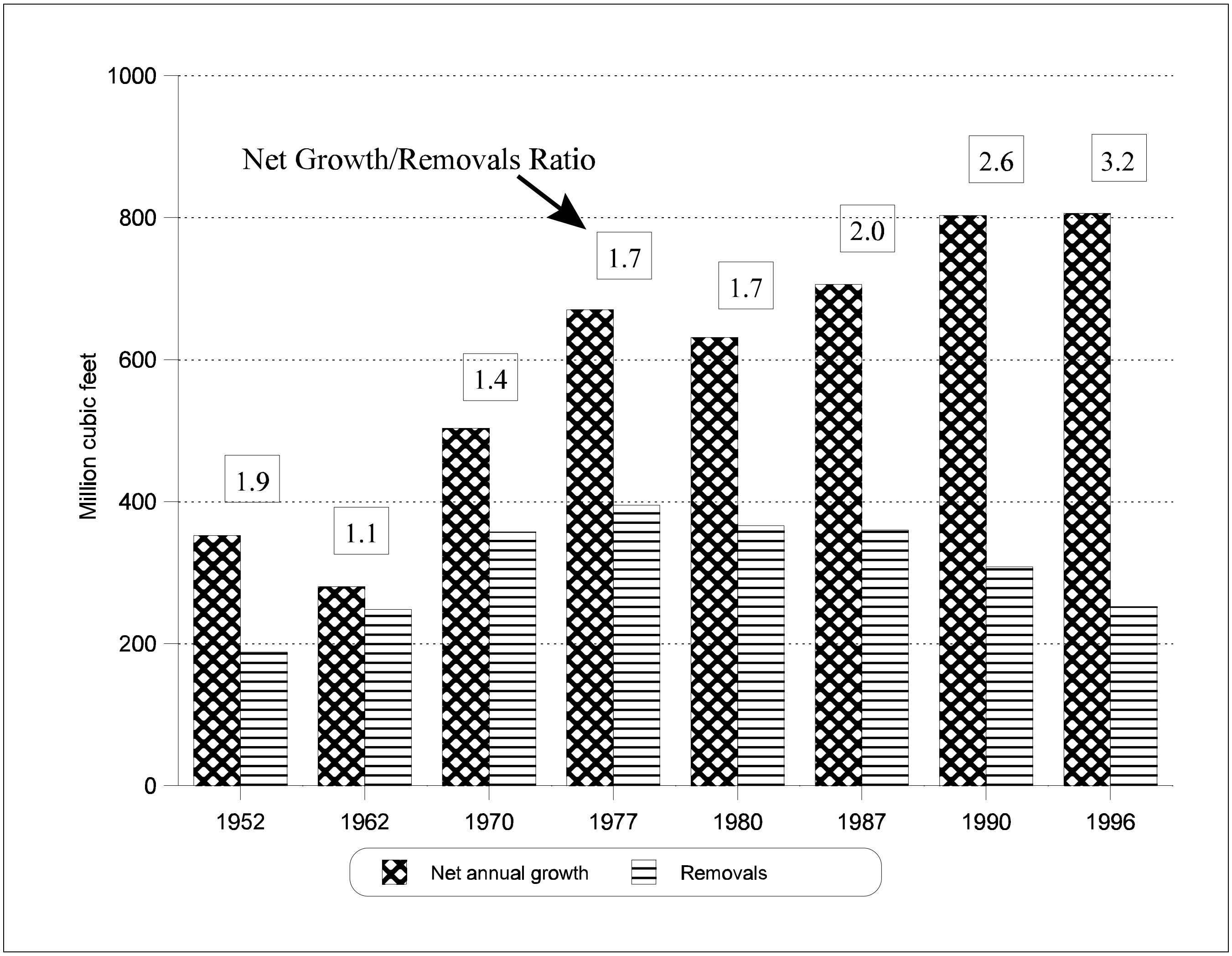

Figure ES-3. Idaho trends in net annual growth and removals, with growth/removals ratio, 1952-1996.

Sources: USFS (1958), USFS (1965), USFS (1973*a*), USFS (1982), Benson et al. (1987), Waddell (1992), Brown and Chojnacky (1996), Smith (1999).

One of the indicators of forest condition that has been measured for several decades, and will continue to be measured in more extensive sets of indicators, is the relationship between forest growth and mortality. According to Brown and Chojnacky (1996), annual mortality as a percent of gross annual growth for different ownerships in 1990 were: national forests (29%), other public owners (26%), forest industry (18%), and other private owners (19%). The mortality rate on national forests as a whole was 37% higher than on other ownerships combined.

Fire suppression and timber harvesting practices over the last 50 years have changed forest composition and density, and thus affected mortality rates. Firs, which are more susceptible than pines to many insects, diseases, and fires, have become more prevalent in the forests than pines (see O'Laughlin et al. 1993). Average timber volume per acre, based on statewide totals, has increased 22% since 1952 (Brown and Chojnacky 1996). Based on the condition of Idaho's forests using available data and the criterion of tree growth efficiency, expressed as the relationship of forest growth and mortality, some forests in Idaho appear to be healthier than others. Health problems exist throughout the state, with more problems on national forests than on other ownerships. Why is the mortality rate higher on national forests? The answer lies, partially, in differences in management objectives that result in different stand densities. National forests are managed for multiple uses. State forests, private industry forests, and some other private forests tend to have timber production as their main management objective. Stand densities are more likely to be closely monitored and controlled when timber production is a primary objective.

A fundamental problem with the forest health concept today is a lack of agreement on an appropriate "cure" to improve forest conditions. Many researchers believe that active management is the preferred health management strategy (e.g., O'Laughlin et al. 1993; Quigley et al. 1996, 1998), but other researchers disagree (e.g., DellaSala et al. 1995, Peters et al. 1996). A critical issue for resolving forest health issues is determining what the management objectives of particular forests are, particularly our national forests. Present concerns over forest health reflect a failure to define management objectives that are acceptable to society (Kolb et al. 1995). Balancing social values depends on the political process, not science.

Chapter 4. What policies affect timber harvesting in Idaho?

Policies are purposive courses of action or inaction that governments, businesses, groups, or individuals take to deal with particular situations or problems. Government policies are usually expressed through laws and regulations, but private companies, groups, and individuals also have policies expressed through management objectives, rules, and modes of operation. It is not possible to analyze all the policies that affect timber harvesting in Idaho because there would be almost as many policies as there are owners of timberland. Instead, we describe and analyze the most important and influential policies that affect the major categories or groups of forest landowners in Idaho.

Environmental Laws

Environmental laws are designed primarily to minimize the adverse affects of human actions on human health and the human environment. There are several federal environmental policies that passed into law within the last 25 or 30 years that affect forest management and timber harvesting.

National Environmental Policy Act. The National Environmental Policy Act of 1969 (NEPA) was enacted to insure that federal agencies consider the potential environmental consequences before deciding to proceed with a proposal, and it serves as an environmental full disclosure law. The environmental impact statement (EIS) is probably the most well-known provision of NEPA. Whenever a major federal action significantly affecting the quality of the human environment is proposed, an environmental assessment must be undertaken.

NEPA supports the concepts of sustainability by recognizing the interrelationship of the environment, social, and economic dimensions. Its goal is for the federal government to "fulfill the responsibilities of each generation as trustee of the environment for succeeding generations."

Clean Air Act. The federal Clean Air Act, first passed in 1963 but amended numerous times since, is the primary legal instrument for air resource management. Particulate matter, ozone, and carbon monoxide are the three primary criteria pollutants associated with forest management. Fire is the main activity that affects these criteria pollutants. Maintaining air quality standards under the Clean Air Act has not been a major consideration in policies concerning Idaho forest management and timber harvest. However, that may change if silvicultural prescriptions with more prescribed burning are implemented.

Clean Water Act. The Federal Water Pollution Control Act of 1972 and its subsequent amendments are commonly known as the Clean Water Act. The act established a national objective "to restore and maintain the chemical, physical, and biological integrity of the nation's waters." The act was amended in 1987 to focus more attention on nonpoint sources of pollution as well as point sources because a large portion of the nation's rivers, lakes, and streams have been affected by nonpoint pollution sources from a considerable range of activities including, but not limited to, agriculture, grazing, recreation, mining, and forestry. The Clean Water Act gives states the primary responsibility for achieving the act's goals for nonpoint source pollution (see O'Laughlin 1996*b*).

Idaho Forest Practices Act. Idaho implements the Clean Water Act for forestry activities through the Idaho Forest Practices Act, first passed in 1974. This law applies to federal, state, and private forest land. The act recognizes that "federal, state, and private forest lands make a vital contribution to Idaho by providing jobs, products, tax base, and other social and economic benefits, by helping to maintain forest tree species, soil, air and water resources, and by providing a habitat for wildlife and aquatic life." The act also says that "it is the public policy of the state to encourage forest practices on these lands that maintain and enhance those benefits and resources for the people of the state of Idaho." Forest practices include the harvesting of trees, road construction associated with harvesting, reforestation, the use of chemicals and fertilizers in forest management, the management of slashings, and the salvage of dead or dying timber that is threatened by insects, disease, windthrow, fire, or extremes of weather.

The Idaho Department of Lands (IDL) is responsible for administering the Idaho Forest Practices Act on state and private lands. A landowner, timber owner, or operator must notify the IDL before undertaking a forest practice. In order to meet the requirements of the federal Clean Water Act, Idaho law requires best management practices (BMPs) to protect water quality during timber harvesting and other forestry operations.

National Forest Land-Use Policies

Almost 39% of the land area and 73% of the timberland of Idaho is in the National Forest System managed by the U.S. Forest Service. Therefore, laws and other policies that apply to national forests are of particular importance in Idaho.

Organic Act. The Organic Administration Act of 1897 set out the purposes for which national forests were established, which were “to improve and protect the forest within the boundaries, or for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States.”

Multiple-Use Sustained-Yield Act. In 1960, the Multiple-Use Sustained-Yield Act codified the policy that “national forests are established and shall be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes.” Multiple use is defined as “ the management of all of the various renewable surface resources of the national forests so that they are utilized in the combination that will best meet the needs of the American people.” Sustained yield is defined as “the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the national forests without impairment of the productivity of the land.” The Multiple-Use Sustained-Yield Act includes many concepts embodied in sustainability.

Forest and Rangeland Renewable Resources Planning Act. The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) requires the Forest Service periodically to prepare three planning documents: [1] every ten years an assessment describing the renewable resources of all the nation’s forest and range lands; [2] every five years a program proposing long-range objectives, with a planning horizon of at least forty-five years, for all Forest Service activities; and [3] an annual report evaluating Forest Service activities in comparison with the objectives proposed in the program.

National Forest Management Act. The National Forest Management Act of 1976 (NFMA) amends RPA by requiring land and resource management planning for units within the National Forest System and additional regulation of timber harvesting on national forests. The major provisions of NFMA require [a] public participation in the planning process, [b] regulations for the preparation and revisions of the management plans, [c] resource management guidelines for controversial management activities such as clearcutting, and [d] economic analysis of management alternatives.

In developing forest plans under NFMA, the Forest Service must identify areas “which are not suited for timber production, considering physical, economic, and other pertinent factors to the extent feasible.” NFMA guidelines also say that forest plans should “provide for diversity of plant and animal communities based on the suitability and capability of the specific land area to meet overall multiple-use objectives” and “where appropriate, to the degree practicable for steps to be taken to preserve the diversity of tree species similar to that existing in the region.”

The NFMA and its guidelines represent an ecological approach to sustainability more than any other law (Noss 1993). New regulations for implementing the NFMA emphasize ecological sustainability above all else (65 *Federal Register* 67514 [November 9, 2000]), which seems to be a new management objective for national forests.

Road Management and Roadless Area Protection Policies. Idaho’s national forests contain about 14,000 miles of inventoried roads, most of which were built to access areas for timber harvest. In January 1998, the Forest Service announced that it planned to develop “an improved analysis process that assures that the ecological, social, and economic impacts of proposed construction and reconstruction of National Forest System roads are objectively evaluated” (63 *Federal Register* 4350 [January 28, 1998]). That analysis process was released in August 1999 (USFS 1999*b*), and administrative rules for implementing have been adopted (66 *Federal Register* 3205 [January 12, 2001]). The rule shifts the emphasis of road management from transportation development to managing environmentally sound access. The strategy includes new analytical decision tools, aggressive decommissioning of nonbeneficial roads, and maintenance and improvement of important roads. It is not clear exactly how this strategy will affect timber harvest levels on Idaho's national forests; however, it is clear that road building associated with timber harvesting will be more closely scrutinized.

In October 1999, President Clinton directed the U.S. Forest Service to develop regulations that would "provide appropriate long-term protection" for some 40-50 million acres of roadless areas nationwide. The management of more than nine million acres of roadless areas in Idaho's national forests have long been contentious (see MacCracken et al. 1993). The final environmental impact statement for roadless area conservation nationwide was released November 9, 2000 (USFS 2000*c*). A record of decision in January 2001 made it official.

The preferred alternative in the final environmental impact statement (Alternative 3) would prohibit road construction, reconstruction, and timber harvest except for stewardship purposes within inventoried roadless areas, while excepting road reconstruction needed for road safety improvements and federal highway aid projects (USFS 2000*c*). About 5.7 million of the 9.3 million acres (61%) of inventoried roadless areas in Idaho are currently allocated to management classifications that allow road construction and reconstruction.

The final environmental impact statement (USFS 2000*c*) estimates that timber harvests planned in inventoried roadless areas from FY 2000 to FY 2004 in Idaho's national forests are almost 159 million board feet. Of that total, about 72 million board feet (45%) are in areas that will require road construction or reconstruction, and are thus subject to being eliminated. Almost 84 million board feet of the planned sales can be harvested using helicopters or cable and ground-based systems that do not require road construction or reconstruction. More than 76 million board feet of those sales (91%) are for stewardship purposes (USFS 2000*c*).

Although the policies associated with road management, roadless areas, and timber harvesting on national forests are currently in flux, it appears the results will be reductions in the amount of land where timber management activities take place and in the amount of timber harvested from national forests in Idaho.

Laws Protecting Wilderness and Biodiversity

Congress has enacted several statutes in recognition that development of lands and resources to meet human purposes can diminish other values. Wilderness values and the values associated with biological diversity have been recognized as important social values by Congress.

Wilderness Act. The Wilderness Act of 1964 authorized Congress to create the National Wilderness Preservation System from lands already administered by federal agencies. The purpose of the act is to "secure for the American people of present and future generations the benefits of an enduring resource of wilderness...to be administered for the use and enjoyment of the American people in such a manner as will leave them unimpaired." Timber harvesting in wilderness areas is generally prohibited by the Wilderness Act and U.S. Forest Service regulations.

Wild and Scenic Rivers Act. In 1968, Congress passed the Wild and Scenic Rivers Act, thereby creating the National Wild and Scenic Rivers System. The purpose of the system is to preserve sections of free-flowing rivers and their immediate environments for scenic, recreational, fish and wildlife, and other similar values. Idaho has 574 miles of rivers designated within the system, including portions of the Clearwater, Salmon, Snake, Rapid, and St. Joe Rivers. All rivers in the system in Idaho are managed by the U.S. Forest Service.

The act protects not only the river course, but also a corridor of land on each side along it's length. Timber harvesting practices on federal lands located within the corridor must be designed to help achieve land management objectives consistent with the protection and enhancement of the values which caused the river to be added to the system. Under the act, the only way the federal government can restrict private timber harvesting is through the purchase of timber rights or under cooperative agreement (Interagency Wild and Scenic Rivers Coordinating Council 1999).

Endangered Species Act. The Endangered Species Act of 1973 (ESA) is a federal law that applies to all land ownerships, public or private. The ESA provides for the protection and recovery of plant and animal species that are identified as being threatened or endangered with extinction. Presently, 22 species on the endangered and threatened species list have been identified or "listed" in Idaho. In Idaho, the U.S. Fish and Wildlife Service (USFWS) is responsible for all the listed species, except salmon and steelhead which are the responsibility of the National Marine Fisheries Service (NMFS) because these fish are anadromous, spending a portion of their lives in the ocean.

Habitat alteration and destruction are recognized as being the largest causes of endangerment for many species. "Critical habitat" is the specific geographic area essential for the conservation of a protected species and may require special management considerations or protection.

The ultimate goal of the ESA is to recover species to the point where the protections of the act are no longer necessary. The services must develop a recovery plan for each species that identifies measures that will resolve the threats to the species, the time and costs associated with those measures, and objective quantifiable criteria for determining when the species has recovered sufficiently to be delisted.

The ESA affects forest management and timber harvesting in Idaho because many protected species depend on forests as part of their habitat. U.S. Forest Service managers have identified the ESA as the single most important factor influencing declines of timber harvested from national forests in the 1990s (Haminishi et al. 1995).

NFMA Diversity Mandate. In developing management plans, the U.S. Forest Service is mandated by the National Forest Management Act to "provide for diversity of plant and animal communities." There is little doubt that a principal reason for the recent revisions to NFMA regulations (65 *Federal Register* 67514 [November 9, 2000]) is implementation of the species diversity mandate. Timber harvesting on national forests is affected by the mandate and its regulations.

PACFISH. In 1992, the Forest Service began working on strategies for managing watersheds where anadromous fish are produced. This effort is known as PACFISH. In 1993 the BLM joined PACFISH, and in February 1995 PACFISH guidelines were adopted by both agencies (USFS & BLM 1994*b*). Seven of Idaho's national forests and two BLM districts have portions of their land in anadromous fish habitat and are covered by PACFISH's provisions.

Interim buffer zones, or Riparian Habitat Conservation Areas (RHCAs), have been created because of PACFISH for all riparian areas on USFS and BLM lands in the range of anadromous fish. On fish-bearing streams, the RHCA extends for at least 300 feet on either side of the stream channel. Riparian Management Objectives (RMOs) have been established for the RHCAs and include pool frequency, water temperature, large woody debris, bank stability, lower bank angle, and width/depth ratio. Timber harvesting is prohibited in RHCAs, except salvaging of damaged trees that is consistent with RMOs.

PACFISH has had an impact on timber harvest levels on federal lands in Idaho. The Environmental Assessment for PACFISH (USFS & BLM 1994*b*) estimated its restrictions would reduce harvest by 58 million board feet in the entire action area, including Idaho, Washington, Oregon, and northern California. The Clearwater and Nez Perce National Forests and the Coeur d'Alene BLM District were expected to cancel timber sales volume, and the Clearwater National Forest accounted for about 90% of the volume lost for the entire action area.

INFISH. In July 1995, the U.S. Forest Service undertook the Inland Native Fish Strategy (INFISH). This effort is similar to PACFISH, but designed to protect inland native fish communities, particularly those of bull trout (*Salvelinus confluentus*). INFISH applies only to watersheds on national forests in Idaho not covered by the PACFISH agreement. INFISH uses RHCAs and RMOs similar to those in PACFISH (see USFS 1995*a*).

PACFISH and INFISH will remain in place until a record of decision is reached on implementing an ecosystem-based management strategy throughout the region (see next section). Whether or not that happens, these interim protection strategies can be modified through a process called "watershed analysis" (see **Chapter 6**).

Ecosystem Management

Since at least the late 1980s, federal land and resource management agencies have been struggling to broaden the scope of management considerations from a focus on individual resources and outputs to a more comprehensive or holistic approach to planning and managing lands. The most widely used terms for this new approach to planning and management are "ecosystem management" or "ecosystem-based management."

Ecosystem management is a management philosophy that [a] focuses on desired future conditions, rather than system outputs, and [b] recognizes the need to protect or restore ecological components, functions, and structures in order to sustain resources in perpetuity (Moote et al. 1994). Five principles characterize ecosystem management:

- socially defined goals and management objectives;
- integrated, holistic science;
- broad spatial and temporal scales;
- collaborative decision building; and
- adaptable institutions (Moote et al. 1994).

Ecosystem management has not been expressly sanctioned in any of the governing natural resource or public land management laws (Keiter 1994); however, at least 18 federal agencies and many state agencies and private entities have explored ecosystem management concepts and their implications for various activities. Managing natural resources through ecosystem-based concepts will affect timber harvesting in Idaho in both the public and private sectors.

Interior Columbia Basin Ecosystem Management Project. The Interior Columbia Basin Ecosystem Management Project (ICBEMP) is one of the first efforts attempting to apply ecosystem management at a large, regional scale. The ICBEMP project area includes all the federal lands in the Columbia River drainage east of the crest of the Cascade Mountains. This area includes all of Idaho (except the Bear Valley in southeastern corner of the state), eastern Washington and Oregon, and western Montana. The ICBEMP project area is approximately 144 million acres, of which 72 million acres are public lands administered by the Forest Service or the BLM. The ICBEMP began in 1993, and a final decision has not been reached at the time of this writing.

In December 2000, a Final EIS and proposed decision were issued for public comment. The proposed decision alternative promotes broad-scale restoration and maintenance of ecosystems. It emphasizes two additional levels of analysis prior to conducting management activities. One is subbasin review, the other is watershed analysis. The intent of additional analysis is to "minimize short-term risks from management activities or disturbance events." Timber harvesting would be expected to increase 21% more than the 300 million board feet harvested annually from Idaho national forests in 1995-1997 (ICBEMP 2000).

Management Objectives

Each owner of forest land has a unique set of management objectives or goals that, in part, determine how that land is managed, whether or not timber harvesting is an appropriate activity, and how sustainability is incorporated into management of the land.

The management objective of the U.S. Forest Service for the national forests as stated in law is the Multiple-Use Sustained-Yield Act. National forests are to be managed for outdoor recreation, range, timber, watershed, and wildlife and fish purposes in the combination that will best meet the needs of the American people. However, objectives arising from the implementation of ecosystem management also affect the national forests. The recently adopted planning regulations make sustainability the overall goal of national forest management (65 *Federal Register* 67514 [November 9, 2000]). According to the regulations, the first priority is to maintain or restore the ecological sustainability of national forests. Economic and social sustainability are secondary goals to be sought after ecological sustainability is in place.

State endowment lands in Idaho have a purpose as set forth in the Idaho constitution to be managed "in such manner as will secure the maximum long term financial return." These lands were granted to the state of Idaho by the federal government at the time of entrance into the Union. They must be managed for the benefit of the common or public schools within the state and the other specifically designated beneficiaries of the land grants.

Private industrial lands are managed for a variety of reasons, but they tend to be managed more intensively for the production of timber than lands in other ownerships. Management goals of private industrial owners are often expressed as providing to shareholders financial returns from the manufacturing of timber products. Timberlands provide a secure raw material source for company mills.

The "other" private, or nonindustrial, landowners have forest land for many reasons. Researchers found that wood for domestic use, esthetic enjoyment, and wildlife appreciation were the three major benefits people in Idaho derive from forest ownership (Force and Lee 1991). The most important reason for owning forest land was "to preserve natural beauty and wildlife." This was followed by four other nonmonetary related reasons before the sixth-ranked reason of "to obtain income from timber." Owners of larger forest acreages tended to place more emphasis on timber.

American Indian tribes own about 94,000 acres of timberland in Idaho. These lands are managed for a variety of objectives, including economic development and subsistence use. For example, the Coeur d'Alene Tribe manages about 27,000 acres of forests and harvests about 6.5 million board feet of timber each year (Roesler 1995).

Forest Certification

"Certification" is a new, rapidly developing aspect of forest management. It is the focal point of **Part I** of this analysis, available separately in PAG Report #18 (Cook and O'Laughlin 1999). Certification promotes sustainable forest management by assessing forest management practices and/or forest management systems based on a set of standards (SAF 1995). Most of the private industrial lands in Idaho have been certified "sustainable" or are in the process of certification.

Chapter 5. What are the effects of timber harvesting on other resources?

Forests are complex systems in which multiple dynamic relationships exist between their various living and non-living components. Therefore, it would be impossible for us to examine all the effects of timber harvesting on all other resources. Instead, we have chosen to look at four resources that are affected by timber harvesting and provide some insight into sustainability. The first resource we examine is timber itself and the ability of a site to produce timber again after harvesting takes place. The other three resources we examine are water, wildlife, and scenery.

For several reasons, there is no simple answer to the question of what timber harvesting's effects are on other resources. Each resource is affected differently by timber harvesting. What may be beneficial for one resource may be harmful to another. The way in which harvesting is done also determines effects. Factors such as the percentage of trees removed during harvest and the mechanical means of removing the trees affect results. Lastly, and probably most importantly, the effects of timber harvesting vary because of the diversity of ecosystems in which trees and timber harvesting occur.

Timber

A sustainable timber harvest implies that the site from which timber is harvested will be capable of producing the same amount and quality of timber again in a similar amount of time and can continue to do so into the future. This concept can be called long-term site productivity. Soil is a primary determinant of long-term site productivity.

Timber harvesting can produce a variety of changes in soil properties that affect long-term site productivity. Harvesting can result in changes to microclimate, organic matter, nutrients, erosion, compaction, and microorganisms (see Harvey et al. 1989). However, many of the effects on soil can be reduced and mitigated with appropriate management techniques that

- reduce disturbance severity (i.e., reduce intense burns, soil compaction, or erosion),
- emphasize retention of organic matter,
- emphasize rapid revegetation by indigenous host species and associated beneficial soil organisms, and
- recognize that sites with harsh environments (i.e., cold, drought) are most susceptible to productivity losses (Amaranthus et al. 1989, Harvey et al. 1989).

Another aspect of timber management that is rarely considered in discussions of sustainable forest management is wood quality. Traditionally, management decisions have been based primarily on wood quantity or volume with little analysis of the effects of wood quality. Researchers, producers, and consumers now recognize wood quality as important (e.g, Briggs and Fight 1992, Kennedy 1995, Hansen and Bush 1996).

Changes are taking place in the types of timber being harvested. Much of the slow-grown, mature timber resource has been harvested and is being replaced by harvests of younger and faster-grown trees. The primary concern is that smaller trees and fast-grown trees have a higher proportion of juvenile wood than more mature trees. Juvenile wood is not necessarily "bad" wood and it functions well in certain products, but it has different properties than mature wood (see e.g., Maeglin 1987, Barrett and Kellogg 1991).

Wood quality is very responsive to both silvicultural and genetic manipulation, but there is a general lack of information on wood strength, tree spacing and taper, and other characteristics that affect quality for many species of importance in the Inland Northwest (Kennedy 1995). Although new manufacturing techniques are enabling production of high-quality products from low quality timber, these products are markedly different from those previously available. Tomorrow's forests will supply wood products that are different from those currently being used.

Water

Water is an essential element of ecosystems, and most organisms, including humans, depend on clean water for survival and quality of life. Timber harvesting and its associated activities can affect water quality. Our discussion focuses on moving water, i.e., streams and rivers. In Idaho, water quality policy for most streams translates into providing habitat for aquatic species, particularly for salmon, trout, and other cold-water fish (O'Laughlin 1996*b*).

The effects of timber harvesting on the stream environment include those on structure, streamflow, water chemistry, sediment, mass movement, soils, and large woody debris (see Chamberlin et al. 1991). By far the greatest concerns about timber harvesting and water quality result from roads, and sedimentation is by far the largest concern with roads (see Furniss et al. 1991). In addition, where forests occur on steep terrain, mass soil movement is often the primary mode of erosion and sediment delivery to streams from roads.

Under most circumstances, both timber and fish can be successfully managed in the same watershed if measures to protect water quality and fish habitat are carefully planned and coordinated with timber management operations. Implementation of best management practices, or BMPs, is one way to reduce and mitigate timber harvesting's effects on water quality (see Seyedbagheri 1996).

Wildlife

Timber harvesting can have positive, negative, and neutral effects on wildlife habitat depending on the life requirements of the species inhabiting the area. This makes general discussions of the effects of timber harvesting on wildlife difficult; therefore, our discussion focuses on two specific species: Rocky Mountain elk and northern goshawk. These species were chosen because their habitat requirements are different, and therefore, the effects of timber harvesting on them are different.

Elk. Rocky Mountain elk (*Cervus canadensis*) are tolerant of diverse environments; however, they exhibit preferences for specific vegetation and terrain within areas they occupy (see e.g., Edge et al. 1987). Elk habitat selection is a multidimensional concept including behavior, topography, weather, food, and cover factors as well as interactions among these factors (Skovlin 1982).

Elk management involves two separate issues: elk habitat effectiveness and elk vulnerability (Servheen 1997). Elk habitat effectiveness focuses on providing elk with areas for foraging, calving, nursing, security, and gaining body condition. Elk vulnerability focuses on elk mortality rates as a function of hunter and motorized route densities. Both issues can be affected by timber harvesting.

Timber harvesting probably has greater potential than any other land management activity for either negative or positive influences on elk populations. Timber harvesting has the potential for altering the amount and distribution of cover and forage areas and changing elk movements, distribution, and habitat utilization. In addition to vegetation changes caused by timber removal, the effects of logging slash, and the timing, pattern and duration of logging activity are important considerations. Roads can affect forage areas and travel routes due to slash, road cuts, and fill slopes. Roads substantially reduce elk use in adjacent habitat and increase vulnerability to hunters.

With proper planning, timber harvesting can often be conducted with minimal detrimental, and sometimes positive, impacts on elk habitat. However, access associated with timber harvesting often has negative consequences that are impossible to completely mitigate (Servheen 1997). The Idaho Department of Fish and Game makes several recommendations for minimizing the effects of timber harvesting on elk, including:

- using silvicultural methods that preserve hiding cover;
- maintaining slash depth at less than 1.5 ft.;
- minimizing road construction;
- timing harvesting activities to minimize disturbance to animals;
- providing nearby security areas; and
- protecting elk travel routes (Servheen 1997).

Northern Goshawk. The northern goshawk (*Accipiter gentilis*) is a large bird widely distributed in temperate and boreal forests throughout the higher latitudes of the northern hemisphere (USFWS 1997, 1998). Goshawks use a variety of forest types, forest ages, structural conditions, and successional stages; however, mature or old-growth forests with large trees and high canopy closure are especially important habitat in the western U.S. (Beier and Drennan 1997). Goshawks are found in most forest types in Idaho, including ponderosa pine, mixed-conifer, lodgepole pine, spruce-fir, and aspen (Hejl et al. 1995). The structure of the forest, not the species of trees, appears to be the important factor (Siders and Kennedy 1996).

There is concern that changes occurring in goshawk nesting and foraging habitat, particularly reduction, fragmentation, and deterioration of mature conifer habitat, may be adversely affecting goshawk populations in Idaho and elsewhere in the western U.S. (USFWS 1997, 1998). Habitat changes are due, in part, to the management of forests for timber production. Several factors may contribute to decreased productivity and density in goshawk populations following particular changes in forest structure and composition, including increased predation on goshawks, loss of preferred conditions at nest sites, reduced prey availability, increased competition with other predators, and increased disturbance and human-caused mortality from increased human access (Iverson et al. 1996).

Researchers attempting to develop guidelines for Idaho determined that more and better data were needed specific to Idaho forest types (Patla et al. 1995). Until such time as guidelines specific to Idaho are developed, the guidelines developed for the southwestern U.S. are recommended. They include:

- maintaining nest areas of mature or old trees and dense forest canopies;
- maintaining post-fledging and foraging areas with interspersed small openings, snags, downed logs and woody debris;
- minimizing road densities; and
- limiting timber harvesting activities to the period of October through February (Reynolds et al. 1992).

Scenery

Although "beauty is in the eye of the beholder," over the last two decades, much research has found that there are many common elements in what people find visually attractive about landscapes. Landscapes with a high degree of natural-appearing character are most attractive (Galliano and Loeffler 1995). According to an assessment done for the ICBEMP, nearly two-thirds of the federal lands in Idaho and western Montana are currently rated as "high" or "very high" in scenic integrity, distinguishing them as some of the most scenic areas in the U.S. (Galliano and Loeffler 1995, Quigley et al. 1997).

Timber harvesting and fire probably have the greatest potential for negatively impacting scenic beauty in the short term, and may confound all other relationships between forest characteristics and scenic beauty (Rosenberger 1998). The effects of timber harvesting on scenic beauty will vary by the silvicultural and harvesting system employed. Clearcutting has the greatest negative impact in the short run. As a generalization, the more trees left standing, the higher the scenic quality of the stand. However, thinning of dense stands can increase scenic beauty by increasing visual penetration provided that logging slash is minimized. Recommendations for mitigating the effects of timber harvesting on scenic beauty include:

- leaving some live trees on site;
- designing harvest areas that are smaller with more natural appearing shapes and edges;
- reducing logging slash; and
- using techniques that insure fast and adequate regeneration (Rosenberger 1998).

Chapter 6. Alternative Approaches to Watershed Analysis

In the past decade, "watershed analysis" has emerged as a name for a type of process that may encourage sustainable forest management. Although watershed analysis approaches are still evolving and may differ in their management objectives (see Reid 1998), the intent is basically the same: to understand the ecological processes at work in a watershed and protect some resources from detrimental effects of using other resources. Watersheds are a useful unit of analysis for several reasons, including the relationship of watersheds to water quality and human activity, as well as the relative permanence of watershed boundaries. Watersheds may also be aggregated or disaggregated to different scales, from a creek to the entire Columbia River drainage system. Furthermore, watershed analysis is the direction in which federal land and resource management policy is headed. Watershed analysis is a process whereby regulatory standards, such as riparian buffer widths, can be fine-tuned to fit local conditions.

We look at four approaches to watershed analysis: two state, one federal, and one private. The two state approaches, for Idaho and Washington, are based on a management paradigm called cumulative watershed effects, which is concerned primarily about nonpoint source pollution and water quality. The federal approach extends the cumulative watershed effects model into a planning tool for ecosystem management. It considers a broader range of ecological elements, not just those related to water quality, and economic and social objectives. In the private sector, Plum Creek Timber Company's approach is a synthesis of watershed analysis and ecoclassification.

Cumulative Watershed Effects: State Programs

Idaho's Cumulative Watershed Effects (CWE) Process. The Cumulative Watershed Effects (CWE) process of the Idaho Department of Lands consists of an assessment of erosion and mass failure hazard, canopy closure/stream temperature, hydrology, sediment delivery, channel stability, beneficial use/fine sediment, and nutrients (IDL 2000). It provides keys to determining whether cumulative watershed effects exist for all of the factors assessed along with guidance to help resource managers and landowners design best management practices to alleviate adverse conditions and prevent cumulative watershed effect problems from future forest practices.

The CWE process leads to one of three results for the forest manager:

- guidance for allowing planned forest practices to proceed;
- when the results indicate the existence of a problem, help in redesigning forest practices; or
- when a complex situation exists, guidance for completing additional analysis before proceeding with a forest practice (IDL 2000).

The CWE process is designed to be adaptive in that the decision criteria provided in the process change as new data and information become available. Not all watersheds in the state have been assessed using the CWE process, but in the last few years, increased appropriations to the Idaho Department of Lands specifically for CWE have allowed the department to increase training, assessment crews, data availability, and completion of watershed assessments.

Washington's Watershed Analysis Program. The outcomes from watershed analysis conducted by the Washington Department of Natural Resources include resource condition reports describing watershed conditions, maps locating sensitive areas requiring prescriptions (which may include all or parts of the watershed), and causal mechanism reports describing the sensitive area and the nature of potential problems to public resources supported with facts and data (WFPB 1997). Local land managers and agencies then develop a tailored management plan for the watershed that responds to the resource concerns identified by the scientific investigation. A team of field managers and analysts determine required and voluntary forest practices for each identified sensitive area. Once the watershed plan is developed, further forestry activities in the watershed must be conducted within the provisions of the watershed analysis prescriptions for each sensitive area, unless an alternative plan is approved, with compliance regulated by the Washington Department of Natural Resources.

Federal Watershed Analysis Process

Federal agencies use watershed analysis procedures that build on and move beyond cumulative watershed effects analysis. For federal agencies, watershed analysis is a vehicle for implementing ecosystem management at the watershed scale. It provides a process for melding social expectations with the biophysical capabilities of specific landscapes.

The federal watershed analysis procedure manual, *Ecosystem Analysis at the Watershed Scale* (RIEC 1995), outlines a six-step analysis process:

1. Characterization of the watershed
2. Identification of key issues and key questions
3. Description of current conditions
4. Description of reference conditions
5. Synthesis and interpretation of information
6. Recommendations.

Comparing Watershed Analysis Alternatives

As suggested in the literature (Collins and Pess 1997*a*), we compared the Idaho, Washington, and federal watershed analysis programs using four natural resource management paradigms: cumulative effects assessment, adaptive management, restoration assessment, and ecosystem management. All alternatives exhibited at least some elements of each paradigm. Differences between the processes are numerous, but that should be expected since the goals for each are different.

Our analysis and conclusions are general in nature because they are based only on each entity's general procedures guide for watershed analysis (i.e., IDL 2000, WFPB 1997, and RIEC 1995). Examinations of actual field procedures, reviews of completed analysis reports, and interviews with managers might have produced more detailed and different results.

A Private Sector Approach to Watershed Analysis

Private companies, in addition to the federal and state governments, are developing methods for watershed analysis. One approach, being developed by Plum Creek Timber Company, integrates watershed analysis and ecoclassification (Watson et al. 1998). Plum Creek is in the business of manufacturing wood products from the timber grown on company lands. The company must abide by laws such as the federal Endangered Species Act and state forest practices acts that protect water quality and fish habitat. One of the primary mechanisms for controlling timber harvesting's effects on water quality and fish habitat is the use of riparian buffer zones adjacent to water bodies. The width of these buffers and the management activities allowed in them are the impetuses for Plum Creek's work as part of the company's native fish habitat conservation plan under section 10 of the Endangered Species Act (Plum Creek Timber Company 2000).

Researchers (Watson et al. 1998) tested the hypothesis that a geographic information system (GIS)-based hierarchical ecoclassification can be used to delineate groups of channel segments that exhibit similar characteristics in terms of fish habitat, fish distribution, and sensitivity to land management activities. They also tested the hypothesis that these groups can be used as a template for extrapolating results of watershed analysis from a subsample of the analysis area so as to provide for the effective protection of aquatic resources over a large area. Where the two independent approaches produce complementary results, the two approaches were integrated into a tool for the protection and management of aquatic resources.

We highlight Plum Creek's effort because one of the criticisms of watershed analysis has been that the same process must be repeated in every watershed despite similarities between them. Some view watershed analysis as redundant and overly costly. Plum Creek's approach appears to offer an answer to those criticisms. Also, Plum Creek's process appears to have wider application. The application of the approach need not be limited only to those areas where forestry is the predominant land use. The ecoclassification/watershed analysis synthesis approach may be useful in venues more comprehensive that the forest practices/fish habitat example. This methodology could be applied to other land management practices (Watson et al. 1998). This feature seems to be in line with the broad task of ecosystem management that the federal watershed analysis process was developed to undertake.

As more private companies and government agencies develop methods for watershed analysis, desired characteristics of the process are that it:

- fits the particular needs of the agency or organization instituting it;
- evaluates any potentially important impacts;
- evaluates impacts at any point downstream;
- evaluates impacts accumulating through both time and space;
- evaluates the influence of any expected kind of land-use activity;
- evaluates any lands within the analysis area;
- uses the best available analysis methods for each aspect of the analysis;
- incorporates new information as understanding grows;
- can be done for a reasonable cost over a reasonable length of time;
- produces a readable and useable product; and
- is credible and widely accepted (Reid 1998).

Chapter 7. Conclusions

"Sustainability" is about meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. Sustainable forest management is the expression of "sustainability" for forests. Sustainable forest management is ecologically sound, economically viable, and socially desirable (Aplet et al. 1993).

People not only want to continue to receive the benefits they value from forests, but also ensure benefits will be available to future generations. One of the benefits that people receive from forests is timber—trees used to make products such as lumber, plywood, and paper. People have used products derived from timber for thousands of years. Some people are seriously questioning whether it is possible to continue to produce timber while simultaneously producing and protecting other forest values. People are asking if timber harvesting is a sustainable use of forests.

Is timber harvesting in Idaho's forests sustainable? Sustainable forest management must consider three dimensions—ecological soundness, economic viability, and social desirability. The reply to the question is "yes" for some of Idaho's forests, "no" for others, and "we don't know" for others. The answer depends on many factors, including:

- the ecological conditions existing in the forest;
- the way in which timber harvesting is done;
- the plans for and actions on the site after harvesting;
- market conditions for timber at the time of harvesting;
- the values of the site other than timber;
- the management goals of the forest owner;
- the laws and policies that apply to the owner, the land, and the actions taken.

We know that all these factors will change over time. Sustainable management is not absolute. It is a journey, not a destination. We can develop standards for comparison and say that timber harvesting is either "more" or "less" sustainable in a particular forest than it would be somewhere else at a particular time. We can define sustainable forest management as a goal and measure relative progress toward the goal.

Future Directions

Sustainable forest management is an evolving concept that reflects the changing nature of and perceptions about our world. It is about the values and aspirations people have for their natural resource endowments and the way these resources are managed. Indicators of sustainable forest management are in their developing stages. Until such indicators and procedures for using them to evaluate management methods have been agreed upon, applied, and evaluated, we cannot say much about the sustainability of resource management approaches. Sustainability is also about our place as citizens of Idaho in a bigger world, and it is about our consumption patterns. It is about our values.

Evolving Indicators of Sustainable Forest Management. Since this project was first suggested to the Policy Analysis Group, the concept of sustainable forest management and ways to measure it have evolved. One model for measurement, commonly called "criteria and indicators," or "C&I," has become a popular way to assess sustainable forest management. These efforts are examined in detail in Part I of this analysis, published separately (see PAG Report #18, Cook and O'Laughlin 1999). The Montreal Process C&I are widely accepted and consist of seven criteria and 67 indicators. If Idaho were to conduct its own evaluation of sustainable forest management on different ownerships using the Montreal Process C&I, it would be the first state to do so.

A World Perspective on Idaho's Timber Resources. In this report we have concentrated on Idaho as the geographic scale; however, Idaho does not exist independently in the ecological, economic, or social dimensions. How does Idaho's timber resource fit into the region's, nation's, and world's supply and demand situation?

The forests and people of the world produce billions of cubic feet of wood products each year. Idaho has about 0.2% of the world's forests and almost 3% of U.S. forests. Idaho's 1.8 billion board feet of lumber production in 1996 was about 5% of the softwood lumber produced in the U.S. (WWPA 1997).

What would happen if Idaho either stopped producing timber or dramatically increased its production ? The answers are beyond the scope of this report, but have implications for the sustainability of forest management worldwide. Additional analyses looking at a broader geographic scale would provide insights for managing Idaho's forests to meet peoples' needs today and tomorrow without causing irreversible ecological damage.

Consumption and "Sustainability."

> The long and short of the matter is that forest conservation depends in part on intelligent consumption, as well as intelligent production of lumber (Aldo Leopold, "The Home Builder Conserves," 1928).

Sustainable forest management is not just about production of forest products and other benefits, but also their consumption. Which resources we choose, where we get them, how we use them, and how we dispose of them are all vital issues for sustainable forest management (Temperate Forest Foundation 1998).

We do not have consumption figures specific to Idaho, but on a per capita basis, the U.S. consumes timber at more than four times the world average. Recent reductions in timber harvest levels from national forests in Idaho and other regions of the U.S. have caused many people to ask, if we do not produce timber to meet our needs, are we exporting environmental problems associated with timber harvesting to other countries? The reply to the question depends on questions of fairness, ethics, and morality (Bowyer 1992, Schallau and Goetzl 1992, Brooks 1993). Perhaps further discussion and analysis of consumption patterns and our national responsibility to produce what we consume is warranted.

"Sustainability" and Human Values. In this report, we have only begun to scratch the surface of sustainable forest management issues because ultimately everything is related to sustainability. This includes not just decisions about forests but every decision we make in our daily lives. Sustainability is about resource allocation and social values. Professor William Burch of Yale University's School of Forestry and Environmental Studies summarizes his experience with three central "laws" of resource management (quoted in Grumbine 1997:46):

- All resource allocation decisions are matters of political struggle rather than technical fact.

- Resource management decisions are about use; therefore they are decisions about manipulating human behavior rather than physical things.
- Resource managers, when confronted with social value decisions, will seek to convert them into technical decisions.

The question of whether or not timber harvesting in Idaho is sustainable does not have a technical answer. However, we hope that the technical information provided in this report contributes positively to discussions among all Idahoans and encourages them to make informed decisions about the management of Idaho's forests.

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Chapter 1. What is sustainable forest management?

Sustainable forest management is
- ❖ **ecologically sound**,
- ❖ **economically viable**, and
- ❖ **socially desirable**.

There is no consensus on exactly what sustainable forest management is and what brings it about (Gale and Cordray 1991, Rivlin 1993), but in order to have a meaningful discussion about it we must establish a framework for discussion. One framework that is common in the literature, and we have adopted in the above definition, is that sustainable forest management has three essential dimensions: ecological, social, and economic (Aplet et al. 1993).

Sustainable forest management is a part of the broader idea of "sustainability," and an in-depth discussion of sustainability is warranted in order to set the stage for discussions about forest management.

1.1. Defining "Sustainability"

"Sustainability" is a difficult concept to define because it means different things to different people and is used in reference to a number of issues (Toman 1992, Johnson 1993, Toman 1994*a*). We hear about sustainability in relation to forests, communities, development, and so on, and what is meant is not always clear (Cocklin 1989, O'Connor 1995). Like the concepts of equality, justice, and welfare, sustainability does not have an analytically precise definition (Daly 1996). Some observers have argued that sustainability has become so overused and misused that it has lost any semblance of meaning (Viederman 1996).

Nevertheless, sustainability continues to gain visibility, acceptance, and use as a goal for societies, economies, governments, businesses, resource management activities, and a variety of other human organizations and endeavors. Three rather distinct ideas about "sustainability" are in use today: [1] sustained yield of a resource, [2] sustained abundance and diversity of species and ecosystems, and [3] sustained economic and social development, without compromising existing resources for future generations (Dixon and Fallon 1989, Gatto 1995).

The profession of forestry was founded on the first idea, with timber the primary resource of concern. The other two ideas have become increasingly important in the last two decades. Today, the third use of "sustainability" is the most popular, and it is based on the definition of sustainable development from *Our Common Future* (WCED 1987), often called the "Brundtland Report." Sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987:8). This definition of sustainable development has evolved into the general concept of sustainability (Munro 1995). In the U.S., the concept of sustainable development includes the recognition that neither environmental health nor economic prosperity is viable without the other (National Commission on the Environment 1993).

The concept of sustainability is often described as having three essential dimensions: ecological, social, and economic (Aplet et al. 1993, British Columbia Round Table on the Environment and the Economy 1993, Munasinghe and McNeely 1995, Munro 1995, Sheng 1995, Goodland and Daly 1996, Viederman 1996). Sustainable actions occur at the conceptual intersection of these three dimensions (Figure 1-1), or where the three dimensions are integrated. This three-part model can be traced back at least to Firey (1960), long before the term sustainability became popular.

Ecological sustainability is often stated as ecological soundness or integrity. It focuses on natural biological processes and means that ecosystems support healthy organisms, while maintaining their productivity, adaptability, and capacity for renewal (Brown et al. 1987). For forests, ecological sustainability requires that management respects, and builds on, natural processes (Upton and Bass 1996). Ecological approaches are not sustainable, however, unless they are integrated into the human context (Duffus 1993, Pfister 1993, Allen and Hoekstra 1995), which includes fairness or equity in social and economic dimensions.

Social sustainability includes the continued satisfaction of basic human needs—food, water, shelter—as well as higher-level social and cultural necessities such as security, freedom, education, employment, and recreation (Brown et al. 1987). This dimension of sustainability is sometimes called social desirability or acceptability, and reflects the relationship between actions and social norms—an activity is socially sustainable if it conforms with social norms, or does not stretch them beyond a community's tolerance for change (Munro 1995, Upton and Bass 1996). Social acceptance is fundamental to all societies, but it is especially important in humanitarian societies where freedom of expression, equal

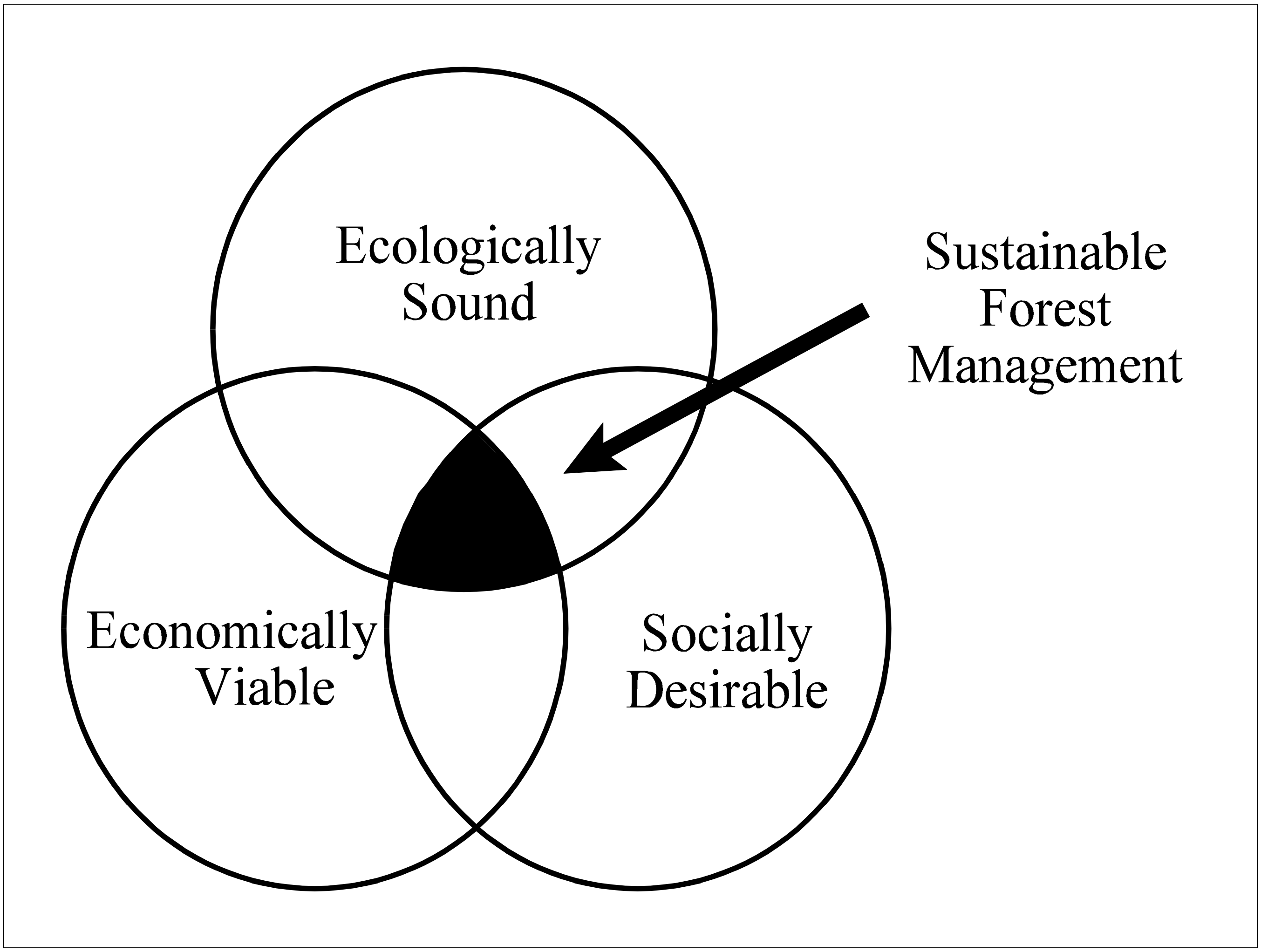

Figure 1-1. Sustainable forest management occurs at the conceptual intersection of ecologically sound, economically viable, and socially desirable actions.

Source: Aplet et al. (1993).

opportunity, self-governance and democracy exist (Pfister 1993, Viederman 1996).

Economic sustainability, also called economic viability or feasibility, requires that benefits exceed or balance the costs incurred (Munro 1995), and that equivalent capital is handed down from one generation to the next (Goodland 1995, Upton and Bass 1996). Current economic activity should not result in disproportionate costs on future generations (Foy 1990). Fairness in the distribution of benefits and costs to the current and future generations is paramount (Goodland and Daly 1996).

1.2. Sustainability Themes

Although there are many definitions of sustainability, key themes emerge consistently: the human perspective, considerations of fairness, and issues of scale. Within these dominant themes, many wide-ranging viewpoints are debated.

1.2.1. Sustainability is Based on Human Values.

> At the broadest level, the [sustainability] concept rests on a certain world view and a certain value judgment: the view that our descendants' well-being may not be as guaranteed as we historically presumed, and the judgment that we *should* care about their well-being (Lélé and Norgaard 1996:354).

Humans created the idea of sustainability, which does not exist independent of human values (Franklin 1993, Allen and Hoekstra 1995). Humans seek to impose some constancy and dependability on the natural environment for the supply of goods and services (Carpenter 1995). People decide what is important and for how long (Allen and Hoekstra 1995).

Sustainability describes a relationship between human actions and the environment (Gonzalez-Caban et al. 1995, Munasinghe and Shearer 1995, Viederman 1996). Any discussion of sustainability is strongly conditioned by human values and objectives, whether these emphasize short-term utility, providing options for future generations, or the inherent right of species to exist (Franklin 1993).

1.2.2. Equity or Fairness. Equity is a question of fair or just distribution of resources, rights, and wealth amongst people and over time (Young 1992). The concept of intergenerational equity, or equity between generations, is the backbone of sustainability (Toman 1992, Meyer and Helfman 1993). Sustainability sets the economic opportunities and ecological foundations of future generations on the same ethical level as those of present generations (Paehlke 1994, Attfield 1998).

Different approaches to measuring intergenerational equity have different implications for policy (Young 1992). How one actually accounts for the responsibility to future generations is a much-discussed point (see, e.g., Pearce 1988, Dixon and Fallon 1989, d'Arge et al. 1991, Beckerman 1992, Young 1992, Toman 1994*b*, Toman and Ashton 1994, Norton 1996, Page 1997).

Sustainability also addresses intragenerational equity, or equity within the current generation (Pearce 1988, Young 1992, Goodland and Daly 1996, Smith 1996). Equal rights and advancement opportunities for all the world's citizens are encouraged (Young 1992). The distribution of costs and benefits of our actions is also important. Are those who benefit also paying the costs? Numerous authors (e.g., Young 1992, Lee 1993) suggest that today many of the costs of our actions are not being borne by those who benefit and movement toward sustainability will require policies that address this situation.

1.2.3. Issues of Scale. Temporal and spatial scales (i.e., time and space) are prominent issues in discussions of sustainability (Brown et al. 1987, Salwasser et al. 1993, Allen and Hoekstra 1995, Holling 1995, Levin 1995, O'Neill et al. 1995). At what physical scale should activities and resources be sustained? And over what period of time?

Defining appropriate scales for managing sustainably is difficult. Ecological systems occur at all spatial scales from the microsite to global (Aplet and Olson 1993). Social systems exist at scales from family and community to the world at large. Economic systems range from the individual to the international level. Time scales are defined from moments to eons.

Sustainability requires planning and management at multiple geographic scales (Greber and Johnson 1991, Allen and Hoekstra 1995, Toman and Ashton 1994). For example, forest ecosystems need to be seen as a nested set of structures embracing the stand, watershed, and the physiographic region (Toman and Ashton 1994). National and global scales are needed in addition to local and regional scales because in the long run it may do little good to manage sustainably in local and regional ecosystems if resultant human consumption of resources depletes the same somewhere else (Salwasser et al. 1993). Sustainability requires that we think and plan at larger spatial scales than we have in the past—landscapes and regions (Franklin 1993, O'Neill 1996)—rather than stands and management units of aggregated stands.

The temporal scales of sustainable management must not only address those relevant to biological organisms or other parts of the biophysical system, but also time periods relevant to societal values (Dixon and Fallon 1989). Often the temporal aspects of sustainability are intertwined with spatial considerations (Allen and Hoekstra 1995).

1.3. Difficulties Implementing Sustainability

> Sustainability is a goal, like liberty or equality: not a fixed endpoint to be reached but a direction that guides constructive change; the realist is as skeptical of claims concerning sustainability as she would be of a claim that perfect liberty had been attained (Lee 1993:563).

As an emerging goal for human activities, sustainability has not been universally accepted as something that societies should pursue. Sustainability may be appropriate in certain circumstances, but not in all situations (Robinson 1993). Sustainability, though, may be a new social paradigm, and its adoption will involve a complex and difficult process of social learning (Gatto 1995, Milbrath 1996).

Whether or not we, as a society, should pursue sustainability as a goal is not addressed herein.

However, we do point out difficulties in implementing policies to achieve sustainability. These include ambiguity, lack of agreement on values and scales, and the substitutability of capital and technology for natural endowments.

1.3.1. Ambiguity in Definition.

> Sustainability is invariably used to describe a goal which, superficially at least, is indisputably desirable. ... On closer examination, however, it is found that the concept is defined so broadly as to be open to widely disparate interpretations, which creates potential for misunderstanding (Dixon and Fallon 1989:73).

Because of the widespread use of "sustainability" today, concern exists that the debate over sustainability is not fruitful because people think they are addressing the same issue, when in fact they are not (Gatto 1995, Goodland 1995). The concept of sustainability can be approached either as a guiding principle or as an operational strategy (de Vries 1989). As a guiding principle in the broad sense, sustainability suggests how we should think of and act in the world. It is an ethical code for the pursuit of long-term survival and prosperity of humankind (de Vries 1989).

The other approach to sustainability is to look for an operational definition. The aim, then, is to design and implement resource management strategies which preserve those life-support systems thought to be vital to long-term survival and prosperity of mankind (de Vries 1989). Some observers feel that sustainability is not well enough defined to be put into operation (de la Jara 1994, Wiersum 1995, Daly 1996). Others observe that the rhetoric and literature of sustainability are filled with vagueness, inconsistencies, and oversimplifications, and these weaknesses impede effective policies and implementation (Lélé 1991, Mathews 1991, Toman 1994*a*).

Many discussions of sustainability lack reference to specific spatial and temporal dimensions of the systems of concern (de Vries 1989), and they lack reference to specific problems and management goals (Woodmansee 1992). Discussions of sustainability often fail to clearly answer the crucial questions: what is to be sustained, how, and for whom (Lélé 1991, Toman 1992, Johnson 1993, Romm 1993, Marshall 1995). Although there are conditions when the well-being of future generations can be safeguarded while meeting the needs and aspirations of current human communities and protecting non-human species, sometimes conditions are such that tradeoffs will be required (Lélé 1991). Discussions about strategies for achieving sustainability often lose sight of the complex social and economic conditions that substantially determine ecological outcomes (Lélé 1991).

1.3.2. Agreement on Values. Sustainability is based on human values, and it is difficult to reach agreement on the values that define sustainable solutions. Many of the contradictions associated with sustainability can be traced to differing fundamental beliefs and assumptions about the nature of relationships between humans and their environment (Cronon 1995, Rees 1995). For example, some people view some human activities as being unnatural or against nature, while others see humans as an integral part of nature. Each of us sees the world differently. Because we acquire a particular world view simply by living, growing up, and being educated in a particular socio-cultural environment, we are often unconscious that we even have a particular world view and that we operate from it in virtually everything we do (Rees 1995, Smith 1996). Different world views and the variety of values associated with forests are discussed more thoroughly in **Chapter 2**.

1.3.3. Substitutability of Capital and the Role of Technology. Many definitions of sustainability require that the current generation pass on to future generations equivalent capital. Capital is a resource stock that yields a flow of valuable goods and services into the future (Costanza and Daly 1992). Natural capital is the stock that yields the flow of natural resources. Human capital refers to people and the bodies of knowledge that contribute to production and to community. Human-created capital refers to products and technologies created by humans including the built environment. Social capital refers to civic involvement, participation in community, sense of place, and other social attributes of people's lives (Goodland 1995, Viederman 1996).

What defines equivalent capital for future generations is the subject of much debate (Foy 1990). A distinction is made between "strong" and "weak" sustainability (Goodland and Daly 1996). The "strong" argument is that a minimum necessary condition for sustainability is that *total natural capital* be maintained at or above the current level; "weak" sustainability requires only that *total capital* be maintained (Costanza and Daly 1992, Reid 1995, Goodland 1995, Goodland and Daly 1996).

The disagreement arises from differences in beliefs about the substitutability of the different types of capital (Goodland 1995). Can human-made capital replace some forms of natural capital? The reply depends on a person's belief in the types and pace of technological advances in the future (d'Arge et al. 1991, Mathews 1991, Lee 1993, Toman 1994*b*, Toman and Ashton 1994, Goodland 1995, Reid 1995, Lélé and Norgaard 1996).

1.3.4. Agreement on Scales.

> In considering resource substitutability, economists and ecologists often also differ on the appropriate level of geographic scale. On the one hand, opportunities for resource tradeoffs generally are greater at the level of the nation or the globe than at the level of the individual community or regional ecosystem. On the other hand, a concern only with aggregates overlooks unique attributes of particular ecosystems or local constraints on resource substitution and systemic adaptation (Toman 1992:5).

Whether or not sustainability must always be planned for some scale-defined situation is an issue. For example, Noss (1993) argued that ecosystem sustainability must be defined in terms of time period and the proportion of ecosystem structure, function, and composition maintained. Likewise, Toman and Ashton (1994) argued that management of ecosystems cannot be considered without some sort of boundary; human actions have to be defined by both spatial and temporal limits. Allen and Hoekstra (1995) argued that temporal scales must be agreed upon because sustaining everything for all time is worse than impractical; it is meaningless. Although these seem to be reasonable propositions, not everyone agrees that they are (e.g., British Columbia Round Table on the Environment and the Economy 1993, Munro 1995, Daily and Ehrlich 1996).

There is also disagreement on what the appropriate scale for analysis is. For example, at the local level, a forest may be valued most for its wood products; in a nearby city, the same area may be valued for recreation. From the national perspective, the same forest may be important as an element in watershed protection from soil loss, while at the global level, the forest may be too small to significantly affect global climate (FAO 1994*b*). Issues of equity arise when the interests of the local community are at variance with national or international interests (FAO 1994*b*). Rather than trying to determine the correct temporal and spatial scale for sustainability, it may be more fruitful to concentrate on how the different scales interact and how we might construct multi-scale definitions and indicators of sustainability (Costanza et al. 1991).

Herein, we focus on the state of Idaho as the geographic scale of analysis. However, while Idaho may be an appropriate geopolitical scale, it is made up of many, many smaller ecosystems, is a part of a larger bioregion, and economically and socially does not exist independent of the surrounding region, nation, or world. At what geographic scale do we evaluate and manage for sustainability? The replies depend on who is doing the management, what they are managing for, and how evaluation is structured and conducted.

1.3.5. Things Change.

> Sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs (WCED 1987:9).

Moving towards sustainability is difficult because of the dynamic nature of ecosystems, social values, and economic vitality (Bormann et al. 1994*a*, 1994*b*). Sustainability is a moving target (Salwasser 1993).

Ecological systems constantly change (Carpenter 1995, Gatto 1995); change is essential to their integrity (Kimmins 1995). Because of change, the long-term management of ecosystems and their resources must be adaptive rather than deterministic (Salwasser 1993, Bormann et al. 1994*b*, Munro 1995). Some of what we learn in one decade may not be true in the next (Hilborn and Ludwig 1993).

Social values are also dynamic. Resource management values are undergoing a major shift, and a new set of values is emerging (Bengston 1994). The old set of social values emphasized economic growth, control of nature, faith in science and technology, ample reserves of natural resources, the substitutability of resources, and a dominant role for experts in decision making. In contrast, key themes of the new set of values include sustainable development, harmony with nature, skepticism toward scientific and technological fixes, finite natural resources, limits to substitution, and a strong emphasis on public involvement in decision making (Bengston 1994). Of course, individuals may hold values from each set, or values not found in either set (Milbrath

1996). How do we evaluate sustainability in such a dynamic world of values?

Economic sustainability is more easily measured than social sustainability because it can be defined in numerical terms, primarily units of currency. However, it is at least as difficult to predict because it is affected by so many variables (Mangel et al. 1993). Economic sustainability is conditioned by the availability and costs of inputs, the costs of extraction and processing, and the demand for the product. All of these factors are highly variable over time and among the world's regions (Munro 1995).

1.3.6. Institutional Change.

> Moving toward sustainability will require continued purposeful self-directed learning on the part of institutions, organizations and governments. The lessons are difficult because the fundamental aspects of sustainability revolve around the integration of the sociopolitical, economic, and environmental dimensions. These dimensions do not easily mesh because sectors of government, academic training for experts, and institutional activity often take place wholly within only one of the dimensions (Larsen 1994:11).

> Sustainability is fundamentally a problem of human social organization and technology, not simply management of the physical environment and its biological processes (Lee 1992:75).

Institutions, traditions, and precedents often have more to do with the way resources are managed than science or economics (Lee 1993). Institutionalization involves the development of persistent patterns of human behavior expressed as formalized rules, laws, customs or as informal rituals and patterns of social interaction or inaction with the nonhuman environment (Lee 1992). Moving towards sustainability will involve institutional change. However, some organizations and institutions upon which society is structured, both within and outside resource management professions, are not well suited to make the fundamental adaptations that sustainability requires (Sample 1993). Political institutions, in particular, will need to change if sustainability in resource management is to be realized (Woodmansee 1992, Pfister 1993, Pitelka and Pitelka 1993, Rivlin 1993, Leslie 1994, Viederman 1995). Sustainability may imply a thoroughgoing transformation of industrial society (Paehlke 1994).

1.3.7. Science and Sustainability.

> Science can describe, with different degrees of precision, what is, and to a lesser degree, can help us to assess what can be. Science cannot tell us what should be, and that is the key issue of sustainability. Science is a form of know-how: it is a means without consideration of ends. It underlines the differences between knowing how to do something, and knowing what to do (Viederman 1995:37).

What is the role of science in sustainability? A firm foundation of scientific understanding and quantification has generally been described as an underpinning for the value-laden economic, social, political, and cultural components of sustainability (Ehrlich and Daily 1993, Rivlin 1993, Carpenter 1995). However, science has limitations (Kimmins 1993, Meyer and Helfman 1993, Salwasser 1993, Stankey 1996). Although some questions of sustainability involve questions of fact and can be stated in the language of science, they are unanswerable by science (Stankey 1996). Science cannot provide the answers to what is fundamentally a social dilemma (Pfister 1993).

Science can explain what is known about a problem and explain the consequences of different responses (Pitelka and Pitelka 1993). Science can develop estimates of risk, but it cannot say what level of risk is acceptable (Salwasser 1993). Science can provide information to the decision-making process, but, ultimately, society must decide what constitutes "good" and "bad" resource management (Aplet and Olson 1993, Kimmins 1993, Pfister 1993, Regier et al. 1995).

1.3.8. Uncertainty and Risk.

> Nature is not only more complex than we think. It is more complex than we can think. (Egler 1970:21).

> More responsible and ecologically sound decisions would probably result if scientists clearly identified the uncertainties and the possible consequences of alternative actions in the face of those uncertainties, rather than try to reach a consensus on what is true or not (Mangel et al. 1993:575).

Sustainability is an inherently uncertain concept (Carpenter 1995). It requires the ability to predict the future, an activity that is risky at best (Munro 1995).

Part of the uncertainty results from natural variation in natural systems (Carpenter 1995, Gatto 1995). A signal that change in the condition of a system is due to human actions may be hidden in the noise of natural changes in the value measured (Carpenter 1995). In many cases, short-term natural variability is necessary for the long-term sustainability of the ecosystem. By attempting to reduce this variability through technology and management, we may threaten the long-term persistence of the system (Brown et al. 1987).

The lack of rigorous scientific information that can be applied to decision-making processes also contributes to uncertainty (Pfister 1993, Salwasser 1993, Gonzalez-Caban et al. 1995, Toman and Ashton 1994). For example, much of our knowledge about ecology has not been well integrated to the large scale ecosystem and bioregion levels (Kimmins 1993, Toman and Ashton 1994, Winograd 1995). Reductionist science has not provided us with the answers we need at the temporal and spatial scales of complex ecosystems (Kimmins 1993).

Some questions are unanswerable with any exactness or certainty (Costanza 1993, Viederman 1995). People nonetheless must continue to make decisions and take actions that will affect the future. People must decide what is an acceptable risk to take. The difficulties of determining acceptable risk can be described in terms of five problems: [1] ambiguities in how to define a problem, [2] difficulties in ascertaining facts about the matter, [3] uncertainty about whose values are to be represented and how they are to be elicited, [4] the inevitable fallibility of experts, and [5] questions about how to evaluate the quality of the decision process (Brunson 1996). All five of these problems apply to sustainability. We need to recognize the limitations of human knowledge and decide what our tolerance for ignorance and uncertainty is so that we can act in a timely fashion with the highest degree of certainty possible while avoiding harm and doing good in the short and long term (Viederman 1995).

1.4. Sustainability and Forests

Forests cover over one-third of the world's land area. Forests play a critical role in sustaining global environmental systems and, at the same time, have a direct role in sustaining human communities by providing fuel, food, commodities, and income (Brooks 1993). Forests are not only sources of livelihoods, but also shape the institutions and customs of communities. Forests are an integral part of sustainability considerations (FAO 1994*a*). **Chapter 2** discusses more fully the roles forests play in Idaho.

1.4.1. Forest Management. Forests have existed and can exist without human intervention, but today all forests of the world are influenced by humans to some degree. Humans decide where to build habitations, where to clear land for agriculture, where to extract resources from the forest, and where to preserve the forest relatively untouched (Romm 1993). Humans manage all forests in some way.

> Forest management can be defined as:
> the overall administrative, economic, legal, social, technical and scientific aspects related to natural and planted forests. It implies various degrees of deliberate human intervention, ranging from action aimed at safeguarding and maintaining the forest ecosystem and its functions, to favouring given socially or economically valuable species or groups of species for the improved production of goods and environmental services (FAO 1991).

Forest management is therefore a social process rather than a forest condition; it is a regime of actions by which people conserve, augment, modify, and replace features of the forest so as to perpetuate its desired qualities, whatever these may be (Romm 1993).

1.4.2. Sustainable Forest Management.

> Notwithstanding 200 years of efforts to operationalize the concept of sustainability, its exact application in forestry remains troublesome (Wiersum 1995:321).
>
> The challenge is not to define the sustainable forest but to develop social processes that recognize, accommodate, and respond more effectively to diverse and dynamic perspectives of what the forest is and should be. The challenge is to achieve sustainable forestry (Romm 1993:281).

We repeat the definition from the opening paragraph of this chapter (Aplet et al. 1993),

Sustainable forest management is

- ❖ **ecologically sound**,
- ❖ **economically viable**, and
- ❖ **socially desirable**.

Sustainable forest management can viewed as management for sustainability (FAO 1994*b*). It occurs within the conceptual space defined by the intersection of goals for human communities, economic development, and environmental quality, and takes into consideration interregional, international, and intergenerational transfers of benefits and costs in addition to immediate and local needs (Salwasser et al. 1993).

Sustainable forest management depends upon which forest attributes, activities, or effects are to be sustained, at what levels and over what area and time period, by which means, and for and by which people (Romm 1993). It depends on human values, and is a regime of actions that sustains and enhances forest qualities amidst value conflicts that otherwise would weaken possibilities (FAO 1993, Romm 1993:291).

Sustainable forest management involves planning for the production of wood for commercial purposes as well as providing for the other forest products needs of local citizens and others. It includes the protection or setting aside of areas to be managed as plant or wildlife reserves or for recreational or environmental purposes. It is concerned with conversion of forest land to other uses, such as agriculture and housing developments, ensuring that such conversion is done in a properly planned and controlled way. It also covers the regeneration of wastelands and degraded forests (FAO 1993). Sustainable forest management also must define the role of the forestry sector in contributing to all aspects of the economy and society (FAO 1994*b*).

1.4.3. Sustained Yield.

> In its simplicity the concept [of sustained yield] offers an irresistible haven of intellectual security in a world of change, uncertainty, and doubt (Behan 1978:309).

Historically, forestry sought sustainability in the concept of sustained yield, or sustainable yield, expressed predominantly in terms of timber (Dixon and Fallon 1989, SAF 1993, FAO 1994*b*, Wiersum 1995). Sustained yield has been a tenet of faith among U.S. foresters since forestry emerged as a profession in the early twentieth century (Parry et al. 1983, Steen 1984, Walker 1990, Drielsma et al. 1990). In its simplest definition, sustained yield means that a resource is harvested at no greater rate than it is being created. For timber, all that needs to be done is to harvest the wood from a given forest at an average rate over a period of time that is no greater than that forest can grow it (FAO 1993). This generally translates into the idea that in a given year, the *removals* from a forest should not exceed the *growth* for that year. *Removals* are the harvested volumes of timber products and conversions to other land uses. *Growth* is the increment of growth added to the forest that year, net of the mortality from insects, disease, fire, or other causes that year. (Idaho data pertinent to this discussion are analyzed in **Chapter 3**. Overall, *growth* exceeds *removals* in Idaho by a considerable margin.)

The concept of sustained yield of timber is not quite as simple as it appears, however. The technical aspects of sustained yield also are much easier to state in words than to apply in action (Brown et al. 1987, de Vries 1989, Ludwig 1993, Leslie 1994, Gatto 1995). Several observers have suggested that few demonstrated and documentable cases of sustained yield forest management exist (see Mangel et al. 1993, Botkin and Keller 1995, Carpenter 1995).

The connotations and implications of sustained yield are many (Parry et al. 1983, Walker 1990, Alston 1991). In some situations, sustained yield implies *maximum* sustainable yield, or that annual removals *equal* annual net growth. On national forests, this translates into a debate as to whether sustained yield, expressed as allowable sale quantity (ASQ), represents either a precise target or a flexible ceiling for timber harvest levels (Brown et al. 1993*a*). Sustained yield also may imply non-declining even flow, or that harvest levels remain constant year-to-year. This may require achieving a "normal forest" where age or size classes are evenly distributed throughout the forest (Lee 1982, Parry et al. 1983). Deviations from a sustainable yield while achieving a normal forest (i.e., "the allowable cut effect") add to the complexity of the concept.

Sustained yield is a murky concept because how much timber is grown depends on the intensity of investment and management, which are not easy to predict (Behan 1978). The demands placed on the forest and investments in forest productivity are subject to changes in the perception of the social utility of the forest and changes in technology. A perpetual output is inconsistent with change, and physical models of sustained yield bear little relation to economic and social realities (Behan 1978).

Although sustained yield is a biological concept, it serves social functions (Parry et al. 1983). Sustained yield reveals as much about social ideas as it does about well managed forests (Lee 1982). For example, sustained yield became associated with a social function of stabilizing human systems, such as timber-dependent communities, forest-related occupations, and woodworking industries, that were thought to be economically dependent upon the flow of forest products (Wiersum 1995).

Sustained yield in U.S. forestry has a colorful history. It has been used as a mechanism to conserve forests, a social engineering tool to settle migrating woods workers, a control for keeping timber from public lands both off and on the market, a method for attempting to provide jobs and stabilize community economies, and a harvest planning tool (see Behan 1978, Lee 1982, Parry et al. 1983, Schallau and Alston 1987, Schallau 1989, Alexander 1989, Wear et al. 1989, Drielsma et al. 1990, Lee 1990, Carroll 1995, Carroll and Daniels 1995)..

1.4.4. From Sustained Yield to Sustainable Forest Management.

> The timber primacy aspect of traditional sustained yield failed to recognize that while trees may be biologically renewable, cut over forests, in the social sense, are transformed not renewed (Alston 1991).

> It is no longer enough simply to sustain timber yields if it is ultimately the forest that one wants to sustain (Johnson 1993:11).

> Today, it has become increasingly apparent that this notion of sustained yield fails to fully capture what is involved in the sustainability of forest ecosystems with multiple functions and values (Xu et al. 1995:685).

Management of the forest to provide a sustained yield of timber is what some foresters may have in mind when they talk of sustainable forest management. Such a concept focuses on the production of wood and/or wood fiber as an economic commodity and may not address the wider issues of the ecological and social functions of forests, with which timber production may only incidentally be compatible or may even conflict (FAO 1993, FAO 1994*b*).

Sustained yield of timber falls short as a proxy for sustainable forest management (SAF 1993). There are at least three reasons why. Traditional sustained yield forestry [a] does not ensure that the integrity of the system is maintained, in part because the focus on individual stands is too narrow; [b] does not adequately meet the desires of people for more attention to noncommodity values; and [c] is difficult to implement, given the increased emphasis required today on noncommodity values (SAF 1993).

Sustainable forest management means more than continuous commodity production at some rate. It also addresses the social and environmental issues associated with harvesting the resource (Meyer and Helfman 1993, FAO 1994*b*). The public views forests as much more than a supply of wood products and provider of wealth and employment (Kimmins 1995). Professor Wilkinson sums it up:

> [O]ur thinking has evolved; in many national forests, a broader view of sustainability is not being achieved. Only the specific resource being extracted—commercial timber—is being renewed. Other parts of the forests, which must be taken into account to achieve true sustainability, are in jeopardy. The health of certain fish and wildlife populations. Soil on steep slopes. The recreation economy. Species diversity. The ancient forests. View. Beauty. Glory. Awe. Sustainability is measured not by board feet but by the whole forest (Wilkinson 1992:299).

1.5. Conclusions

Sustainable forest management is an emerging paradigm that moves beyond the traditional measurement of sustainability as sustained yield of timber. Sustainable forest management includes ecological, economic, and social dimensions. Although our focus in this report is timber harvesting and forest management related to timber production, our intent is to move beyond the traditional concept of sustained yield and into the broader realm of sustainable forest management.

Timber harvesting is a part of sustainable forest management for some forests in Idaho. Timber harvesting is ecologically sound, economically viable, and socially desirable in some forests. Whether or not timber harvesting is sustainable depends on people's values, the policies that affect a particular forest, the management objectives of the owners of that forest, and ecological conditions and relationships within that forest. In subsequent chapters, we examine these factors that determine sustainability.

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Chapter 2. How important is the timber harvesting issue in Idaho?

As **Chapter 1** indicates, sustainable forest management is a concept based on human values. Social and economic perspectives, along with ecological conditions, determine the degree to which human actions are sustainable. People value forests for many reasons, and the importance they attach to those values determines, in part, whether forest management is sustainable.

Values affect people's views about the appropriateness of timber harvesting in Idaho's forests. In this chapter, we examine some of the social and economic values that make timber harvesting and forest management important and contentious issues in Idaho.

Although we focus on Idaho as the scale of analysis for social and economic values, the boundaries of that scale do not stop at the state line. Idaho participates in a regional and global economy and is part of society that extends beyond state borders. Consider, for example, that the regional economic center for much of northern Idaho is Spokane, Washington; most of the wood products manufactured in Idaho are exported out of state; and the recreation sector of our economy is dependent to some extent on out-of-state visitors. Additionally, more than 60 percent of the land base of Idaho is managed by the federal government for the American people; therefore, social perspectives of people outside of Idaho affect the management of resources within the state.

2.1. Forest Values

> Ideally, data should allow us to quantify and value, on a comparable basis, the full range of goods produced from forests—both timber and non-timber commodities; we also should have a basis for estimating the value placed on services provided by forests. ... For the most part, this remains an ideal. ... Our ability to quantify the magnitude and value of industrial timber products should not overwhelm our recognition of other benefits and values produced by forests (Brooks 1993:9).

Forest values are relatively enduring conceptions of what is good and desirable about forests and forest ecosystems (Bengston and Xu 1995). Numerous classifications for organizing forest values exist. Some models, like the quotation above, are based on an economic perspective, which depends on either tangible market values or proxies for them. Other valuation models list specific tangible or somewhat tangible values (e.g., Driver et al. 1987, Rolston and Coufal 1991, FEMAT 1993, Bengston 1994, Munasinghe and McNeely 1995, Rogers 1996, Forest Health Science Panel 1997). For example, the Forest Ecosystem Management Assessment Team (FEMAT 1993) described the following types of forest values:

- Commodity values—timber, range, minerals
- Amenity values—life style, scenery, wildlife
- Environmental quality values—air and water quality
- Ecological values—habitat conservation, biodiversity, threatened and endangered species
- Public use values—gathering, subsistence, recreation, tourism
- Spiritual values—sacred places
- Health—medicines
- Security—sense of social continuity and heritage (FEMAT 1993).

Other models incorporate a more philosophical approach to the ways humans value the environment (e.g., Merchant 1992, Manning et al. 1999, Parker et al. 2000). We look only at a limited set of tangible values in this chapter.

Determining the relative importance of values depends upon the ability to measure them, and therein lies a problem. Techniques for measuring some types of values are more developed and widely accepted than others. Commodity values, such as timber, are traded in the market place, and their value is usually quantified in monetary terms, or prices. This monetary or material worth is one of the common uses of the term "value." Ecological and environmental values are often quantified by describing the functions they serve. Public use and spiritual values are often quantified via surveys, rankings, and other social assessment techniques.

A second problem arises if one attempts to compare different types of values using a common metric because one does not readily exist. For example, attaching a price to the spiritual value of a particular place is not only methodologically difficult, but may be offensive to the sensibilities of some citizens (Bengston 1993).

Forest management has been called a "wicked problem" (Allen and Gould 1986) because it deals with competing values and views about resource allocation and use (Carroll et al. 1989). The question of what is valued in forests is crucial in the process of choosing between values, and ultimately, through the selection of appropriate criteria to be used in defining values, in determining how resource values are distributed among potential recipients (Bradley 1984). A broad array of disciplinary perspectives and methods—both quantitative and qualitative—is required to increase our understanding of all of the values of forests (Bengston and Xu 1995).

2.2. Social Values

> The paradox is that those social values for which our ability to define and measure is poorest, are the very ones that appear to be of increasing importance in our society (FEMAT 1993:VII-33).

> Foresters can probably manage for whatever values the public wants—but the current problem lies in achieving a consensus for what those values are (Gregg 1992:17).

2.2.1. Value Orientations. Individuals view the world differently. A particular perspective can be called an orientation, worldview, or paradigm, but regardless of what it is called it is a dominant belief structure that organizes the way people perceive and interpret the functioning of the world around them (Brown and Harris 1992). A person's perspective on the environment is based on her or his fundamental beliefs about the relationship between nature and humanity, other species' rights, humanity's right to change or manipulate nature, and society's responsibility to future generations (Kempton et al. 1995).

Value orientations regarding the natural environment have been categorized as a continuum with two ends—an anthropocentric (or utilitarian) end and a biocentric (or ecosystem) end (Brown and Harris 1992, Shindler et al. 1993). An anthropocentric perspective is a human-centered orientation toward the nonhuman world and thus gives a central position in these relationships to humans, human needs, and human satisfaction. Moreover, it assumes the nonhuman part of the environment is material to be used by humans as they see fit, which means that the environment is defined in terms of the resources it provides to humans rather than to other species. The nonhuman world is viewed as a storehouse of resources and is considered to have instrumental value only (Steel et al. 1994).

A biocentric perspective on nature does not give primacy to human wants and desires. Instead, it is a "nature centered" or "ecocentered" orientation. The biocentric view elevates the requirements and values of all natural organisms, species, and ecosystems to center stage and, in some versions, holistic views of the earth or nature become moral considerations. The biocentric orientation does not deny that human desires and human values are important, but places them in a larger natural or ecological context. In addition, it assumes that environmental objects have an inherent as well as instrumental worth. Adherents to biocentrism value the nonhuman world for its own sake rather than for only the sake of its utility to humans (Steel et al. 1994). The biocentric view is what many people characterize as environmentalism.

Some researchers have identified an anti-environmental view that lies beyond the anthropocentric end of the spectrum. The anti-environmental view suggests that the natural world is evil and dangerous, and needs to be conquered by humans. Sometimes this view is associated with particular Judeo-Christian beliefs, however this association has been refuted in a study of religion and environmental ethics in the southern United States (Parker et al. 2000). Although a perception exists that some individuals and groups hold an anti-environmental viewpoint, there is no evidence that people inhabiting the western states are more anti-environmental than people from elsewhere (Nie 1999).

Different value orientations toward nature are reflected in different views about forest management. People with more anthropocentric orientations tend to approach forest management with a utilitarian or resource conservation perspective that forests should be used for the betterment of humankind. Economic rationales and utilitarian social benefits dominate such thinking about forests (Steel et al. 1994). People with more biocentric orientations view human economic uses and benefits as not necessarily the most important uses of forests. There are noneconomic values and inherent values in forests that are just as distinctive as, and in some cases, more significant than, economic ones. In matters of human management, these values are to be equally respected and preserved even if they conflict with human-centered values (Steel et al. 1994). People with a more biocentric orientation are more likely to oppose traditional forest management practices than those with a more anthropocentric orientation (Steel et al. 1994).

The biocentric/anthropocentric spectrum of orientations toward nature has been reflected in resource management history for more than 100 years (see, e.g., Norton 1991, Cronon 1995, Callicott and Nelson 1998). The orientations are reflected in public resource management agency culture and actions (see, e.g., Hays 1959, Wellman 1987).

Because anthropocentric and biocentric viewpoints represent ends of a spectrum of values, individuals can have values that occur anywhere along it. Individuals can hold a mix of values that conflict with each other (Hays 1988). Such people may not be readily labeled as either anthropocentric or biocentric (Shindler et al. 1993).

Different segments of the public may hold different values. Values may vary by geographic area (e.g., Manning et al. 1999, Parker et al. 2000) or by professional training. For example, professional forestry literature expresses different values than mainstream environmental group literature, and environmental group literature expresses different values than mainstream news media (Bengston and Xu 1995). Scientists, administrators, and lay people have expressed differences in their environmental values (Kempton et al. 1995).

People's views on the sustainability of timber harvesting are affected not only by values, but also by perceptions and beliefs about the existing state of the forest and the consequences of actions affecting it (Harris, review comments). For example, in a survey of U.S. Forest Service employees, Brown and Harris (1998) found that respondent's beliefs about the resiliency of ecosystems to human actions were correlated with employee's anthropocentric/biocentric orientation.

It should be noted that the anthropocentric/biocentric spectrum is a Euro-American construct (Carroll, review comments). Although differences exist between tribes, in general, the American Indian worldview sees the land as simply home to people and all other organisms (see, e.g., Standing Bear 1933, Callicott 1983). Some evidence exists that American Indians view the natural world in a more spiritual and holistic manner than other Americans (Jostad et al. 1996), but debate exists as to how American Indian orientation towards the environment has translated into management of resources. The icon of the "ecological Indian" is ingrained in American culture—both Euro-American and American Indian. However, some historical perspectives question this stereotype (Krech 1999).

2.2.2. Values Shift.

> The widespread and intense debate reflects a new public conception of the purpose of forests in America. While the old view emphasized forests as sources of commodities such as timber, water, minerals, and rangeland, the new emphasizes forests as human environments that can be managed for the enjoyment of human life. Although commodities still play an important role in that enjoyment, a new set of values, emphasizing the benefits of natural environments, now play an increasingly important role in defining the American standard of living (Hays 1988:517).

> In addition to traditional forest-based commodities (timber, water, wildlife, forage), society increasingly values forests for such things as age, absence of human disturbance, biological diversity, and their role in regulating and mitigating climate change. Many of these newly emphasized values depend on an intact forest rather than on products, such as timber, that can be removed. It is important to recognize that these 'new' emphases are, at their core, still utilitarian and therefore in keeping with the traditions of forest management. But forest managers are understandably frustrated by the challenge of balancing and satisfying these diverse and often mutually exclusive expectations (Brooks and Grant 1992:25).

Since the 1960s, people in the U.S. have had an increasingly positive orientation toward environmentalism (Dunlap and Scarce 1991, Dunlap 1992, Bosso 1994). Environmentalism goes deeper than just opinion or attitude to core values and fundamental beliefs about the world (Kempton et al. 1995). Public attitudes toward natural resource use also have shifted, and research suggests that the long-dominant utilitarian and anthropocentric management paradigm is becoming more environmentally oriented and biocentric (Brown and Harris 1992, Shindler et al. 1993, Brunson and Steel 1994).

Forest values have shifted away from easily defined and measured economic or utilitarian values, and toward values that are much more difficult to measure such as "life support value" that have often been neglected or ignored (Bengston and Xu 1995). This shift in values is manifested in a new, more biocentric or holistic resource management paradigm emerging in the ranks of professionals in the U.S. Forest Service (Brown and Harris 1992). In 2000, this shift can be evidenced in new planning regulations elevating ecological sustainability and a national forest roadless area protection policy.

2.2.3. National Attitudes Towards Forest Management. The evolution in forest values involves increased diversity in the values various groups hold regarding forest resources and, therefore, increased complexity in demands placed on forest resources (Carroll et al. 1989). There is no consensus on how forests should be managed, and this is one reason why the public debate about the future of America's forest is so intense. For example, a poll by the citizen conservation group American Forests found that 52% of American voters favored managing forests, and 40% favored letting nature take her course (Smith and Clark 1994). To 47% of the respondents, managing forests includes logging on national forests, though a nearly equal number (44%) oppose timber harvests on national forests. Nationally 55% of respondents oppose more road building while 40% favor it (Smith and Clark 1994). Although a lack of consensus at the national level is evident, in 2000 new planning regulations make timber harvest in national forests more difficult, and a roadless area protection policy removes more than 50 million acres of national forests, or one-third of the system lands, from development consideration.

2.3. Forest Values in Idaho

What forest values are important to the people of Idaho? Unfortunately, there has not been an extensive, systematic research effort to look at forest or environmental values only for Idahoans. The research that exists either looks at a broader or more select group of people or does not probe deeply into values. Much of the research analyzes attitudes or opinions that are built upon values but may not be as deeply held (see McCool et al. 1997). Following is a summary of the limited research that has been done.

2.3.1. Environmental Protection and Economic Development. Since 1990, the Survey Research Center at Boise State University has conducted an annual *Idaho Public Policy Survey* of a random sample of Idaho residents addressing various policy issues, including environmental issues. Although the survey does not specifically address forest values, opinions about environmental policy may reflect underlying values about the environment and forests. Almost half (49%) of Idahoans feel emphasis in the development and management of Idaho's natural resources should be placed on the environment rather than on making the economy grow. About one third (33%) opt for making the economy grow over the environment. About one in six respondents (17%) think the emphasis should be placed on both goals (Scudder and Willmorth 1995). This question has been asked in every *Idaho Public Policy Survey*, with similar results (Moncrief 1994).

Idahoans are almost evenly split on how the amount now being spent on environmental protection should be changed. One third believe it should be increased, one third favor maintaining current levels, and one third believe it should be decreased (Scudder and Willmorth 1995). Also, Idahoans are almost evenly split between agreement (43%) and disagreement (45%) that environmental protections should be continued regardless of the cost (Scudder and Willmorth 1995). With such a split in public opinion, it is no wonder that environmental issues in Idaho are contentious.

2.3.2. Recreation and Timber Harvesting. In 1997, 77% of Idahoans agreed that timber harvesting is an appropriate use of a national forest (Scudder et al. 1998). In 1992, 62% of Idahoans approved of timber harvesting on public land (Raymond 1993). The 1997 survey found that 41% of Idahoans agreed that recreation uses should take preference over resource extraction activities on federal lands in Idaho; 52% disagreed (Scudder et al. 1998). A 1998 poll by Mason-Dixon Political/Media Research found that 47% of Idahoans believed there was too much emphasis on recreation and tourism on public lands, while 28% felt that there was too much emphasis on logging, mining, and grazing (Barker 1998). Most Idahoans appear to believe that timber harvesting is an appropriate use of public forests.

2.3.3. Federal Land Management. Much of the recent work on environmental and forest values in Idaho was done as part of the federal Interior Columbia Basin Ecosystem Management Project (ICBEMP). All of Idaho, except for the Bear River Valley in the southeastern corner of the state, is included in this region-wide assessment, along with the eastern parts of Oregon and Washington, and western Montana. When asked what the three most important factors concerning the future of public lands in the interior Columbia River basin (including Idaho) were, basin residents reported: resources for future generations, ecological health, and quality place to live (McCool et al. 1997). However, more basin residents reported timber production, livestock grazing, and economic opportunity as one of their top choice than did members of a national sample (McCool et al. 1997).

A majority of interior Columbia River basin residents agreed with the following views on federal land management policies: local communities should be given highest priority in decision-making (51%), endangered species laws should be altered to maintain timber and ranching jobs (53%), and greater protection should be given to fish (54%) and wildlife habitat (54%). Forty percent or more agreed that the survival of timber workers and their families is more important than preservation of old growth forests (42%), more wilderness should be established (40%), and greater efforts should be made to protect rare plant communities (42%). Only 15% of respondents agreed that insect outbreaks should be allowed to run their natural course (Trent 1995).

In a survey of residents of 8 selected counties within the 100 county interior Columbia River basin region, Rudzitis et al. (1995) found that the four most important ways federal land should be managed were to protect water/watersheds (20% of respondents), protect ecosystems (18%), recreational uses (17%), and timber harvesting (16%). By collapsing the categories of land management into either protective or commodity-based categories, protective strategies accounted for 75% of the responses, with commodity-based strategies making up the remaining 25% (Rudzitis et al. 1995).

2.3.4. Forest Management and Timber Industry. In 1992 and 1997, the Idaho Forest Products Commission—a quasi-state agency with an education mission, funded largely by forest products manufacturing company dues—sponsored a survey of Idaho residents to find out their attitudes about forest management and the forest products industry (IFPC 1992, IFPC 1997). When asked what was the most important environmental issue facing Idaho, the most frequent response (after "don't know") was water quality (19% in 1992, 16% in 1997). Only 2% in 1992 and 6% in 1997 identified the timber industry and logging as the most important issue. Timber harvesting can affect water quality, but the most salient issue to people was water quality itself.

In 1997, respondents were asked to rate the importance of various uses of Idaho's public forests. Source of clean water was rated most important, followed by fish and wildlife habitat, jobs, recreation, source of wood products, and monies for schools and roads (IFPC 1997).

In 1997, 75% of respondents thought that the term "forest management" brought forth positive connotations, and 83% believed that public forests benefit from management (IFPC 1997). In the 1992 survey, when asked what one concern they had about forest management in Idaho, one-third of respondents had no concern or did not know. Overcutting (12%), lack of reforestation (10%), and clear-cutting (8%) were the most frequently named concerns (IFPC 1992). In the 1997 survey, when asked what the most negative aspect of the forest products industry was, 25% did not know and 21% answered clearcutting/stripping of trees/cutting too many trees. The most positive aspects of the forest products industry included: employment (23%), products (15%), and income (12%) (IFPC 1997).

In 1997, when asked about the current level of timber harvest, 55% of respondents believed it should be maintained, 16% believed it should be increased, and 21% believed it should be reduced (IFPC 1997). These are almost identical to the 1992 findings (IFPC 1992).

In the 1992 survey, when asked about the future role of the timber industry in Idaho, 37% of respondents believed the industry would maintain its current level of importance. Almost an equal number of respondents believed that the industry would decrease in importance (28%) and increase in importance (27%) (IFPC 1992). In the 1997 survey, when asked to rate the importance of various industries to Idaho's overall economy, 60% of respondents rated the timber industry as important, but it ranked behind tourism and recreation (IFPC 1997). (Economic values associated with recreation are addressed in section ***2.4.3. Recreation***.)

2.3.5. Residential Differences in Values. One often hears debate about whether the values of those living in rural areas are different than those in urban areas and whether newcomers are different from long-time residents (see Fortman and Kusel 1990). McBeth and Foster (1994) found that rural Idahoans care about clean and abundant water, clean air, and open spaces. Although newcomers to Idaho expressed stronger environmental attitudes than long-time residents, both groups valued the quality of their environment (McBeth and Foster 1994).

2.3.6. Differences Between National and Local Values. In Idaho, it is particularly relevant to look at differences between national and local values because of the large amount of federally administered land in Idaho. Both local and national values are supposed to be taken into account in managing Idaho's national forests.

National and regional constituencies may place differing values on forests (Shindler et al. 1993, Brunson et al. 1994, Steel et al. 1994). No studies have compared only Idaho to national values, but several studies have looked at neighboring states or included Idaho as part of a larger, regional study.

Researchers used an array of statements classified into "commodity-based orientation" (anthropocentric) and "ecosystem-based orientation" (biocentric) to look at attitudes towards federal forest management in Oregon and nationwide (Shindler et al. 1993). They found that Oregonians were more supportive of commodity-based management than the public nationwide, but ecosystem-based orientation still received more support than commodity-based management. The difference was in the intensity of support rather than the direction (Shindler et al. 1993).

Although respondents to a survey in Oregon tended toward ecosystem-based orientation, a majority of respondents agreed that forest resources can be improved through human management (Steel et al. 1994). Also, respondents who depended on the timber industry for their economic livelihood were significantly less likely to have biocentric value orientations than their non-timber-dependent counterparts (Steel et al. 1994). The researchers hypothesized that Oregonians attitudes may be different from national attitudes because of the number of people employed, the visibility of forest management issues, and identification with the natural resource extraction culture and industry (Steel et al. 1994). Because both Oregon and Idaho are among the top three states in the percentage of labor income derived from forest products manufacturing (Keegan et al. 1997), the same relationship may hold in Idaho.

Brunson et al. (1994) used much the same questionnaire and techniques as Shindler et al. (1993) to assess attitudes in the Interior Columbia River Basin, including Idaho, and nationally. Again, eastside residents were slightly more likely to express anthropocentric attitudes than the national sample, but it was a matter of degree not broad philosophical disagreement (Brunson et al. 1994). In relation to federal land management, eastside respondents tended to favor economic over environmental concerns, whereas national respondents tended to favor environmental over economic concerns. "It is important to note, however, that even in the eastern Columbia Basin there are a substantial number of citizens who favor environmental protection, just as a substantial number of persons nationally lean toward economic protection" (Brunson et al. 1994:15).

2.3.7. Public Opinion vs. Public Judgment. The preceding survey results suggest that Idahoans, like most Americans, express positive opinions about many forest values—timber products, clean water, wildlife habitat, recreation, and aesthetic beauty, among others. The percentage of the population expressing those opinions varies depending on the wording of questions and what alternatives or trade-offs are included. Idahoans' values appear to be somewhat more commodity-oriented than the nation as a whole.

Surveys of public opinion have limitations as tools for public policymaking, however (Yankelovich 1991). Opinions may not be as deeply held as values and thus more subject to change. Surveys also do not tell us much about the salience of issues. For example, the large number of "don't know" answers in the Idaho Forest Products Commission surveys (1992, 1997) suggests that forest management may not be at the forefront of people's daily concerns. Survey questions also tend to be general and do not ask about specific places and actions. Surveys do not allow for in-depth exploration of alternative policies and their consequences.

Yankelovich (1991) has suggested that public policymaking might improve if "public judgment" were to replace public opinion. Public judgment exhibits "more thoughtfulness, more weighing of alternatives, more genuine engagement with the issue, more taking into account a wide variety of factors than ordinary public opinion as measured in opinion polls" (Yankelovich 1991:5). He suggests a three-step process to reach public judgment of "consciousness raising, working through, and resolution." If a public judgment process could be designed and implemented, perhaps the contentiousness of forest management issues could be reduced. However, processes for determining "public judgment" of sustainable forest management ends and means have not been devised.

2.4. Economic Values of Idaho Forests

Economics is the study of the way people, both individually and collectively, allocate resources. Economics is one way to describe how people make decisions about their well-being, or welfare. Economic theory assumes that people make allocation decisions based on the value resources have to them, and that the goal of each person is to maximize his or her welfare. Economic studies usually quantify value in terms of money and welfare in terms of income and jobs. Although these measures have their shortcomings, they nevertheless provide a common approximation of value.

2.4.1. Wood Products. The term "wood products," "forest products" and "timber products" are often used synonymously. These terms describe products that are made from the wood of the boles (trunks) of trees. These products include lumber, plywood and other wood-based panels, and paper and paper products.

Estimates of the amount of wood products consumed only by people in Idaho are not available; however, estimates are available for the entire United States. Since 1965 consumption of wood has risen from about 13 billion cubic feet to 20 billion cubic feet in 1998 and is projected to continue to rise (Figure 2-1) (Haynes et al. 1995, Howard 1999). Per capita consumption of wood has risen from 68 cubic feet/person to 74 cubic feet/person over the same period. Projections for the consumption of wood products are based on population, personal income, and overall economic activity, all of which are expected to continue to increase (Haynes et al. 1995).

Idaho's consumption of wood probably will follow the pattern of consumption for the rest of the U.S., perhaps growing even more rapidly. One reason is that Idaho's population is growing faster than the rest of the nation. Between 1990 and 1996, the population of Idaho grew 17.5%, well above the national 6.4% increase (Idaho Dept. of Labor 1997).

The forest products industry manufactures wood and paper products and historically has been and continues to be a significant part of Idaho's economy. (For a complete descriptive analysis, see Keegan et al. 1997, with some updated statistics in Keegan et al. 2000). Idaho's primary and secondary

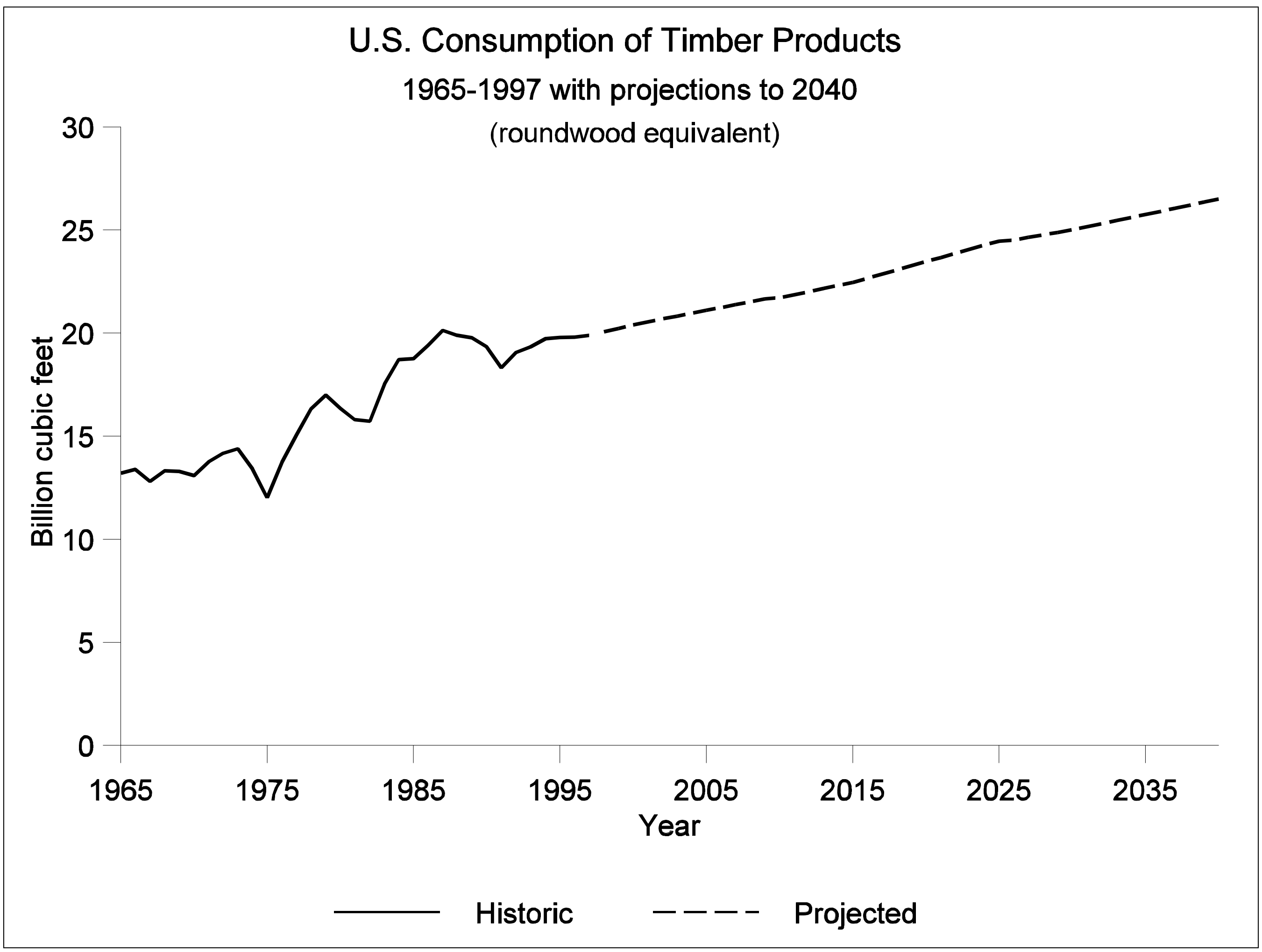


Figure 2-1. Estimated consumption of timber products in the U.S., 1965-1997, and projection of consumption, 1998-2040.

Sources: Haynes et al. (1995), Howard (1999).

forest products industry posted sales exceeding $2.4 billion in 1995 (Keegan et al. 1997). The forest products industry contributed approximately 12% of Idaho's gross state product in 1987 (Robison et al. 1991). Only agriculture (21%) and food processing (15%) contributed a larger share. However, the forest products industry is not spread evenly throughout the state. In 1987, in northern Idaho, the forest products industry contributed almost 45% of the region's gross product, while in southern Idaho it contributed only 4% (Robison et al. 1991).

In 1995, a total of 149 primary forest products plants operated in 29 of Idaho's 44 counties. Total sales in the Idaho primary forest products industry (i.e., lumber, plywood, and paper) were about $1.55 billion in 1995. In 1995, the 62 sawmills in Idaho used about 75% of the timber harvested in the state and produced about 1.7 billion board feet of lumber and other sawn products (Keegan et al. 1997).

Since 1954 lumber production in Idaho has ranged between 1.5 and 2.0 million board feet per year, except for three brief downturn periods (Figure 2-2). Idaho has consistently produced 5 to 6% of all softwood lumber manufactured in the U.S. (WWPA annual, 1962-1996).

In 1999, the forests product industry accounted for about 19,750 jobs in Idaho (Keegan et al. 2000). The industry provides about 10% of all basic industry employment in Idaho (Keegan et al. 1997). Employment in the forest products industry in Idaho has varied over the last 30 years, with a peak at about 22,700 jobs in 1979 and lows of about 15,400 in 1970 and 16,000 in 1982 (Figure 2-3).

The types of jobs within the forest products industry have been changing, too. The primary forest products industry, which produces products

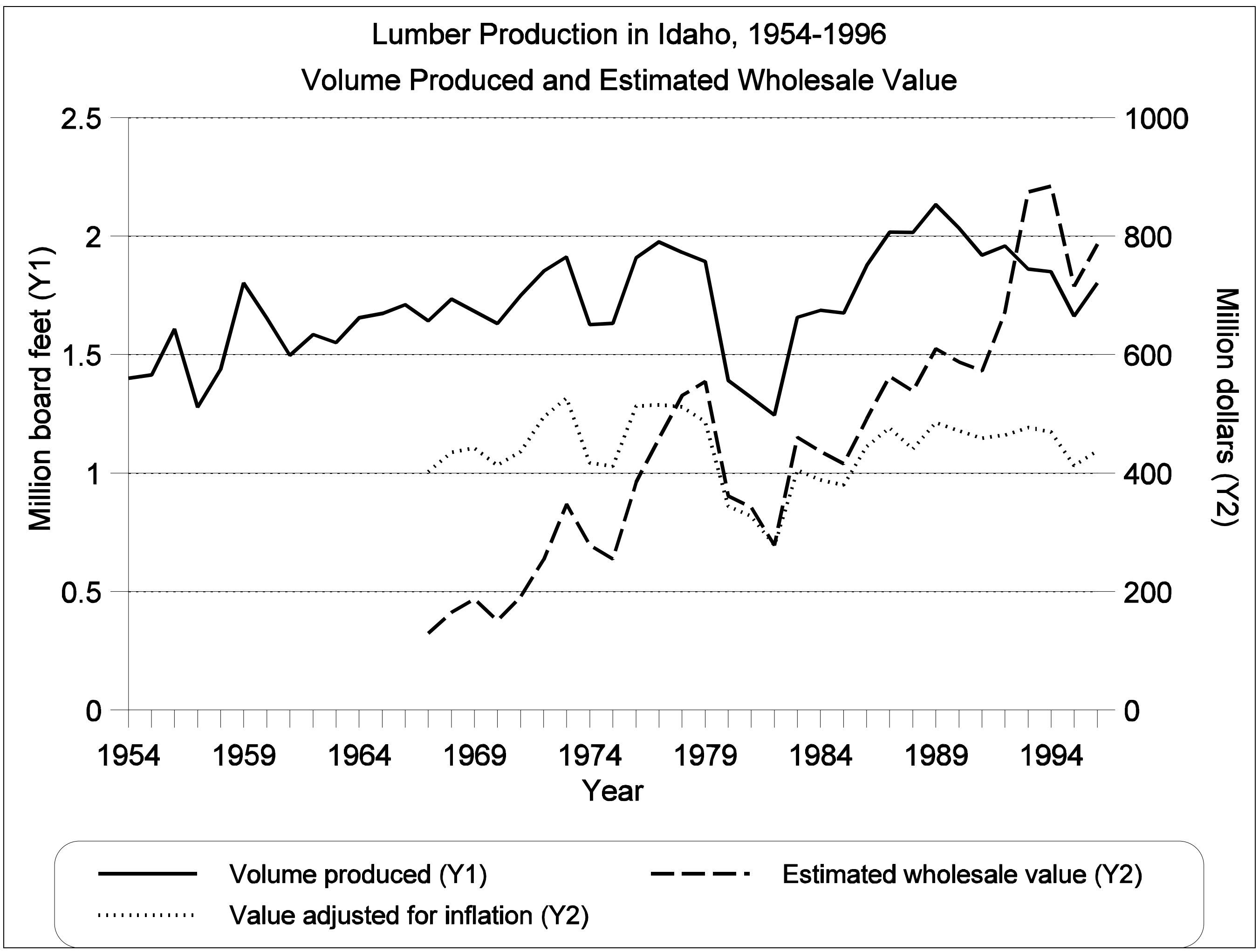


Figure 2-2. Volume of lumber produced in Idaho, 1954-1996, and estimated wholesale value 1967-1996.

Sources: WWPA (annual, 1963-1996).

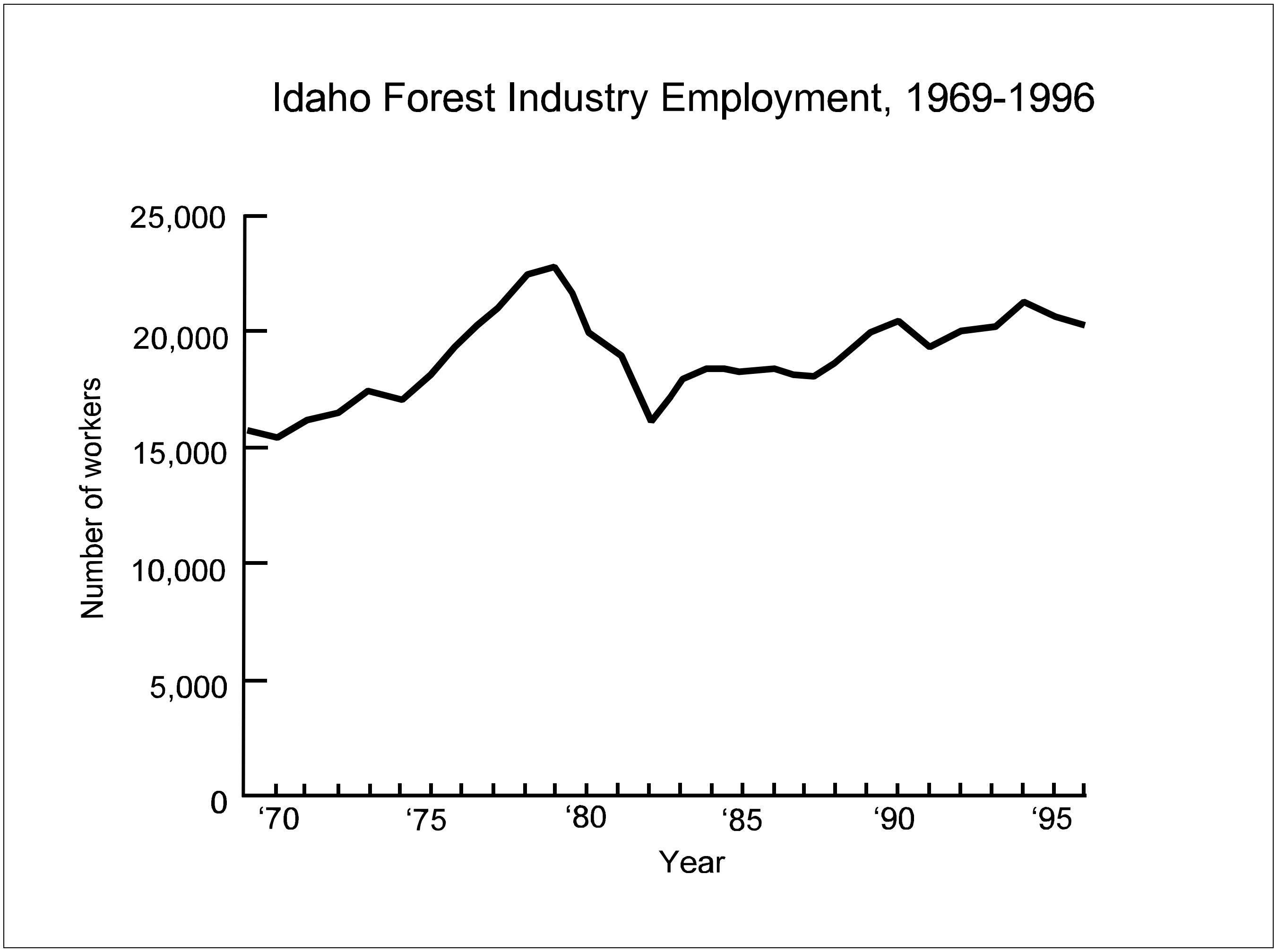


Figure 2-3. Idaho forest industry employment, 1969-1996

Source: Keegan et al. (1997).

directly from trees—lumber, plywood, pulp, paperboard, poles, etc.—experienced a decrease of 2,200 workers, or 13%, between 1990 and 1995. However, the secondary forest products industry—which uses the output of the primary industry to make items such as doors and windows, prefabricated buildings, containers, and furniture—has grown from 3,500 workers in 1990 to 5,800 workers in 1995, an increase of 66% (Keegan et al. 1997).

Forest industry labor income from 1993 through 1996 averaged $893 million. The industry accounts for about 16% of all basic industry income in Idaho. Idaho's forest products industry is a relatively high-wage industry, averaging $43,500 per worker in annual labor income in 1996, compared to $27,600 for all basic industries in Idaho (Keegan et al. 1997).

2.4.2. Non-timber Forest Products. People consume other products from forests besides wood. Many of the other uses of trees and forest plants have been termed "special forest products," or more recently, "non-timber forest products." Non-timber forest products include cones, boughs, wildflowers, herbs, berries, mosses, mushrooms, nuts, burls, bark, and other parts of the flora of the forest (Schnepf 1992, USFS & BLM 1994*a*, Freed 1995). These products are used for food, aromatics, basket making, decorative greenery, dyes, spices, flavorings, medicinals, and a variety of others uses (Schnepf 1992, Thomas and Schumann 1993, USFS 1993*a*).

Although people have been collecting and using non-timber forest products for thousands of years, only recently have researchers begun to gather information about the economic characteristics of these activities (Schnepf 1994, Savage 1995, Schlosser and Blatner 1995, Schlosser et al. 1995, Schlosser and Blatner 1997). The non-timber forest products industries are increasing in economic magnitude throughout the northwestern U.S. (Savage 1995). Schlosser et al. (1995) focused on the Northern Rockies, including northeastern Washington, northern Idaho, and northwestern Montana. Although non-timber forest products industries are smaller in this region than in the coastal regions of Oregon and Washington, they still provide some employment and income, and researchers believe that the potential for growth exists (Schlosser et al. 1995).

Information specific to Idaho was found in one study of the wild edible mushroom industry (Schlosser and Blatner 1995). In 1992 nearly half a million pounds of mushrooms per year were harvested from Idaho's forests, and 170,000 pounds were processed within the state (Schlosser and Blatner 1995). The total value of the mushroom industry in Idaho that year was $1.6 million (Schlosser and Blatner 1995).

2.4.3. Recreation. Recreation is another forest "product" that receives much attention. Although not all outdoor recreation is forest-based, much of it is, and even activities that may not take place directly in the forest are dependent on forests. For example, fishing takes place in streams, rivers, and lakes, and forests help control the quantity and quality of water in forested watersheds.

A word of caution is warranted about the estimates of recreation visitation presented in this section. Several researchers have questioned the reliability of these estimates, particularly those made by the U.S. Forest Service (see Schallau et al. 1998). For example, most estimates for wilderness visitation are based on "observation and 'best guesses,'" and in 1989, only 13 percent of U.S. Forest Service wilderness areas used systematic counts to estimate visitation (Cole 1996). More accurate and consistent recreation visitation data are needed (see Loomis 2000).

Although no estimates for consumption of all forest-based recreation in all of Idaho exist, several sources provide useful pieces of information. The Interior Columbia Basin Ecosystem Management Project (1997) said that 80% of Idahoans reported hiking or camping in the past year and 56% reported fishing or hunting. In 1991, 77% of Idaho residents reported participating in wildlife-associated recreation (e.g., hunting, fishing, birdwatching), which often takes place or is dependent on forests (USFWS & USBOC 1993). In 1995, an estimated 14.5 million recreation visitor days took place on national forests in Idaho, up from 9 million in 1976 (Figure 2-4).

Consumption of forest-based recreation has been increasing and is expected to continue to do so (Cordell et al. 1990). One projection estimated a tripling of demand for recreation trips in the Rocky Mountain region between 1987 and 2040 (English et al. 1993).

Determining the economic value of forest-based recreation is not an easy task. Unlike timber, which is sold in the market place and its value imputed from its price, much forest-based recreation, particularly on public lands, is provided at no direct cost to the consumer. While consumers may pay taxes, incur travel expenses, and purchase equipment, for many activities entrance fees or prices that reflect the value of the activity are not charged.

Economists have taken several approaches to estimating the economic value of recreation (see, e.g., van Kooten 1995, Swanson and Loomis 1996, Loomis and Walsh 1997). It is beyond the scope of this report to debate the technical merits of these approaches, except to say they are controversial, but we will provide some examples of results.

One approach is to measure the monetary transactions (spending and income) that are related to recreation. Recreation and leisure travel ranks fourth—behind agriculture, food processing, and wood products—among natural-resource-based industries in terms of the proportion of Idaho's income produced (Harris and Robison 1992). The U.S. Fish and Wildlife Service and U.S. Bureau of the Census (1993) estimate that residents and non-residents spent $206 million in 1991 on trip-related expenditures for wildlife-related recreation in Idaho. Many species of wildlife depend on forests.

Another study found that non-resident rafters on the Middle Fork of the Salmon River spent an average of $1,284 within the state of Idaho (English and Bowker 1996). Each 1,000 outfitted trips involving non-residents created $2.2 million in total industrial output (the market value of goods and services produced), $1.2 million in income, and 55 jobs. At 1992 trip levels, this accounted for $9.7 million in industrial output, $5.2 million in total income, $5.8 million in value added, and 238 jobs (English and Bowker 1996). While not all of this income and spending is directly related to forests, the Middle Fork of the Salmon flows through a forested watershed that affects the water quality, aesthetic quality, and the overall recreational experience.

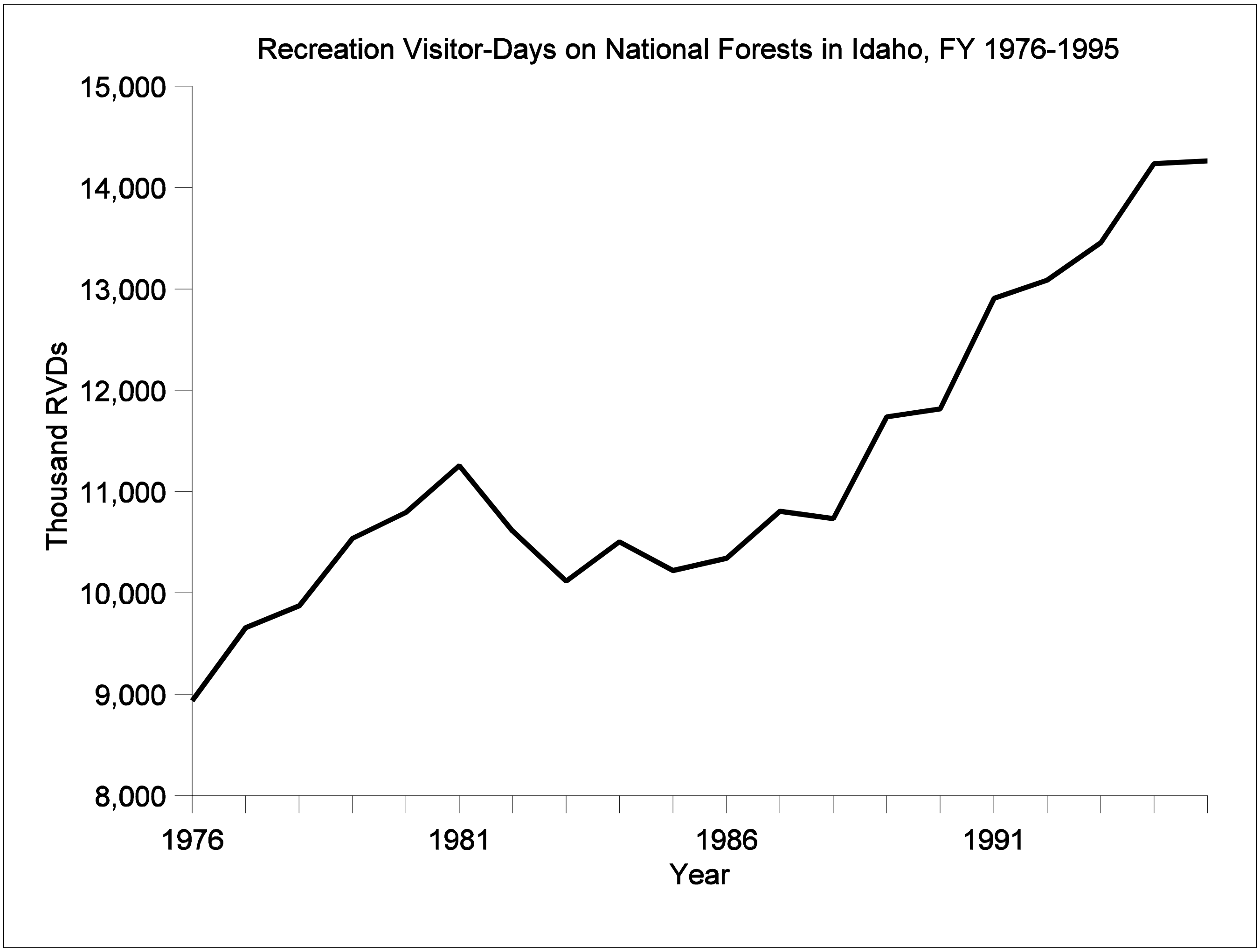


Figure 2-4. Recreation visitor-days on national forests in Idaho, FY 1976-1995.

Source: USFS (annual, 1976 to 1996).
Note: A recreation visitor-day (RVD) is 12 hours of visitation by one or more persons.

Another approach to determining the economic value of recreation involves determining the value of the recreation experience above the expenses incurred, or the "net" economic value. Many recreation opportunities, particularly on public lands, are provided at little or no charge to the recreationist other than the cost of getting to the recreation site. Yet, people value these experiences and would be willing to pay more for them. The difference between what they actually pay and their "willingness to pay" is the net economic value. In the mid-1980s, the U.S. Forest Service published a series of studies that valued many types of wildlife-associated recreation in Idaho (Donnelly et al. 1985, Loomis et al. 1985, Sorg et al. 1985, Sorg and Nelson 1986, Donnelly and Nelson 1986, Young et al. 1987, Sorg and Nelson 1987).

As an example, Sorg and Nelson (1986) found fishing valued at $21 to $27 per day. If these values remained unchanged in 1991 when more than 3 million days of fishing took place in Idaho (USFWS & USBOC 1993), the net economic value of fishing would be $66 to $85 million for that year.

2.4.4. Other Economic Values. We have barely scratched the surface of what the total economic value of forests in Idaho might be. Studies to determine the economic value of the environmental services of forests at large scales have only recently been undertaken (e.g., Randall et al. 1990, Costanza et al. 1997) and face many methodological problems. Determination of economic values and the contribution of nonmarket products of forests continues to be a ripe area for research inquiry.

2.4.5. Growth and Development. In addition to questions about the value of various products from forests, broader questions exist about how these values fit into the overall economic and social structure of Idaho. What are the roles of forests, and the various resources we get from forests, in the growth and development of Idaho? For many years, resource extraction has been a primary source of economic and social development. For example, local economies were built around sawmills and other wood product manufacturing facilities. Social structures developed around these "timber towns." But just as the array of values people expect from forests is changing, so is the array of forest values that contribute to economic growth and social development.

There seem to be two viewpoints on the role of forests in economic development. One view is based on the traditional "resource extraction" model, the other is the "quality of life" model. There are important policy debates conducted over which of these models is appropriate. The PAG has undertaken a project to report on these issues at a later date.

2.5. Importance of "Place"

It is easy to talk in generalities about people valuing forests for timber, wildlife, recreation, scenery, and other attributes, but often what is important to people are specific forests or areas within forests, i.e., "places." Over the last decade, research has begun to explore how and why people value, care about, and become attached to particular places. "Place," "place attachment," and "sense of place" are all terms used for concepts in this field of research (Williams and Stewart 1998, Walsh 2000).

In the research literature, a "place" is a geographic area that has meaning to people. It is through the mental construct of place that people relate to and understand a geographic area (Kaltenborn 1997, Galliano and Loeffler 1999). A place is a collection of meanings, beliefs, symbols, values, and feelings that individuals or groups associate with a particular locality (Williams and Stewart 1998). Sense of place refers to the connections people have with the land, their perceptions of the relationships between themselves and a place, and is a holistic concept that encompasses symbolic and emotional aspects (Brandenburg and Carroll 1995, Kaltenborn 1997, Galliano and Loeffler 1999, Eisenhauer et al. 2000).

Research studies that have generalized people's concerns about forest uses or focused solely on economic considerations have not been sufficient for understanding public perceptions of forest management decisions and actions. Those approaches need to be supplemented with considerations of sense of place and other social phenomena to better comprehend factors that influence reactions to management actions (Mitchell et al. 1993, Williams and Patterson 1996, Williams and Stewart 1998, Eisenhauer et al. 2000). Policies based on substitutability will not be acceptable to users because of the nature of their connections with places regarded as special (Eisenhauer et al. 2000).

Resource managers are just beginning to recognize the importance and impact of attachment to place in forest planning and management (Williams et al. 1992). Attachments to places heighten concerns about their management (Eisenhauer et al. 2000). Exploring the concept of "place" can be useful to forest managers offering them a way to anticipate, identify, and respond to the bonds people form with places (Williams et al. 1992, Mitchell et al. 1993, Williams and Stewart 1998, Eisenhauer et al. 2000).

Idaho has many special places, and we are just beginning to understand people's attachment to them. This may be one reason arguments about timber harvesting and forest management are so passionate. Although we often use generalities in this report, as a statewide analytical scope requires, the reader should bear in mind that it is specific places in the forest that people care about upon which generalizations are built.

2.6. Conclusions

How important is the timber harvesting issue in Idaho? The answer depends on how importance is measured. In this chapter, we looked at social and economic values as measures of importance. People value forests in Idaho for many reasons, and timber harvesting has the potential to affect those values. Timber for wood products has value, but people also value forests for less tangible things such as recreation, scenic beauty, and solitude. Some values can be measured better than others, and some can be expressed in monetary terms. We have reported on many of those values here. However, the values that are difficult to measure and cannot be expressed monetarily may be just as important as those we can. To move towards sustainable forest management, we need to increase our understanding of all forest values and how they are affected by timber harvesting.

Chapter 3. What is the timber situation in Idaho's forests?

As **Chapter 2** emphasizes, the forests of Idaho produce many products and services that people value, and one of those products is timber. Because a focus of this report is the sustainability of timber harvesting, this chapter provides basic information about Idaho's timber resources. Given that there are millions of acres and billions of trees, quantitative data can become numbingly abstract, especially when presented in tabular formats. We use charts and graphs to illustrate key analytical points.

Most of the statistics presented herein are based on the periodic forest inventory conducted by the U.S. Forest Service. These basic statistics have been collected at irregular intervals since 1952. With appropriate caution these data are used to describe trends in forest conditions. We summarize these trends somewhat like an earlier PAG report on forest health conditions in Idaho (PAG Report #11, O'Laughlin et al. 1993). In section **3.4. Sustaining Healthy Forests** we update the concepts and data associated with forest conditions in Idaho since the PAG's 1993 work.

3.1. Timberland Base

Approximately 22.3 million of the 53.5 million acres in Idaho are classified as forest land, i.e., land at least 10% stocked with trees (see **Glossary**). About 21.4 million acres of the forest land in Idaho are classified as timberland, i.e., forest land where at least 10% of the trees are those traditionally harvested for industrial wood products (Brown and Chojnacky 1996). Almost 4 million acres of timberland (18%) are reserved, i.e., withdrawn from timber harvesting by statute, specifically the Wilderness Act. Timber harvesting is not prevented by law on the remaining 17.6 million acres (82%) of timberland. However, administrative designation in 2000 of approximately 9 million acres of national forests in Idaho as protected roadless areas removes at least 2 million acres of undeveloped timberland from timber harvesting (from data in PAG Report #11, O'Laughlin et al. 1993, Table 1-2). Throughout the remainder of this chapter, "timberland" will be used to refer to the non-reserved timberland that existed in the last statewide inventory statistics published by the U.S. Forest Service (see Brown and Chojnacky 1996).

More than 14 million acres (81%) of timberland in Idaho are in public ownership (Table 3-1). Almost 13 million acres (73%) of timberland are in the National Forest System that is managed by the U.S. Forest Service. Other public agencies own 9%; much of that is state of Idaho timberlands (5%). Forest industry owns 7%, and other private entities own 11% of the timberlands (Table 3-1).

A look at the trend in timberland acreage reveals that it has remained relatively constant since 1952 (Figure 3-1), but it also illustrates a problem with looking back at previous inventories. From 1952 until 1970, timberland acreage remained at about 15 million acres. By 1977 that figure had dropped slightly, to 13.5 million acres, not because of reduced areas covered with trees, but because of administrative withdrawals, such as wilderness study areas, that reduced the amount of non-reserved land.

The increase of 3.1 million acres in timberland between 1987 (14.5 million acres) and 1991 (17.6 million acres) is more difficult to explain. One reason is that the definition of timberland was made less restrictive in the *Idaho Forests, 1991* analysis by the U.S. Forest Service (see Brown and Chojnacky 1996). That analysis relaxes the requirements for timberland. The standard definition of timberland used by the U.S. Forest Service is land capable of producing 20 or more cubic feet per acre per year (see **Glossary**). The redefinition of timberland by the Forest Service does not entirely explain the difference because, according to Brown and Chojnacky (1996), only 382,493 acres of non-productive (<20 cu.ft./acre/year) "timberland" exist in Idaho. Most of the three million acre difference in the 1987 and 1991 Forest Service reports cannot be explained. This does not surprise us. As careful students of public lands statistics, we have previously noted that the federal government has "lost" more than one million acres of federal land in Idaho in its statistical reports. This was a result of a 1988 Forest Service reporting error that has not yet been corrected in the *Public Lands Statistics* reports published periodically by the U.S. Department of the Interior-Bureau of Land Management.

3.2. Timber Inventories

One prerequisite to determining a sustainable timber harvest level is an adequate inventory of the timberland base (AFSEEE 1994, Van Deusen et al. 1999). It is not clear, however, that such data exist for the state of Idaho as a whole. Timber inventories tend to vary in their timeliness, accuracy, and usefulness because of the variety of ownerships of the timber

Table 3-1. Idaho timberland area by ownership, 1991.

Ownership class	*1,000 acres*	*percent*
Public		
National forest	12,808.5	72.7
Other public		
Bureau of Land Management	522.3	3.0
Miscellaneous federal	39.9	0.2
State	968.3	5.5
County and municipal	6.6	<0.1
Total other public	1,537.1	8.7
Total public	14,345.6	81.4
Private		
Tribal trust	93.8	0.5
Forest Industry	1,239.5	7.0
Other private	1,934.5	11.0
Total private	3,267.8	18.6
Total timberland area	17,613.3	100.0

Source: Brown and Chojnacky (1996).

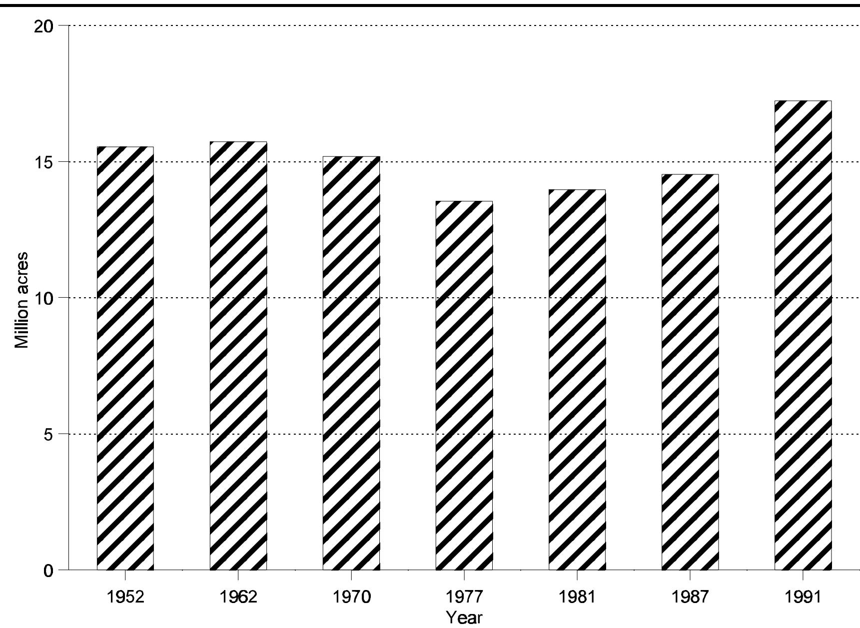


Figure 3-1. Idaho timberland area, 1952-1991.

Sources: Benson et al. (1987), Waddell (1992), Brown and Chojnacky (1996).

Table 3-2. Most recent inventory for Idaho national forests, as of 1996.

National forest	Inventory date
Idaho Panhandle N.F.	1988
Clearwater N.F.	1991
Nez Perce N.F.	1991
Boise N.F.	1983
Caribou N.F.	1993
Challis N.F.	1974
Payette N.F.	1991
Salmon N.F.	1989
Sawtooth N.F.	1981
Targhee N.F.	1991

Source: Brown and Chojnacky (1996).

resource and institutional arrangements between public owners.

Timber inventories are conducted by a variety of entities, depending upon land ownership. Non-industrial private forest owners may inventory their lands, but are not required to do so. Industrial forest owners usually keep an accurate and up-to-date inventory because the success of their industrial forestry operations as a source of fiber for manufacturing facilities depends on it. Industrial and non-industrial private owners' inventories are private records; therefore, these owners can choose how much information to share with the public.

On state timberlands the Idaho Department of Lands (IDL) uses permanent plots located throughout its lands to conduct its timber inventory. These plots have been established for more than 30 years. In the past, state lands have been inventoried on a 10-year remeasurement cycle, but IDL is currently switching to a 5-year cycle. Each of the eight IDL supervisory areas in the state is responsible for its own inventory, but there is coordination and analysis at the state level (Ron Litz, personal communication).

The timber inventories for national forest lands we report herein were conducted by each national forest; however, the responsibility for conducting such forest-wide inventories is changing (see ***3.2.3. New Directions for the Forest Inventory and Analysis (FIA) Program***). National forests were supposed to conduct forest-wide inventories at least every 10 years or as planning needs dictated (USFS 1992); however, the cycle has tended to be longer (Gillespie 1999*b*). In Idaho, the most current forest-wide inventory information for national forests is almost 10 years old, or in some cases, older (Table 3-2).

3.2.1. The Forest Inventory and Analysis (FIA) Unit of the U.S. Forest Service. The Forest Inventory and Analysis (FIA) program is a research work unit of the U.S. Forest Service. The FIA unit is responsible for collecting, analyzing, and reporting inventory information for all forest ownerships. This information is used by a variety of public agencies and private entities for planning at many levels (Gillespie 1999*a*, Van Deusen et al. 1999). The FIA's work program is designed to present a broad-scale picture of forest resources, useful from the national scale down to areas of about 200,000 acres (Gillespie 1999*b*). The FIA's analysis is public information and provides the data base for the analysis in this chapter, most of which appears in the Forest Service report by Brown and Chojnacky (1996). A convenient feature of the FIA program is the availability of the forest inventory database on the internet (see USFS 2000*a*).

Until 1998, the FIA program used its own sampling and inventory procedure for all ownerships, except national forests (USFS 1992). In the western U.S., including Idaho, the FIA relied on the national forests' own inventories. The FIA's remeasurement cycle was 10 years, with Idaho's most recent measurements in 1990 or 1991 (Brown and Chojnacky 1996). In 1998, the FIA program became responsible for inventory on all forest ownerships, including national forests, and set new targets for the remeasurement cycle (see ***3.2.3. New Directions for the Forest Inventory and Analysis (FIA) Program***). However, the data we report herein are based on pre-1998 inventories.

The FIA had been criticized because its analyses relied on inventories conducted by individual national forests (Gillespie 1999*b*). Another criticism was that not enough attributes of the forest ecosystem were being measured; the variables were concentrated too much on the timber resource. Additionally, the FIA was criticized because sampling design varied between regions (Frayer and Furnival 1999). Timeliness of FIA information was also a concern (Van Deusen et al. 1999). In 1992, the Blue Ribbon Panel on Forest Inventory and Analysis proposed six high priority areas for improvement of the FIA work unit, including expanded information on ecosystem and noncommodity values; more emphasis on social impacts on forest productivity; a five-year inventory cycle; uniform inventory procedures for all ownerships; consistency between different FIA units; and enhanced coordination between the FIA and other public agencies (Blue Ribbon Panel 1992). A second Blue Ribbon Panel, convened in 1997, found the U.S. Forest Service had made little progress toward the priority areas set by the first panel (Blue Ribbon Panel 1998).

3.2.2. Problems With Inventories of the National Forests. The lack of timeliness and questions about accuracy have led many observers to question the usefulness of any and all national forest inventory data. National forests in Idaho are administered by two regions of the U.S. Forest Service: Region 1, the Northern Region, includes national forests in northern Idaho and Montana; and Region 4, the Intermountain Region, includes national forests in southern Idaho, Wyoming, Utah, and Nevada. The following critique emphasizes problems in Region 1, particularly in Montana, and may or may not be indicative of inventory problems in the national forests of Idaho.

Accurate inventories of national forest resources are required by the National Forest Management Act (NFMA, 16 U.S.C. § 1603). Work done by Montana researchers leads one to question whether the Forest Service has such information. In 1992, a study team was convened to assess the timber supply situation in Montana. The team included representatives from the University of Montana, the Montana Department of State Lands, and the U.S. Forest Service Intermountain Research Station. The study team was unable to reach any conclusion regarding the sustainability of harvest on national forest lands in Montana because existing inventory data for the national forests were inadequate (AFSEEE 1994, Jackson 1994).

One problem appears to have been that the Forest Service was unable, or perhaps unwilling, to separate inventory data on lands identified as "suitable for timber production," a requirement of the NFMA, from information about all its lands. There were indications by regional staff that inventory data had been lost (Jackson 1994). In addition, the Montana study team was working with data based on field work that was two decades old. Although the plot data were updated in 1990, methods of updating were not documented (Jackson 1994).

Problems with national forest inventories are not confined to Region 1. In an October 1992 memo from the Washington office to regional foresters, a Forest Service official noted that "some western Regions were unable to provide adequate data to meet regional and national needs for forest growth, mortality, and forest health information" (Jackson 1994, quoting George Leonard). The memo directed regional foresters to initiate a new timber inventory that would allow the agency to examine timber trend information (Jackson 1994).

In a different study, Yanishevsky (1994) noted that the Forest Service has failed to develop comprehensive, reliable old-growth inventories. Without inventories of old-growth habitat at the landscape level, it is impossible to analyze the cumulative effects of timber management. The Forest Service typically prepares old-growth maps only for specific analysis areas, and only when a timber sale is proposed (Yanishevsky 1994). An exception is the Idaho Panhandle National Forest, which has field-verified a substantial portion of old-growth stands;

Table 3-3. Standard sampling error for growing stock on non-reserved timberland in Idaho.

	National forest	Other owners	Total
Attribute	*Percent standard error*		
Net volume, 1991	1.8	3.5	1.6
Annual mortality, 1990	5.3	8.5	4.5
Net annual growth, 1990	3.3	4.6	2.7

Source: Brown and Chojnacky (1996).

however, the proportion varies among ranger districts (Yanishevsky 1994).

3.2.3. New Directions for the Forest Inventory and Analysis (FIA) Program. In 1998, Congress recognized the shortcomings of the FIA forest inventory data and passed legislation requiring a more timely and thorough forest inventory for every state (Public Law 105-185, Agricultural Research, Extension, and Education Reform Act of 1998, § 253 (c)). Public pressure helped create this mandate for change (Van Duesen et al. 1999). The law requires the implementation of an annual forest inventory system. A wider array of data is to be collected on 20% of all plots in every state every year. Reports for each state are to be produced at five year intervals (USFS 1998, Gillespie 1999*a*). The U.S. Forest Service has developed a strategic plan for implementing the law and estimates the cost of the new program to be $82 million per year (USFS 1998). For comparison, the total funding available for the FIA program in FY 1999 was $28 million (USFS 2000*a*).

The revamped FIA program integrates the former FIA program with the field portion of the Forest Health Monitoring program. This will increase efficiency by eliminating duplication between these programs and will deliver a more integrated, easy-to-use database covering a wider array of ecological data about forests. The FIA program is now responsible for conducting consistent, strategic-level forest inventory on all forest lands of the U.S., including national forests (Gillespie and Smith 1998, USFS 1998).

The new FIA program will have approximately 80 core variables that are collected on all plots each year and approximately 45 extended core variables that are collected on a subsample of forested plots each year. These variables will be documented in a national field guide and will be implemented in a consistent fashion across the country (Gillespie and Smith 1998, USFS 1998).

The transition to an annual inventory system and expanded array of forest ecosystem variables, along with other changes under the new FIA program, in the long run will be in the best interest of customers whose greatest needs are for current information and a flexible program framework (Gillespie 1999*a*). If the new program can simultaneously address the existing problems of inconsistency in methods and incompleteness in coverage and can form partnerships to make available the resources needed to increase the timing and scope of data collection and analysis, then it will be able to create a collaborative FIA program that will deliver better information for many years to come (Gillespie 1999*a*).

3.3. Idaho Timber Statistics

Despite the shortcomings outlined above, the FIA program provides the only statewide forest inventory data for all ownerships in Idaho. The most recent published reports are *Idaho's Forests, 1991* (Brown and Chojnacky 1996) and the *1997 RPA Assessment of the Nation's Forests* (draft USFS 1999*a*). The data and accompanying analysis in U.S. Forest Service reports are the basis for many of the statistics reported in this chapter. In addition, we computed additional statistics using the FIA program's interactive database (cited as Forest Inventory and Analysis 1997). The standard errors for sampling in Idaho as reported in Brown and Chojnacky (1996) are presented in Table 3-3. Definitions of technical forest inventory terms used in this section can be found in the **Glossary**.

Table 3-4. Idaho timberland area by productivity class and ownership, 1991.

	Ownership group				
	National forest	**Other public**	**Forest industry**	**Other private**	**All ownerships**
Productivity class (cu.ft./acre/year)	*1,000 acres*				
225+	8.9	0	7.1	0	16.0
165-224	227.4	78.5	83.6	97.0	486.5
120-164	1,535.0	298.8	280.6	416.2	2,530.6
85-119	3,230.0	538.0	555.3	655.6	4,978.9
50-84	4,065.0	394.5	291.8	674.1	5,425.4
20-49	3,395.8	213.9	20.9	162.7	3,793.3
0-19	346.4	13.4	0.0	22.7	382.5

Source: Brown and Chojnacky (1996).

Readers may notice a difference of 382,493 acres between the 17,613,343 acres of timberland reported by Brown and Chojnacky (1996) and the 17,230,850 acres of timberland used as the basis for some of the figures we calculated. This results from Brown and Chojnacky (1996) including the lowest productivity class (0 to 19 cubic feet per acre per year) in their analysis, whereas FIA's interactive database (Forest Inventory and Analysis 1997) does not include this acreage. This illustrates part of the consistency problem described by critics of FIA (Blue Ribbon Panel 1992, 1998).

We also urge caution in interpreting values for trends and particularly those including volume measurements. We have assembled whatever trend data for timber inventory was available. Trends show what has happened to forests over a period of time. Because changes in ecological, social, and economic systems affect forests, a look at trends in timber inventory statistics seems appropriate. However, the accuracy of the trend analysis is only as good as the data on which it is based. Brown and Chojnacky (1996) warn that methods for obtaining land area data are fairly consistent over time, but volume estimation can vary due to field sample selection, data collection, and data processing methods. Although U.S. Forest Service data analysts (Brown and Chojnacky 1996) suggest restricting trend comparisons with earlier inventories only to land area data, we nevertheless present some trends in volume-related statistics. We believe the direction and magnitude of changes are accurate trends, although the exact values may be inaccurate.

3.3.1. Productivity. How productive a forest is depends on the product and how production is measured. For timber, productivity is measured as the potential timber yield capability of the forest, generally measured in cubic feet per acre per year, and is usually calculated as a function of site index (Brown and Chojnacky 1996). Site index is an attempt to measure the inherent productivity of the land, or the ability of the land to produce timber regardless of the type and condition of forest on the land.

In Idaho there are slightly more than 3 million acres of high productivity timberlands—producing at least 120 cubic feet per acre per year (Table 3-4). More than half of these are national forest lands. Idaho timberlands, especially those in the northern part of the state, are among the most productive in the nation (Wilson and Van Hooser 1993). Only five southern states and three western states (California, Oregon and Washington) have more acres of high productivity lands than does Idaho (data from Powell et al. 1993).

Table 3-5. Idaho timberland area by age class, 1991.

Age class	Ownership group				All ownerships
	National forest	Other public	Forest industry	Other private	
years	*1,000 acres*				
1-10	929.8	131.5	226.5	123.2	1,411.0
21-30	272.5	50.5	38.4	66.8	428.2
31-40	324.2	59.8	76.0	106.2	566.1
41-50	802.8	86.6	70.4	246.0	1,205.8
51-60	1,124.2	174.1	111.5	207.0	1,616.8
61-70	1,198.8	179.8	153.0	393.3	1,925.0
71-80	1,474.5	192.9	148.0	308.9	2,124.3
more than 80	6,335.3	671.6	459.9	486.9	7,953.7
Total	12,462.1	1,546.7	1,283.7	1,938.3	17,230.9

Source: Forest Inventory and Analysis (1997).

3.3.2. Age. The age of trees is a key characteristic of forests. The issues of "old growth" and "ancient forests" relate to forest age; however, usually it is the increased size of trees and structure of the forest resulting from age that is important, not age itself. Large trees and complex structure are important habitat attributes for some wildlife species. Age may also play an important part in the psychological and cultural significance people attach to a forest. From a timber growing perspective, age is important because older trees grow more slowly and become more susceptible to mortality from pests and diseases.

A forest may be even-aged, where all trees growing in a particular area are basically the same age, or uneven-aged, where trees ages vary. These two types of forests develop under different ecological conditions and silvicultural treatments. Many of Idaho's dry forests developed under fire regimes that tend to result in even-aged forests. Forests that result from clearcutting and reseeding or replanting tend to be even-aged. Forests where fire has been excluded and wet forests tend to be uneven-aged. Both even- and uneven-aged forests occur without human influence. Forest inventories record stand age classes by the age of the dominant and co-dominant trees, so not all tree ages are recorded; therefore, it is difficult to determine from statewide forest inventory data acreages of even- and uneven-aged forests.

Almost half of Idaho's timberlands are in the over 80 years age class (Table 3-5). Almost one-fourth are between 60 and 80 years old. Age distribution is not even across ownerships. Over half (51%) of national forest timberlands are stands over 80 years old, but only 36% of forest industry lands and only 25% of other privately owned timberlands are that old. Forest industry has a greater percentage of timberlands (17%) in 1-10 year old stands than the other ownership categories. These data reflect different management objectives.

The median age for national forest stands is more than 85 years old; the median age of stands on other ownerships is 69 years old (Brown and Chojnacky 1996). No trend data for age class are available.

3.3.3. Size. Age and size of trees are related, as trees get larger as they grow older. Numerous factors, including tree species and site conditions, determine how fast and large trees may grow. From a timber products perspective, the diameter of trees is important because harvesting and manufacturing costs and potential end products and values all vary by the size of trees being removed from the forest. Large trees present lower harvesting costs per unit of wood volume than small trees. Larger trees can produce more valuable wood products. However, large trees

Table 3-6. Number of live trees on Idaho timberland by diameter class, 1991.

Diameter class	Ownership group				All ownerships
	National forest	Other public	Forest industry	Other private	
inches at breast height	*million trees*				
1.0-4.9	2,941.2	379.1	464.1	396.0	4,180.5
5.0-8.9	1,091.1	113.0	98.7	152.3	1,455.2
9.0-14.9	594.7	65.7	55.7	79.2	795.4
15.0-20.9	154.7	20.4	14.4	18.8	208.3
21.0-28.9	53.7	6.2	3.7	4.2	67.7
29.0 and over	15.7	1.7	0.5	0.5	18.4
All	4,851.2	586.0	637.2	651.0	6,725.4

Source: Forest Inventory and Analysis (1997).

also provide important habitat for some kinds of wildlife and contribute to the scenic beauty of forests.

On all Idaho timberlands, 62% of trees are 1-5 inches in diameter-at-breast-height; only 4 percent are 15 inches or greater (Table 3-6). Few differences exist in the percentages of number of trees in each diameter class by ownership.

Like age class, diameter class does not tell us much about how trees are arranged in the forest. Is a particular forest made up only of one size tree or a variety of sizes? Although not a precise measure, stand-size class is an expression of the size of trees within a particular forest tract. On Idaho timberlands, 70% of the acres are in the sawtimber stand size class (Table 3-7) with each ownership having 59% to 72% of its acres in sawtimber. Other size classes are less evenly distributed. Forest industry has a lower percentage of acreage nonstocked, a much larger percentage of its acreage in the seedling and sapling class, and much less in poletimber than other ownerships.

3.3.4. Stocking. Stocking is a term used to describe the extent to which growing space is effectively used by trees (Brown and Chojnacky 1996). Stocking is a function of the number of trees per acre and the diameter of trees. Stocking level implies a management objective (USFS 1985) and is reported in terms such as "overstocked," "fully stocked," and "poorly stocked," which do not provide a precise measure of conditions. Much has been written about

Table 3-7. Idaho timberland area by stand-size, 1991.

Stand-size class	Ownership group				All ownerships
	National forest	Other public	Forest industry	Other private	
	1,000 acres				
Sawtimber	9,300.0	1,046.8	788.8	1,200.3	12,335.9
Poletimber	1,732.7	171.1	70.1	304.6	2,278.5
Sapling &seedling	1,019.3	212.2	338.1	331.5	1,901.1
Nonstocked	756.5	107.0	42.4	191.9	1,097.8

Source: Brown and Chojnacky (1996).

Table 3-8. Idaho timberland area by stocking class, 1991.

Stocking class	Ownership group				All ownerships
	National forest	Other public	Forest industry	Other private	
	1,000 acres				
Over-stocked	1,022.8	115.4	124.2	118.8	1,381.3
Fully stocked	2,685.4	300.3	266.5	356.4	3,608.5
Medium stocked	5,176.0	675.8	462.2	710.1	7,024.1
Poorly stocked	3,116.1	341.4	384.6	591.4	4,433.6
Non-stocked	461.7	113.8	46.1	161.6	783.3

Source: Forest Inventory and Analysis (1997).

many of Idaho's forests being overcrowded; however, statewide statistics that indicate the number of trees per acre are not readily available.

Overall, 8% of Idaho's timberlands are considered to be overstocked while 21% are considered to be poorly stocked (Table 3-8). The medium stocking class is the largest with 40% of the acres. No large differences between ownerships in the percentage of acres in each stocking class exist, except that national forests and forest industry have a lower percentage of nonstocked acres than other public and other private ownerships.

3.3.5. Net Volume. Idaho's timberlands contain almost 40 billion cubic feet of wood (Table 3-9). National forests contain 76% of this volume; forest industry has about 6%; and other public and other private owners have about 9% each.

Almost one-third of the volume is Douglas-fir. Grand fir and lodgepole pine each make up 14% of growing stock volume. National forests have a higher percentage of growing stock volume in lodgepole pine and subalpine fir than other ownerships. Forest industry has a lower percentage of volume in Douglas-fir and a higher percentage in grand-fir and western redcedar. Other private owners have more ponderosa pine and hardwoods than other ownerships.

Trend data is available for softwood growing stock, which currently makes up 95% of growing stock volume. Softwood growing stock on Idaho's timberlands increased by 35% from almost 29 billion cubic feet in 1952 to almost 39 billion cubic feet in 1991; however, the species composition has changed considerably (Figure 3-2). White pine blister rust and other diseases and insects, preferential logging of western white pine and ponderosa pine, and the exclusion and suppression of fire have been the primary causes of the species change. Species decreasing since 1952 are western white pine (−86%) and ponderosa pine (−35%). Species increasing are true firs (grand fir and subalpine fir, +112%), Douglas-fir (+64%), lodgepole pine (+45%) and various other species (+50%).

3.3.6. Annual Mortality. Death is a normal part of the life cycle of a tree; however, the quantity of dead trees may also indicate that problems exist in the forest. Trees die for many reasons, and the death of too many trees for particular reasons may indicate that ecological problems exist. Much of the forest health debate centers around how much mortality should occur in the forest and what various causes of death mean about the condition of the forest (see O'Laughlin et al. 1993 and section **3.4. Sustaining Healthy Forests**).

From a timber harvesting perspective, live trees are more valuable for harvesting because the wood in dead trees deteriorates, lowering the value of products that can be made from them. Dead trees also, obviously, do not grow and add increments to the growing stock volume of wood in the forest. From an ecological perspective, dead trees serve important functions in the forest, including providing soil nutrients and habitat for wildlife (Bull et al. 1997).

Mortality in Idaho's forests was 290 million cubic feet in 1991, of which 76% occurs on national

Table 3-9. Net volume of growing stock on Idaho timberland by species, 1991.

Species	Ownership group				All ownerships
	National forest	Other public	Forest industry	Other private	
	million cubic feet				
Douglas-fir	9,443.5	1,116.2	645.8	1,201.3	12,406.8
Grand fir	3,930.1	715.7	661.1	442.2	5,749.1
Lodgepole pine	4,934.5	186.2	110.2	298.2	5,529.1
Subalpine fir	3,398.8	201.2	71.7	55.5	3,727.2
Ponderosa pine	1,844.8	224.1	125.7	539.3	2,734.0
Englemann spruce	2,202.5	149.8	111.3	24.2	2,487.8
Western redcedar	1,515.7	250.2	330.6	176.9	2,273.4
Western larch	906.8	161.2	201.6	206.8	1,476.4
Western hemlock	556.2	80.3	180.5	78.0	895.0
Mountain hemlock	573.7	142.9	26.5	14.7	757.8
Western white pine	301.1	43.2	50.2	42.3	436.8
Other pines	256.9	15.5	13.0	12.4	284.8
Aspen	248.8	75.1	3.0	182.8	509.7
Cottonwood	28.6	65.4	17.6	180.9	292.5
Total	30,142.2	3,420.4	2,535.9	3,461.9	39,560.4

Source: Brown and Chojnacky (1996).

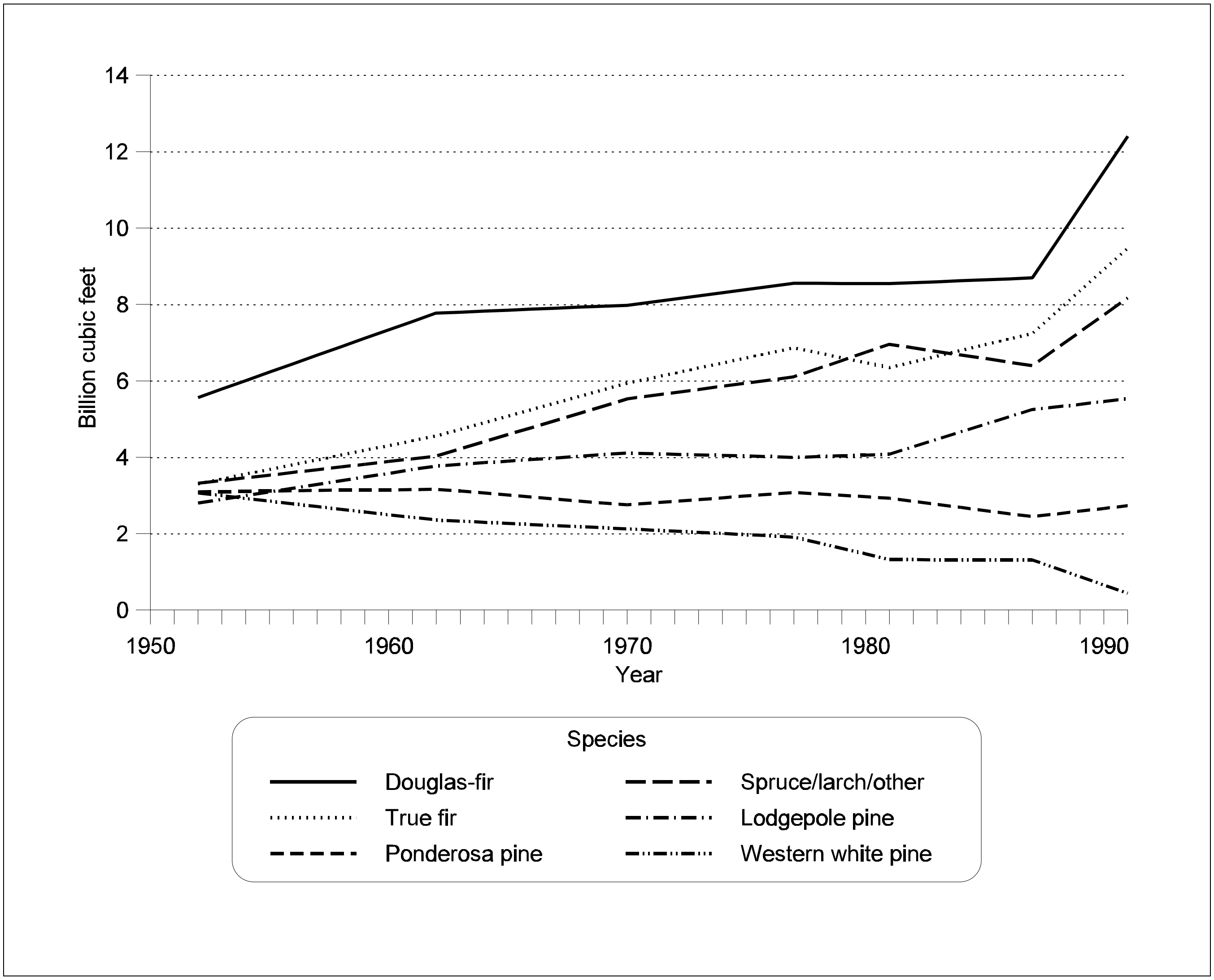


Figure 3-2. Idaho trends in softwood growing stock by species, 1952-1991.

Sources: USFS (1958), USFS (1965), USFS (1973*a*), USFS (1982), Benson et al. (1987), Waddell (1992), Brown and Chojnacky (1996).

forests (Table 3-10). This is consistent with the fact that national forests account for 73% of the timberlands and 75% of the growing stock volume. Douglas-fir accounts for the most mortality volume (22%) of any species, which is not surprising as it also accounts for the most live volume (31%). There are some notable differences between live volume percentages (Table 3-9) and mortality volume percentages (Table 3-10). For example, Englemann spruce accounts for only 6% of live volume, but 13% of mortality. Likewise, subalpine fir accounts for almost 17% of mortality, but only 9% of live volume. Differences are also noticeable between ownerships.

Almost 39% of the mortality in Idaho's forests is caused by unknown agents, or not attributed to a specific cause (Table 3-11) and national forests have more mortality in the unknown category than any other ownership. It is unclear whether this level of unknown causes for mortality is caused by a lack of monitoring or that the causes of mortality are undeterminable. The largest known causes of mortality are insects and diseases. Insects are the largest known cause of mortality on national forests, whereas diseases cause more mortality for other ownerships. Fire causes more mortality on national forests than on other ownerships. Weather causes a higher percentage of forest industry's mortality than it does on other ownerships. Logging causes less

Table 3-10. Annual mortality of growing stock on Idaho timberland by species, 1991.

Species	Ownership group				All ownerships
	National forest	Other public	Forest industry	Other private	
	million cubic feet				
Douglas-fir	47.2	6.8	3.7	5.5	63.2
Grand fir	13.4	4.5	4.8	5.2	27.9
Lodgepole pine	39.6	1.2	1.3	2.8	44.9
Subalpine fir	42.3	4.4	1.2	0.7	48.6
Ponderosa pine	7.3	1.6	0.5	3.5	12.9
Englemann spruce	33.7	1.8	0.9	0.0	36.4
Western redcedar	3.3	0.0	0.0	0.1	3.4
Western larch	10.1	0.1	1.0	0.7	11.9
Western hemlock	2.1	0.0	0.1	0.7	2.9
Mountain hemlock	2.0	0.0	0.6	0.0	2.6
Western white pine	12.8	3.4	2.4	1.0	19.6
Other pines	1.4	0.0	0.0	0.0	1.4
Aspen	5.3	1.7	0.0	6.3	13.3
Cottonwood	0.1	0.1	0.0	0.8	1.0
Total	220.8	25.8	16.5	27.2	290.3

Source: Brown and Chojnacky (1996).

Table 3-11. Annual mortality of growing stock on Idaho timberland by cause of death, 1991.

Cause of death	Ownership group				All ownerships
	National forest	Other public	Forest industry	Other private	
	million cubic feet				
Insect	73.9	7.4	4.1	4.6	90.0
Disease	26.6	12.2	6.5	14.6	59.9
Fire	9.0	0.2	0.0	0.3	9.5
Animal	0.6	0.0	0.1	0.1	0.8
Weather	8.3	1.2	2.7	2.2	14.4
Suppression	0.3	0.6	0.1	0.5	1.5
Unknown	101.0	3.9	3.2	4.4	112.5
Logging	0.8	0.2	0.1	0.4	1.5
All	220.6	25.7	16.8	27.0	290.0

Source: Forest Inventory and Analysis (1997).

than one percent of the mortality to residual trees on all ownerships, except other private where it causes 1.8%.

3.3.7. Net Annual Growth. Net annual growth is the annual incremental increase in forest growing stock volume minus annual mortality. Net growth in Idaho's forests was almost 816 million cubic feet per year in 1991 (Table 3-12) with national forests accounting for 68% of the total. Douglas-fir accounts for the largest amount of growth in all ownerships, except forest industry where grand fir accounts for the greatest percentage. This reflects the species distributions in each ownership's growing stocks (Table 3-9).

Negative net annual growth (indicated by parentheses, Table 3-12) means that mortality exceeded the incremental growth increase in a given year. In 1991, net annual growth was negative for western white pine in all ownerships except other private. Mountain hemlock had negative net annual growth in the forest industry ownership, and aspen had negative net annual growth in the other private ownership group (Table 3-12).

3.3.8. Net Annual Growth and Removals. This section looks at removals of growing stock and compares them to net annual growth based on 1990-1991 data. Removals include land clearing, changes in land use, timber harvesting, and silvicultural operations such as thinning (Brown and Chojnacky 1996). In section 3.3.11 we look more specifically at *sawtimber* harvest with more current data.

In Idaho in 1990, overall removals from the growing stock were about 309 million cubic feet (Table 3-13). Net annual growth was 816 million cubic feet, 507 million cubic feet more than removals.

The balance between growth and removals can be expressed as a ratio of growth to removals (Smith 1999). A ratio exceeding 1 means that growth exceeds removals for the year in question; a ratio of less than one indicates removals in excess of growth and—for that year—a resulting decrease in inventory volume. If the growth side of the ratio is greater than 1, the timber harvest meets the traditional physical measure of sustained yield of timber. In Idaho in 1990, the ratio was 2.6:1. Another way of saying this is that net annual growth was 2.6 times greater than harvest. Perhaps the simplest way to state this

Table 3-12. Net annual growth of growing stock on Idaho timberland, 1991.

Species	Ownership group				All ownerships
	National forest	Other public	Forest industry	Other private	
	million cubic feet				
Douglas-fir	166.6	25.1	17.1	41.3	250.1
Grand fir	109.5	21.2	24.5	20.3	175.5
Lodgepole pine	103.0	4.1	1.4	7.6	116.1
Subalpine fir	57.8	0.0	2.5	1.7	62.1
Ponderosa pine	31.6	4.0	4.3	17.7	57.6
Englemann spruce	6.2	1.4	4.3	0.6	12.5
Western redcedar	33.2	6.7	10.7	7.5	58.1
Western larch	10.5	3.2	3.3	7.0	24.0
Western hemlock	19.7	3.2	6.9	3.8	33.6
Mountain hemlock	10.1	2.7	(0.3)	0.6	13.1
Western white pine	(2.9)	(1.6)	(0.4)	1.2	(3.7)
Other pines	3.1	0.8	0.0	0.1	4.0
Aspen	4.0	0.6	0.1	(0.1)	4.7
Cottonwood	0.3	1.7	0.5	5.5	8.0
All	552.8	73.1	75.1	114.7	815.7

Source: Brown and Chojnacky (1996).

Table 3-13. Removals of growing stock on Idaho timberland by species and ownership, 1990.

Species	Ownership group				All ownerships
	National forest	Other public	Forest industry	Other private	
	million cubic feet				
Douglas-fir	29.8	9.0	11.3	17.9	68.0
Lodgepole pine	15.8	3.0	5.2	9.8	33.8
True firs	25.0	11.9	22.2	14.1	73.2
Ponderosa pine	24.0	4.7	6.8	12.3	47.8
Englemann spruce	4.1	1.1	1.8	2.1	9.2
Western redcedar	9.1	6.4	10.8	6.6	32.9
Western larch	7.3	2.7	3.7	4.1	17.9
Western hemlock	3.5	1.3	2.1	3.4	10.3
Western white pine	4.2	2.4	3.7	4.3	14.6
Aspen	0.0	0.0	0.0	0.0	0.0
Cottonwood	0.1	0.0	0.1	0.5	0.7
Unknown	0.1	0.0	0.0	0.1	0.2
All	122.9	42.6	67.9	75.3	308.7

Source: Brown and Chojnacky (1996).

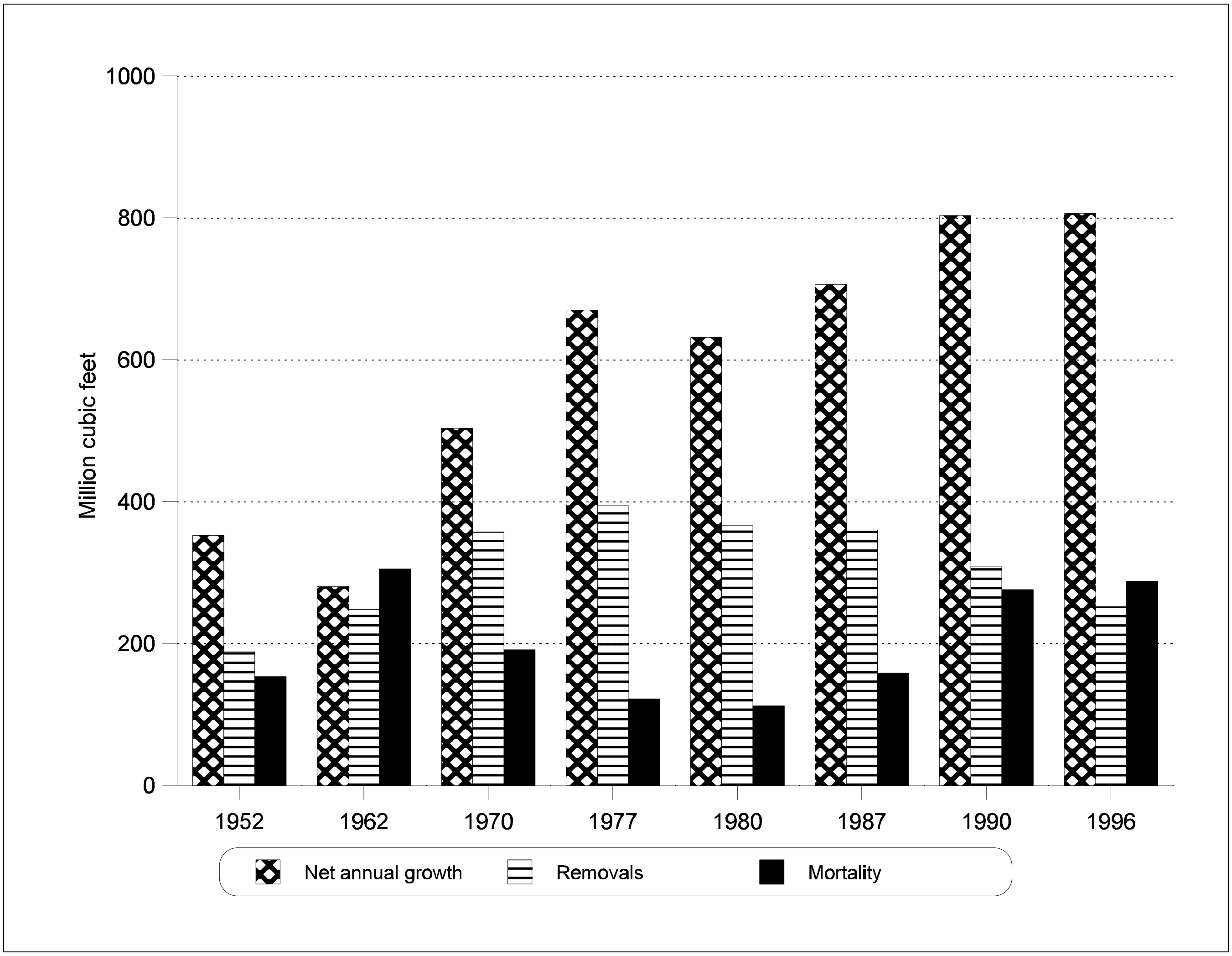


Figure 3-3. Idaho trends in net annual growth, removals, and mortality of growing stock, Idaho, 1952-1996.

Sources: USFS (1958), USFS (1965), USFS (1973*a*), USFS (1982), Benson et al. (1987), Waddell (1992), Brown and Chojnacky (1996), Smith (1999).

same relationship is to say that Idaho's timber harvest in 1990 was 38% of the net annual growth.

In 1990, some species were being removed at rates faster than their growth (Tables 3-12 and 3-13). Western white pine was being removed at a rate faster than it was growing on all ownerships. Ponderosa pine was being removed at a rate faster than it is growing on other public and forest industry ownerships. Lodgepole pine was being removed faster than it was growing on forest industry and other private ownerships. Both western redcedar and western larch were being removed at slightly higher rates than they were growing on forest industry lands.

3.3.9. Trends in Net Annual Growth, Removals, and Mortality. Net annual growth of growing stock increased almost continuously between 1952 and 1996 (Figure 3-3). A loss in net growth measured in 1962 reflects an increase in mortality reported that year. Removals increased from almost 200 million cubic feet in 1952 to almost 400 million cubic feet in 1977. Since the 1977 measurements, removals declined to 309 million cubic feet in 1990 (Brown and Chojnacky 1996) and 252 million cubic feet in 1996 (Smith 1999).

A trend in mortality is harder to establish. Between 1952 and 1963, mortality doubled from 153 million cubic feet to 305 million cubic feet (Figure 3-3). By 1980 mortality had dropped to 112 million cubic feet, but began to rise again to 276 million

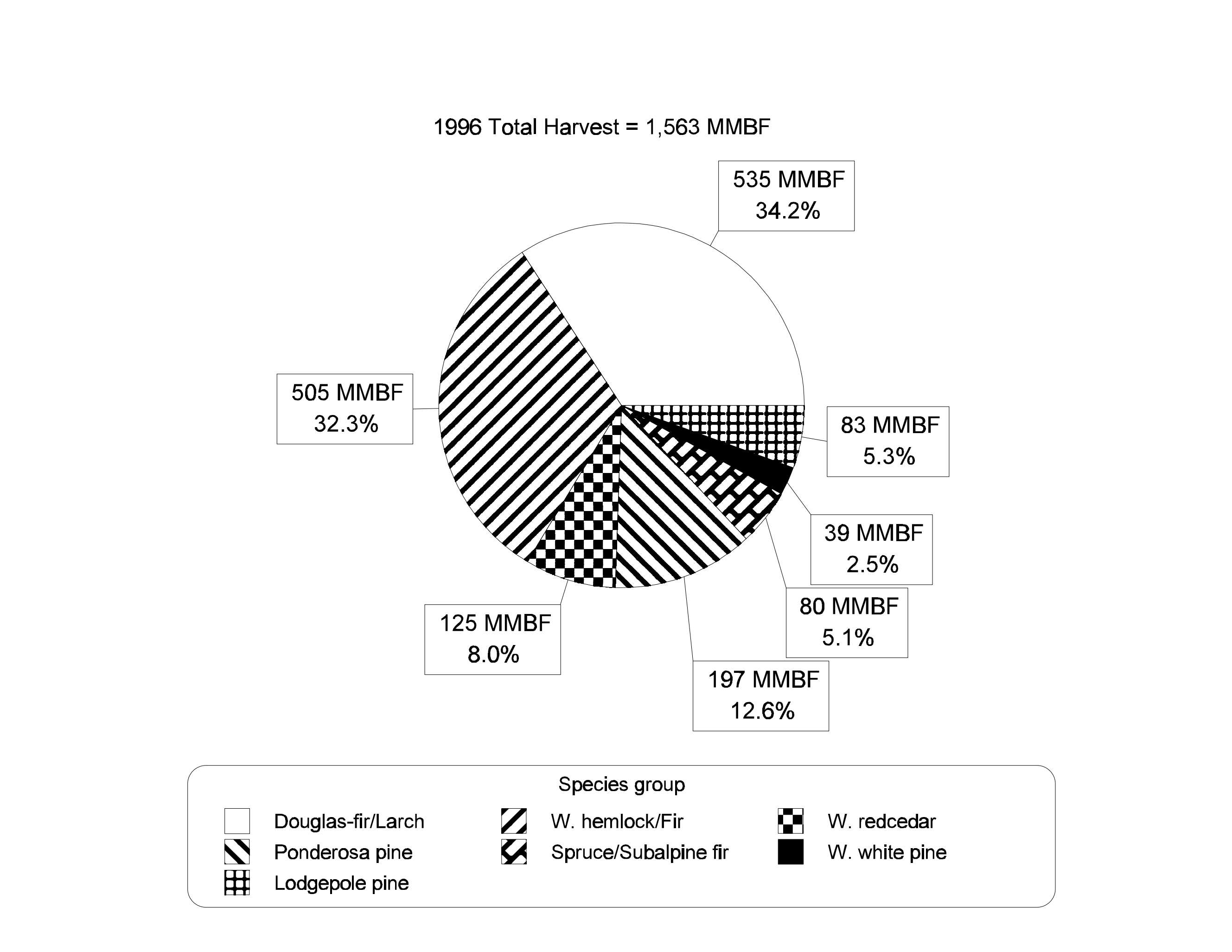


Figure 3-4. Idaho softwood sawtimber harvest by species group, 1996.

Source: Wagner et al. (1997).

cubic feet in 1990 (O'Laughlin et al. 1993), reaching 288 million cubic feet in 1996 (Smith 1999). The rising level of mortality and its causes and cures are the essence of the forest health debate. Timber inventory information relevant to that debate is presented in section **3.4. Sustaining Healthy Forests**.

3.3.10. Softwood Sawtimber Harvest. This section presents recent data on Idaho's softwood sawtimber harvest. Softwoods and sawtimber are only portions of growing stock, and timber harvest is only a portion of growing stock removal from the forest; therefore, these data are less inclusive than those presented above. Also, sawtimber is measured in board feet, whereas growing stock is measured in cubic feet.

Idaho's 1996 softwood sawtimber harvest was 1.56 billion board feet (Wagner et al. 1997). Douglas-fir and larch made up about one-third of the volume, western hemlock and true firs made up another third, and the remaining third was a variety of other species (Figure 3-4). Four ownership groups provided 99% of the sawtimber harvest volume: forest industry (34%), non-industrial private (30%), national forests (22%) and state of Idaho lands (13%) (Figure 3-5).

One conventional definition for a sustainable yield of timber is that net annual growth of timber must at least equal harvest. Assuming that 1996 net annual growth is the same as it was in 1990, which may not be realistic due to changing timber conditions, the 1996 timber harvest level was 1.9 billion board feet less than net annual growth (Figure 3-6).

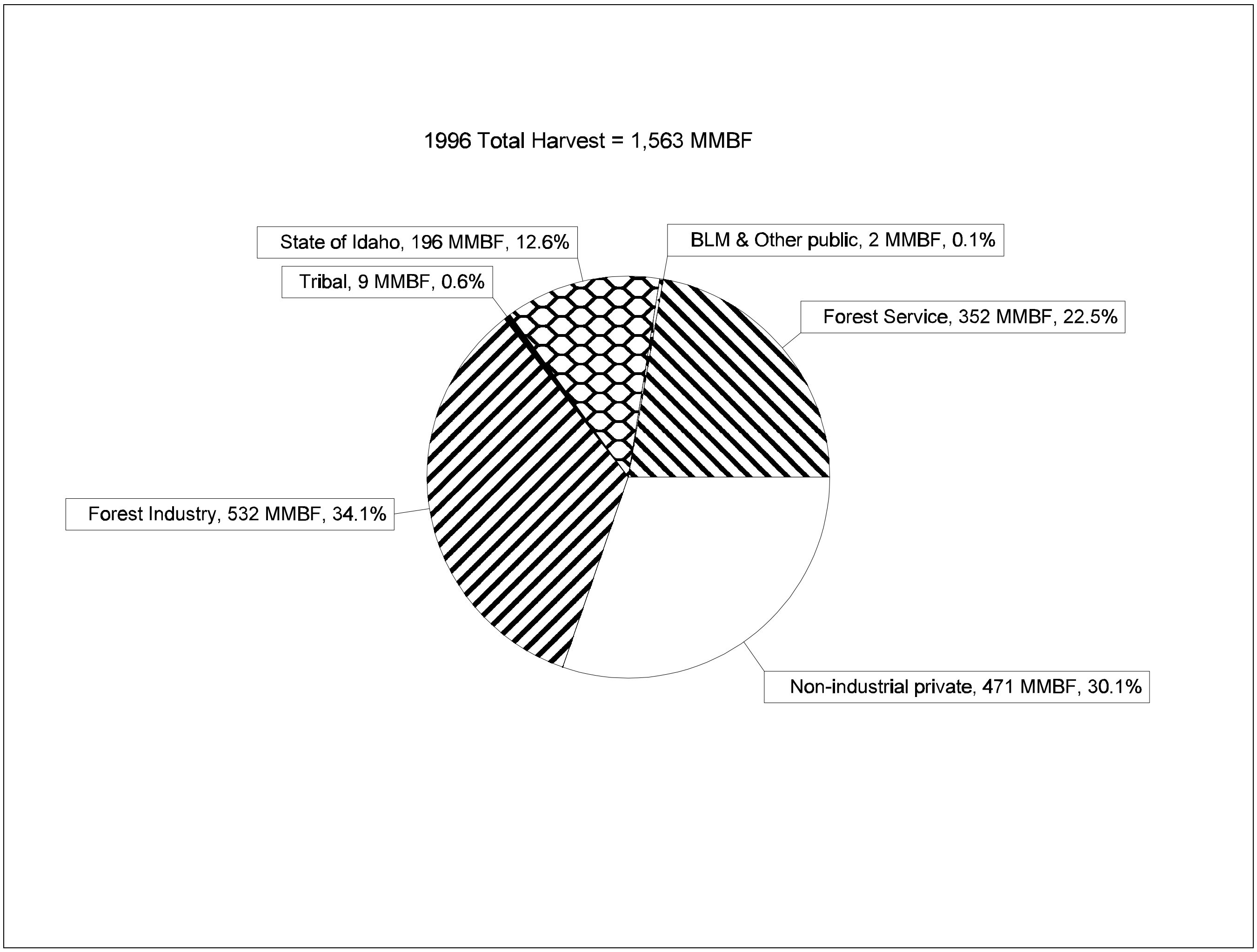
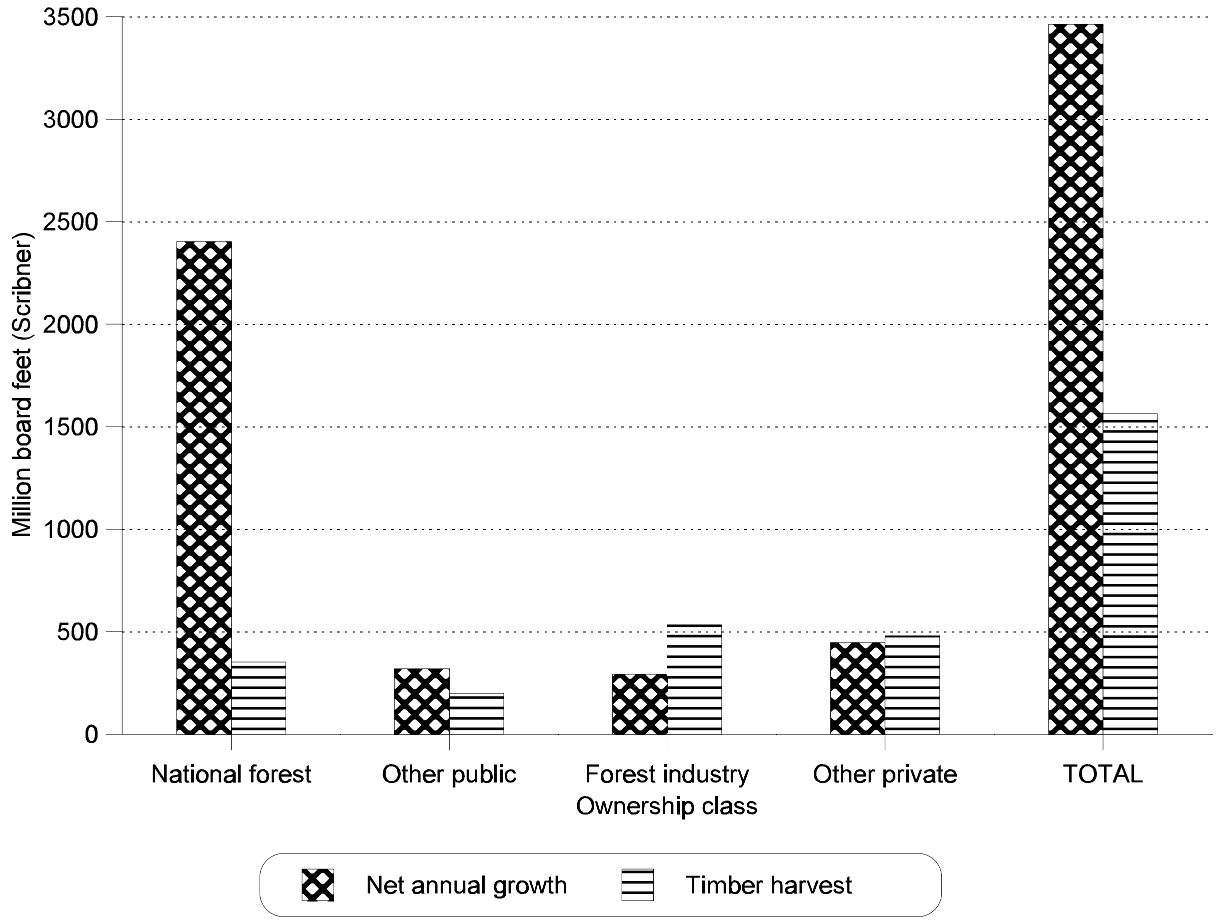


Figure 3-5. Idaho softwood sawtimber harvest by ownership group, 1996.

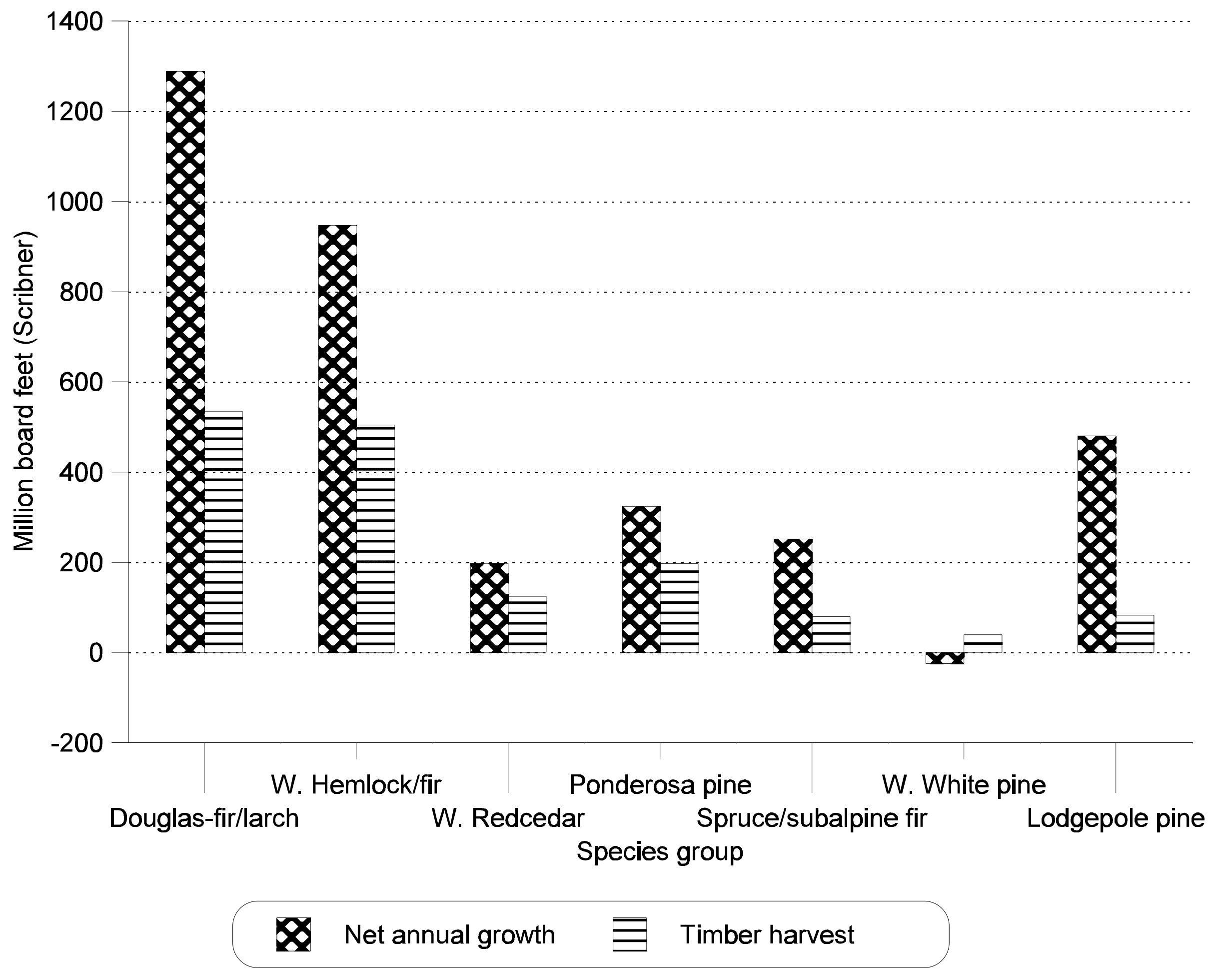
Source: Wagner et al. (1997).



	Ownership class				
	National Forest	Other public	Forest industry	Other private	TOTAL
Net annual growth (MBF)	2,413,983	321,569	292,564	447,592	3,475,708
Sawtimber harvest (MBF)	351,626	198,503	532,582	480,507	1,563,218

Figure 3-6. Idaho annual softwood sawtimber growth, 1990, and sawtimber harvest by ownership group, 1996.

Sources: Brown and Chojnacky (1996), Wagner et al. (1997).



	Species group						
	Douglas-fir/ larch	W. Hemlock/fir	W. redcedar	Ponderosa pine	Spruce/sub-alpine fir	W. white pine	Lodge-pole pine
Net annual growth (MBF)	1,288,989	946,452	197,666	323,072	251,835	-24,516	480,214
Harvest (MBF)	535,072	504,504	125,022	197,152	79,787	39,128	82,553

Figure 3-7. Idaho annual softwood sawtimber growth, 1990, and harvest by species group, 1996.

Sources: Brown and Chojnacky (1996), Wagner et al. (1997).

In other words, sawtimber harvest was 45% of net annual growth of sawtimber (Wagner et al. 1997). However, the results vary by ownership. On national forests, harvest in 1996 was 15% of net annual growth. On other public lands 62% of net annual growth was harvested in 1996. On forest industry lands timber harvest exceeded growth by 82%, which is in part a reflection of 27% of the acres in this ownership class being in the seedling and sapling stand-size class (Wagner, review comments). On other private lands harvest exceeded net annual growth by 7%. Results by species group show that for all species, except western white pine, net annual growth exceeded harvest (Figure 3-7).

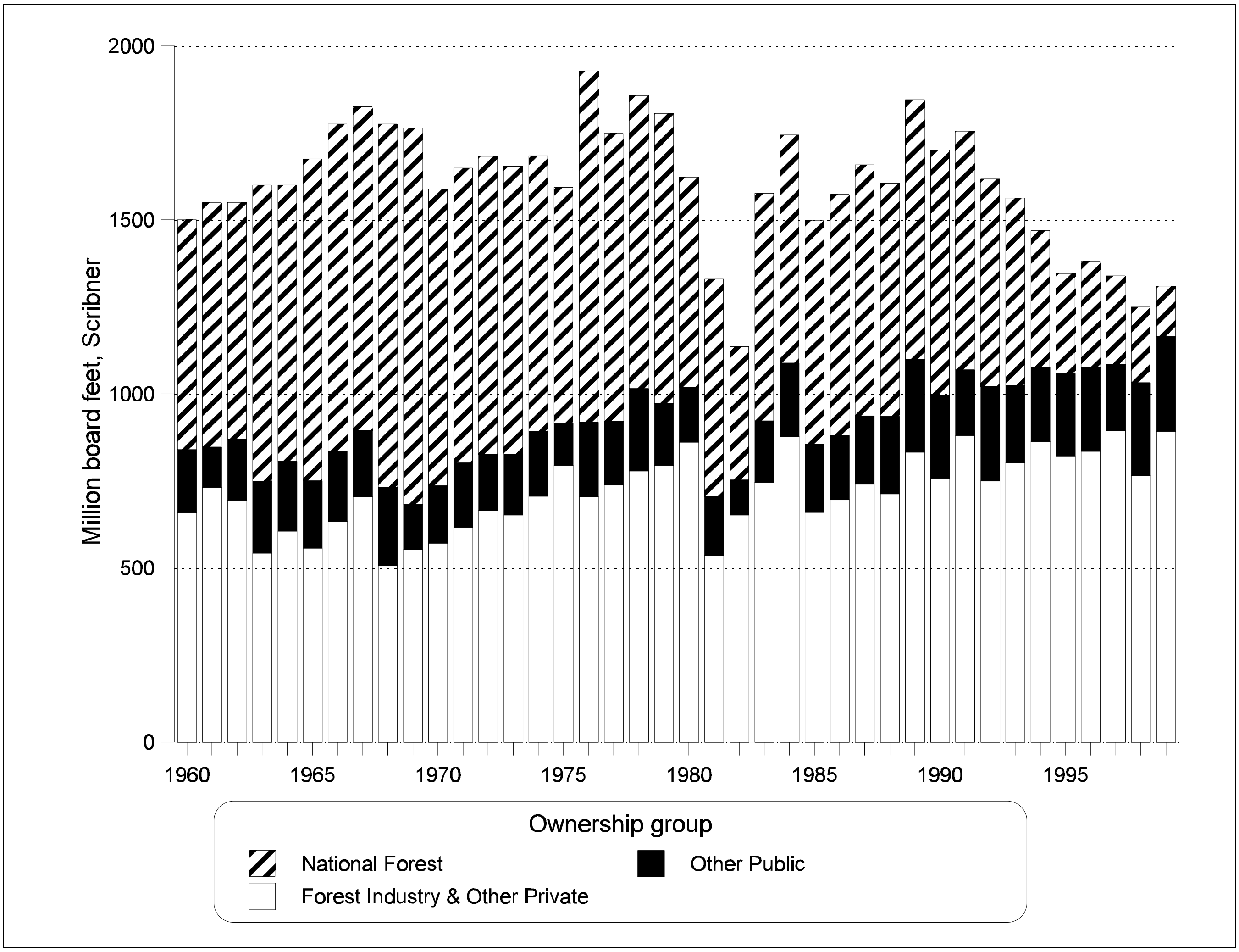


Figure 3-8. Idaho trends in softwood sawtimber harvest by ownership group, 1960-1999.

Source: Keegan et al. (2000).

Recent softwood timber harvest trends tend to reflect the changing species composition of the growing stock. Western white pine decreased from 19% of harvest in 1969 to 3% in 1995. Douglas-fir increased from 18% of harvest in 1969 to 27% in 1995 (Keegan et al. 1997). Although ponderosa pine growing stock has declined, it has remained between 12 and 17% of harvest volume.

Timber harvest levels peaked at 1.9 billion board feet in 1976 and except for an economic recession in the early 1980s remained above 1.5 billion board feet through the early 1990s. The current level is about 1.3 billion board feet. There has been a shift in the contribution of each ownership group to timber harvest levels (Figure 3-8). In the years between 1979 and 1990, national forests accounted for between 40 and 47% of Idaho's softwood timber harvest volume. By 1999, this share decreased to 11%. Each of the other ownership groups have increased their share of harvest, but the harvest level overall has declined 23% since 1990.

3.4. Sustaining Healthy Forests

Sustainable forest management includes concerns about the health of forests. The concept of forest health and its application to forest resource management in Idaho were the focal points of a study of *Forest Health Conditions in Idaho* published in 1993 as PAG Report #11 (O'Laughlin et al. 1993). The analysis generated replies to two questions. First, is there a forest health problem in Idaho? Second, if so, what can be done about it; if not, what can be done to prevent it? These were controversial questions when the project was undertaken in 1992 and remain so today.

3.4.1. What is forest health?

> Forest health is a condition of forest ecosystems that sustains their complexity while providing for human needs (O'Laughlin et al. 1993, O'Laughlin 1994, Sampson et al. 1994, O'Laughlin 1996*a*).
>
> Forest health is a way for people to express and understand ideas about the condition of a particular forest place composed of definable elements; what changes are likely to affect it; how they feel about those possibilities; and what, if anything, they want to do to affect that condition or those changes. While it can be greatly assisted by good science and improved by technical understanding, facts, and data, people's ultimate appraisal of the health of the forest is based on the values they hold (Sampson 1996).

Forest health is a multidisciplinary concept that integrates a variety of resource management concerns and relates them to something familiar to people—human health. Like sustainability, forest health is a value-based concept (Allen 1993, SAF 1997, Hirvonen 2000) and explicitly includes social considerations as to what people want from forests (Kolb et al. 1994, Oliver et al. 1997, Atkins et al. 1999). Judgments about forest health are therefore subjective because different perspectives and values are involved.

There is no widely accepted definition of forest health (Riitters et al. 1990, Allen 1993, Dahms and Geils 1997), and it means different things to different people (SAF 1997, Hirvonen 2000). Part of the reason is semantic. "Health" has two common definitions: one is a neutral description of overall condition; the other implies an optimal or "good" condition. The definition at the beginning of this section is based on the latter definition of health, but not all definitions are. It is essential that a common definition and conceptual understanding of forest health be agreed upon each time it is introduced into discussion (Kolb et al. 1995). The Society of American Foresters concluded that forest health is "an informal and technically inexact term" (SAF 1997:8).

Forest health nevertheless has two primary uses. First, it is used as an ecological framework for integrated resource management, the desired outcome being sustainable forest ecosystems. Second, it is a device to facilitate communications among forest researchers of different disciplines, between researchers and managers, and between foresters and their clients. As it does in the human health context, forest health can motivate individuals towards management action to alleviate unhealthy situations.

Both uses of forest health can be problematic. The concept of forest health is based on an analogy with human health (O'Laughlin et al. 1993, SAF 1997). Human health can be described by the absence of disease, but in ecosystems, diseases are essential members of the biotic community with important roles in determining ecosystem structure and function (Dahms and Geils 1997). The health status of a particular forest assumes that there is a baseline or normal state with which to compare (Allen 1993), yet ecosystems tend to be chaotic in behavior and not "in balance" especially when viewed over long periods of time (Kolb et al. 1995, Hirvonen 2000). The difficulties of defining an optimal condition for ecosystem health and the lack of universally accepted indicators to measure ecosystem health have led some researchers to conclude that the concept of ecosystem health is ecologically inappropriate (Ehrenfeld 1992, Wicklum and Davies 1995).

As a communications device, the concept of forest health offers some potential for miscommunication (Kolb et al. 1995). There are some problems due to the lack of a widely accepted definition, as outlined above. There is also a paradox created by circular logic whereby a desired state of forest health depends on the occurrence of a healthy forest (Wagner 1994, Kolb et al. 1995). For this reason, forest health is not appropriate as a management objective.

People approach forest health from at least two different perspectives: the utilitarian and the ecosystem (Allen 1993, Kolb et al. 1995, Jenkins 1997, Edmonds 2000, see also ***2.2.1. Value Orientations***). The perspective of the beholder determines, in part, whether or not a forest is healthy or unhealthy.

From the utilitarian perspective, forest health is a condition where biotic and abiotic influences on forests do not threaten management objectives now or in the future (Kolb et al. 1995, Edmonds 2000). Utilitarian management objectives for forests are usually related to timber production, but do not have to be (Kolb et al. 1995). From the utilitarian perspective, if the primary objective of a forest is timber production, large numbers of dying trees–or the potential for dying trees–indicate forest health problems (Peters et al. 1996, Jenkins 1997). From this perspective insects, diseases, and other non-timber elements of forest ecosystems are seen as good or bad based on how they affect the growth rates of commercial tree species (Peters et al. 1996, Hirvonen 2000). This perspective has tended to focus only on the trees within forest ecosystems (DellaSala et al. 1995, Peters et al. 1996).

The utilitarian perspective of forest health is especially appropriate for those situations where management objectives are unambiguous and consist of a small number of complementary human uses (Kolb et al. 1995). Some researchers suggest this situation is largely restricted to private industrial forest lands. Application of the utilitarian definition of forest health to forest lands managed for multiple objectives, such as most of the National Forest System, is problematic because management for multiple uses complicates the prioritization of management objectives and thus judgments about health status (Wagner 1994, Kolb et al. 1995, Edmonds 2000).

For those with an ecosystem perspective, forest health focuses on the whole ecosystem (Peters et al. 1996, Hirvonen 2000). Forests satisfy a range of diverse objectives and forest health is defined in terms like resiliency, balance, and function. Ill health is associated with declines in biodiversity, loss of primary productivity, reversal of successional patterns, widespread and severe disease, and loss of nutrient capital. A sick forest is not simply a matter of tree mortality (Jenkins 1997). Insect herbivores and disease-causing pathogens are not viewed strictly as "pests" but recognized as important facilitators of natural processes contributing to compositional, structural, and functional diversity (Mason 1993, Schowalter 1994, Ostry and Nicholls 1998).

Despite problems with the analogy, definitions, and perspectives, forest health has become a common metaphor not only in the forestry literature, but also in discussions about forest management. The definition of forest health that opened this section is from earlier PAG work (PAG Report #11, O'Laughlin et al. 1993) and was purposely designed to draw people into discussion about what forest ecosystem complexity is all about, and how forests can contribute to meeting peoples' expectations. The definition was developed to be concise yet broad in scope. It incorporates concerns for ecosystem structure, function, and process. Spatial and temporal scale complexity is included, as is sustainability. The definition also incorporates the idea of sustaining a wide variety of human uses. These are to be determined according to the various dimensions of forest location, ownership objectives, and other forest policies (see **Chapter 4**).

3.4.2. Measuring Forest Health. Assessment of forest health requires an understanding of both the condition of the forest and forest management objectives (Jenkins 1997, SAF 1997). Scientists can measure forest condition objectively, but assessments of forest health involve subjectivity because forest condition is evaluated against management objectives (O'Laughlin et al. 1993, SAF 1997).

In the past forest condition assessment has focused on trees, particularly timber species. Some researchers have been critical of this focus (e.g., Schowalter 1994, DellaSala et al. 1995, Kolb et al. 1995, DellaSala and Olson 1996), and scientists are beginning to develop a broader set of indicators to measure forest condition.

For example, the national Forest Health Monitoring (FHM) Program, established in 1990, is a cooperative program between numerous federal and state agencies, and several universities (USFS 2000*b*). Idaho joined the program in 1996. To assess forest condition, the FHM program has established permanent plots that will be remeasured on a four-year cycle. The program currently measures indicators such as lichen communities, ozone bioindicator plants, tree damage, tree mortality, vegetation structure, plant diversity, tree crown condition, tree growth, and tree regeneration (USFS 2000*b*), and as the program develops, new indicators, such as soil conditions and understory vegetation, will be added to supplement current measurements (Atkins et al. 1999).

Until a more extensive set of forest condition indicators is measured, monitored, and interpreted, timber-dominated indicators are one of the few ways to assess condition. However, the limitations of what has been measured and the implications of the findings must be recognized.

One of the indicators of forest condition that has been measured for several decades, and will continue to be measured in the more extensive sets of indicators, is relationship between forest growth and mortality. Many researchers have recognized that forest growth and mortality is a fundamental part of forest condition assessment (Riitters et al. 1990, Smith 1990, Innes 1993, Norris et al. 1993).

3.4.3 Idaho Trends in Mortality as a Percent of Growth. One way scientists have assessed forest condition is by comparing current conditions with the historic range of dynamics the system has experienced through the past. This is generally called the historic range of variability (Morgan et al. 1994, Atkins et al. 1999).

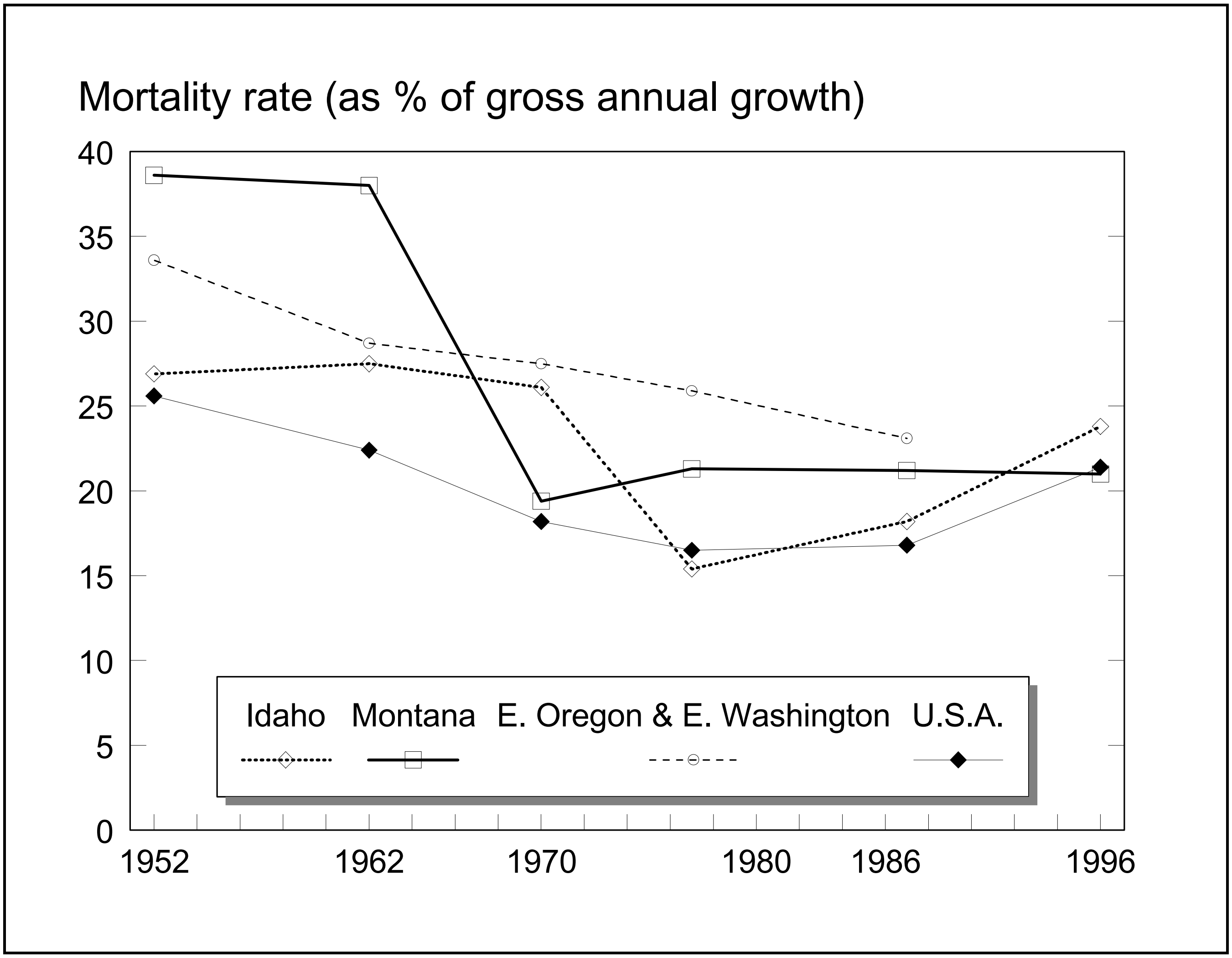


Figure 3-9. Annual mortality rate as a percentage of gross annual growth: Inland Northwest trends, with the U.S.A. for comparison, 1952-1996.

Source: Data compiled from various U.S. Forest Service reports.

Timber inventory data for the inland northwest region show that mortality as a percent of gross growth ranged between 25-38% in 1952, with a downward trend to 15-24% until the early 1980s and then increasing to 21-24% more recently (Figure 3-9). The trends reflect increasing gross growth more than declining mortality. A regional range was developed from the high and low data points at each time interval in Figure 3-9 and is portrayed as a baseline for comparing Idaho data (Figure 3-10).

The most current data available for Idaho individual national forests and other forest ownership groups were plotted in Figure 3-10 for comparison with the regional range. Specific data for southern Idaho timberlands outside national forests after 1991 were unavailable, which account for 9% of the timberlands in the state.

Two national forests—Payette and Boise—represent approximately 15% of the timberlands in the state, and both forests were in a situation in the early 1990s where mortality exceeded gross annual growth. On suitable timberlands during 1987-1992, the mortality rate in the Boise National Forest was 105% of growth annual growth; it was 140% on the Payette National Forest (Figure 3-10). Three national forests in northern Idaho—Panhandle, Clearwater, and Nez Perce—have approximately 29% of the timberlands in the state, including 1.5 million acres of some of the most productive timberlands in the nation, and 43% of the growing stock volume in all Idaho forests (Waddell 1992). U.S. Forest Service disease surveys initiated in 1985

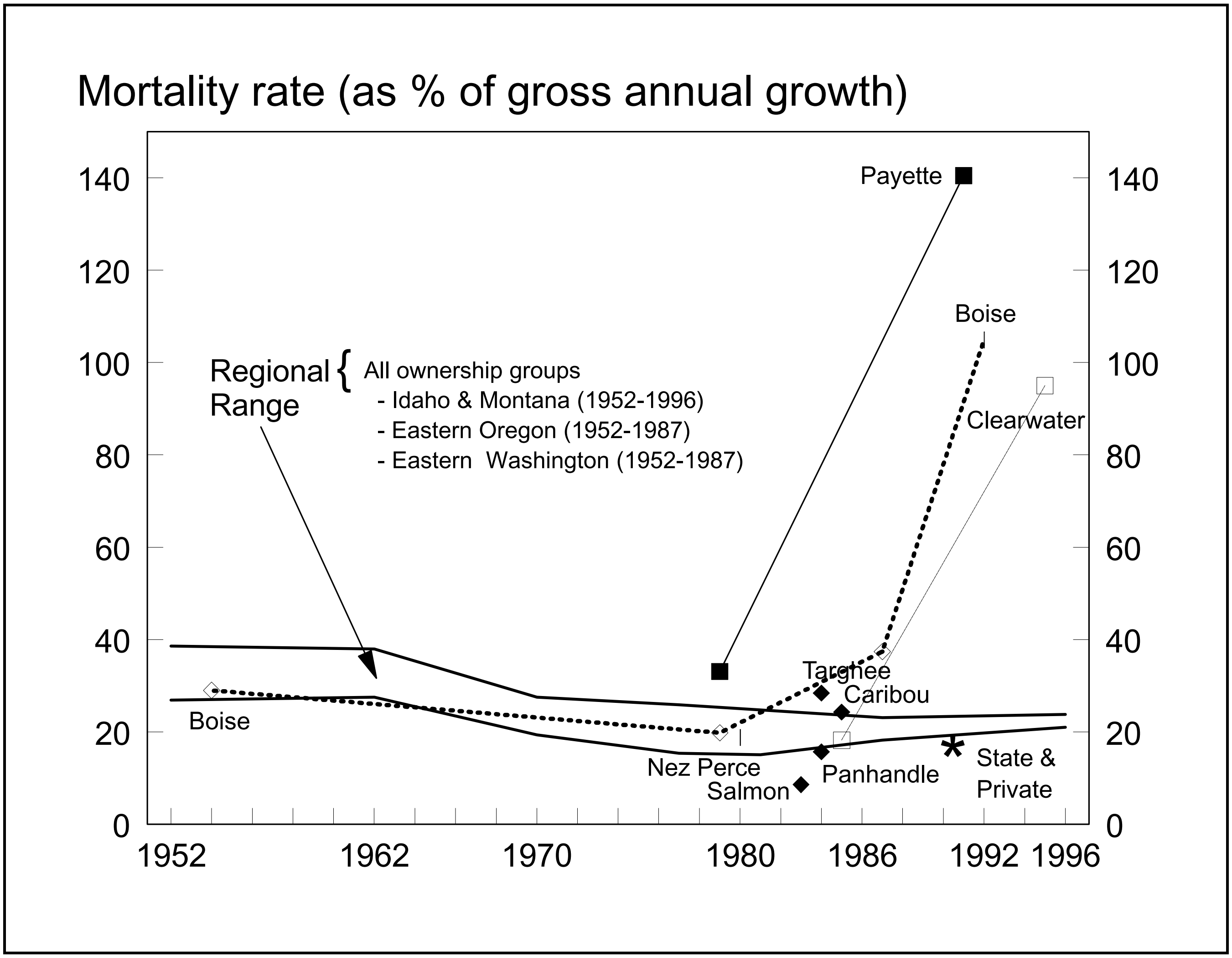


Figure 3-10. Annual mortality as a percentage of gross annual growth: Inland Northwest regional range, 1952-1996, and the most recent data for 91% of Idaho timberlands, with 9 national forests.

Source: Data compiled from various U.S. Forest Service reports.

reveal that these northern Idaho national forests are suffering from chronic root disease, as evidenced by reduced canopies, unstocked areas, and declines in productivity (Hagle and Byler 1993, Byler et al. 1994). More recent data from the Clearwater National Forest (1997) indicates annual mortality is 95% of the gross annual growth.

Also displayed in Figure 3-10 is recent inventory data for private and other public forests (i.e., non-national forests) in northern Idaho (Wilson and Van Hooser 1993). These forests represent 24% of the timberland and a like amount of the timber growing stock volume in Idaho. Mortality rates are within the regional range.

In summary, the most recent timber inventory data in Idaho indicate higher mortality rates in national forests than on state and private forests. The three national forests in northern Idaho are losing productive potential to root diseases. The two national forests in southwestern Idaho had substantial declines in gross annual growth from the 1970s to the early 1990s. Mortality in these two forests exceeded gross annual growth, meaning there was a net loss of growing stock from mortality in these forests.

This analysis presents a different picture than does examination of data presented by Brown and Chojnacky (1996). According to that data, mortality as a percent of gross growth for national forests, other public owners, forest industry, and other private owners are 29%, 26%, 18%, and 19%, respectively. While mortality rates on national forests as a whole are 37% higher than on other ownerships, the rates do not approach those reported on the Payette, Boise, and Clearwater National Forests reported above. The difference may have to do with the amount of time that has elapsed since the inventories on national forests reported in Brown and Chojnacky (1996) were done (Table 3-2). More than half of Idaho's timberlands are national forests that have not been inventoried in a decade or longer.

More recent inventory data for these national forests may reveal much higher mortality rates, especially in southern Idaho due to prolonged drought conditions that began in 1987. Stress induced by competition for limited moisture in densely-stocked stands invites insect and disease outbreaks.

3.4.4. Changes in Idaho's Forest Structure and Composition. In addition to the trend in mortality rates outlined above, the structure and species composition of Idaho's forests changed between 1952 and 1991. Firs increased from 42% of the growing stock volume to 57% and pines declined from 39% to 22%. In 1991 Idaho forests had 35% more growing stock volume than in 1952, and they are now different kinds of forests. Firs are more susceptible than pines to many insects, diseases, and fires, especially in dense stands.

A principal cause of the shift from pines to firs is fire exclusion, and one consequence is reduced productivity of timber species. Fire exclusion has increased the incidence of root disease in northern Idaho (Hagle and Byler 1993, Hagle et al. 1994, Byler et al. 1994). Fuel loads in many such forests have increased to levels that threaten fire control efforts and place many forest ecosystem values at risk (Harvey 1994; Harvey et al. 1994, 1995).

Stand densities have also been affected by fire exclusion and the shift in species composition. Stand density is a likely causal factor affecting forest health, but definitive research studies have not been done (O'Laughlin et al. 1993). Many researchers agree that stand densities have increased, but the relationship is difficult to verify because the measurement of stand density is a function of both number and size of trees, and old reports do not provide the information needed to understand that relationship. Volume per acre is one measure of stand density, but the same volume can be created by many small trees or a few large trees. Old reports include volume and acreage figures, but not data on tree size and numbers.

In 1952, average volume per acre based on statewide totals was about 1845 cu.ft./acre in Idaho (Waddell 1992). By 1991, that had increased to 2246 cu.ft./acre, a 22% increase (Brown and Chojnacky 1996). Between 1952 and 1991, average volume per acre on national forests increased 38% from 1710 cu.ft./acre to 2353 cu.ft./acre.

Currently, public and private resource managers agree that a major difference between national forests and private ownerships in Idaho is that national forests have higher densities of trees (O'Laughlin et al. 1993, Blatner et al. 1994, Morelan et al. 1994). National forests average 20% more volume per acre than other ownerships combined (2353 cu.ft./acre versus 1960 cu.ft./acre) (Brown and Chojnacky 1996); however, differences in tree sizes and numbers on different ownerships may account for some of the difference.

It is not possible to overemphasize the role of wildfire in creating and maintaining forests in Idaho. By effectively suppressing fire and excluding it from performing its ecological role for more than 80 years, the composition and structure of Idaho's forests have been altered. Timber harvesting practices have acted together with fire suppression to create more dense forests with tree species poorly suited to sites affected by drought or root disease.

Fire exclusion has altered the composition and structure of Idaho's national forests, which in turn has resulted in increased mortality, creating stand conditions that place all forest values at risk from the likelihood of high-intensity wildfires. Conditions on federal lands in Idaho make it three times more likely that stand-replacing or lethal fires will occur (Quigley et al. 1996). These fires pose threats to ecological integrity, water quality, endangered species recovery, and rural homes (Quigley and Cole 1997).

3.4.5. Are Idaho's forests healthy? The reply to the question are Idaho's forests healthy is a matter of opinion. Our reply takes a utilitarian perspective. Although the Society of American Foresters suggested forests can be considered healthy when there is an *appropriate balance* between growth and mortality (Norris et al. 1993), it did not indicate what an *appropriate balance* might be. Guidance from other published sources is elusive. Some people may call the conditions in Idaho's national forests unhealthy (e.g., Harvey et al. 1995). Others suggest that all this is just one more change in ecosystem dynamics.

Based on the condition of Idaho's forests using available data and the criterion of tree growth efficiency, expressed as the relationship of forest growth and mortality, some forests in Idaho appear to be healthier than others. Health problems exist throughout the state, with more problems in national forests than on other ownerships. Part of the cause of the health problems is fire suppression and timber harvesting that have changed forest composition and density. This has resulted in elevated levels of timber mortality (O'Laughlin et al. 1993).

In 1991, national forests had 37% more mortality (expressed as a percentage of growth) than other forests (Brown and Chojnacky 1996). Why is the mortality rate higher on national forests? In part, because differences in management objectives result in different stand densities. National forests are managed for multiple use, although the manifestations of this objective are changing (see **Chapter 4**). Other public forests, private industry forests, and some nonindustrial private forests tend to have timber production as their main management objective. Stand densities are more likely to be closely monitored and controlled when timber production is a primary objective.

3.4.6. Health Management Strategy.

> [A]ctive management appears to have the greatest chance of producing the mix of goods and services that people want from ecosystems, as well as maintaining or enhancing the long-term ecological integrity of the [interior Columbia River] Basin (Quigley et al. 1996, 1998).

A fundamental problem with the forest health concept today is a lack of agreement on an appropriate "cure" if a forest is found to be unhealthy. As the above quotation indicates, many researchers believe that active management is the preferred health management strategy (e.g., O'Laughlin et al. 1993; Quigley et al. 1996, 1998). Actively managed forests are those receiving intensive applications of labor and capital to land. The alternative is passive management, which means extensive or custodial management involving little expenditure of labor or capital.

Two key words in a forest health management strategy are restoration and prevention. ***Restore*** the tree species best suited to individual sites. In many Idaho forests those are ponderosa pine, western larch, and western white pine (blister rust-resistant, of course). ***Prevent*** unhealthy conditions. This involves reducing stand density and favoring the species best adapted to site conditions by using practices that replicate the beneficial effects of low-intensity fires.

If forest stand conditions are unhealthy, practices such as thinning dense stands, the use of prescribed fire where fuel loads are not hazardous, and regeneration of more resistant and resilient tree species can help restore healthy conditions on lands suitable for timber production. Thinning is the most important part of an active forest health management strategy, because it can be designed to alter species composition and reduce stand density. The strategy for root-diseased areas is different, but simple: reforest affected sites with species resistant to root diseases.

Not all researchers are in agreement about active management strategies. Some, not all, types of forests can benefit from active restoration, and caution must be exercised in every case (Peters et al. 1996). Some effects of active management may not be desirable. The effects of intensive management on the behavior of wildfires are not known, particularly at the landscape level (DellaSala et al. 1995, MacCracken 1996).

3.4.7. Policy Issues. Public policy and public trust are two interrelated and seemingly formidable barriers to active management strategies for addressing forest health. Today's public policies for managing the national forests were developed in the 1960s and 1970s, and resulted from public distrust of the way managers were caring for the national forests (Cubbage et al. 1993).

Forest health is ultimately a policy question, not a science question, because healthy conditions can only be judged in the context of what the purpose of a forest is, and that is a policy matter. How can the words "maintaining healthy and sustainable forest ecosystems" be translated through resource management policy to forestry activities on the ground? Scientists and managers have begun to consider forest health only recently.

Forest health is difficult to translate into a policy objective. Instead it is a component of ecosystem-based management strategies. This is now the operational philosophy for federal land and resource management. Indeed, some scientists have defined ecosystem health as sustainable ecosystems (see Aplet 1992, Everett et al. 1994, Maser 1994). Policy for maintaining and restoring forest ecosystem health is now called policy for sustaining ecosystems. This is the subject matter of **Chapter 4**.

3.4.8. Conclusion on Forest Health. These conclusions represent the PAG's several years of experience attempting to provide some useful perspectives on the concept of forest health, and are summarized by O'Laughlin (1996*a*). The value of the forest health concept is to relate complex ecological and managerial issues to something people think they understand. Forest health has served as a useful catalyst, causing resource managers, researchers, policy makers, and the public to take a critical look at past management practices and their results. Ecosystem processes that were not previously considered now are beginning to drive strategies and policies.

In the end, the beginning of the solution to forest health problems is to channel the diverse interests now evidently concerned about forest health into an interdisciplinary approach. A suggested first task is seeking agreement on measurement methods and standards for identifying ecosystem health problems. That will help the concept of forest health become more useful as a communication device. Atkins et al. (1999) have begun to do that in Idaho, noting that forest health issues include exotic species introductions, watershed health, wildland interface development, forest growth, insects and diseases, fire, and biological diversity.

Because the science associated with forest health is only beginning to emerge and monitoring of non-timber resources has not been seriously undertaken, at present forest health assessments include only the condition of trees. Because other ecosystem components are related to the condition of trees and therefore affected by forestry practices, forest health monitoring activities should be continued, redirected from pest assessment to an integrated vegetation inventory and monitoring project, and expanded to include information about how other ecosystem components are related to the condition of trees. While trees are being measured and tree data compiled and analyzed, perhaps other measurements can be taken and additional analyses performed. Forest scientists of different disciplines will need to work together, and work with other disciplinary specialists. Forest health assessments currently confine their focus to the action of causal agents (or "stressors") and their effects on the condition of vegetation. That alone is a large research and monitoring agenda. Until forest health reports include more than trends in tree conditions, forestry professionals will have to plead *nolo contendere* ("no contest") to the charge that they can't see the forest for the trees.

The other vital forest health issue is determining what the management objectives of particular forests are, particularly our national forests. Present concerns over forest health reflect a failure to define management objectives that are acceptable to society (Kolb et al. 1994, Kolb et al. 1995). Resolving this issue is a political process not a scientific one.

3.5. Conclusions

To even the most casual observer it is apparent that Idaho has lots of trees. Almost 42% of our state is forested, and most of that is capable of growing timber, i.e., trees used for commercial forest products. One facet of understanding whether management of Idaho's timber resource is sustainable involves collecting and analyzing information about the amount of timber in Idaho's forests and how much it is growing, dying, and harvested. We presented that information in this chapter.

Is our information perfect? No. Information about timber resources—and other forest resources—is not as good as we would like. Many inventories are outdated, and the accuracy of others is questionable. Procedures for measuring some forest characteristics and conditions have changed over the years, so trends are not as accurate as we would like. Some attributes of forests have not been measured in the past that we now think are important and wish had been measured so we could estimate trends. Despite its flaws, we have to work with the information that is available, and although not completely accurate, we believe it is in the neighborhood of reality.

Idaho's timberlands contain almost 40 billion cubic feet of wood, 35% more than in 1952. The wood in these forests is growing about 816 million cubic feet per year; about 290 million cubic feet per year are dying; and about 250 million cubic feet are being removed, mostly from timber harvesting. Each year more wood is being added to Idaho's timber inventory than is being removed.

Does a growth-removal balance of 2.6:1 mean that Idaho's forests are being managed sustainably? As other chapters of this report indicate, timber statistics alone can't answer the sustainability question. Although the timber inventory and harvest data meet the traditional definition of sustainable yield, other forest values must be accounted for.

Chapter 4. What policies affect timber harvesting in Idaho?

Policies are purposive courses of action or inaction that governments, businesses, groups, or individuals take to deal with particular situations or problems (Cubbage et al. 1993). Government policies are usually expressed through laws and regulations, but private companies, groups, and individuals also have policies expressed through management objectives, rules, and modes of operation. We examine both types in this chapter. It is not possible to analyze all the policies that affect timber harvesting in Idaho because there would be almost as many policies as there are owners of timberland. We describe and analyze the most important and influential policies that affect the major categories or groups of forest landowners in Idaho.

Citizens of the U.S. have become increasingly pluralistic in their views and participative in their actions over the past three decades (Maxwell and Randall 1989). Policies and actions of federal land and resource managers are now deliberated by wide-ranging publics who view forests in non-traditional ways, through lenses ground by opticians outside the resource management professions (Allen and Gould 1986). Pluralism, along with major advances in our scientific understanding of ecosystem dynamics, has led to the widespread call for new perspectives and new approaches to achieve sustainable forest management (Behan 1990, Alston 1991, Castle 1993, Iverson and Alston 1993).

Some government policies that directly affect resource management apply only to federal lands. Other public policies apply to both public and private lands. Some policies, such as federal income tax and local property taxes, may have an indirect influence over the amount and timing of timber harvesting from private lands. Although tax effects may be substantial, they are beyond the scope of this report.

During the 1990s ensuring sustainable patterns of resource use became one of three core values of an environmental perspective (Paehlke 2000). Policies related to the other two core values provide the organizing framework for this chapter. They are, first, the minimization of adverse impacts on human health, which is the purpose of our environmental laws. Second is the protection of wilderness and biological diversity, which is the purpose of another set of laws. These policies affect federal lands more than non-federal, so between these two sets of policies we have inserted a section on the many laws governing the use and management of federal lands. Because of their importance in Idaho relative to other forest landownerships, we focus on the National Forest System. Policies for managing and sustaining ecosystems on these lands are analyzed in some detail.

4.1. Environmental Laws

There are several federal environmental policies that passed into law within the past 25 or 30 years that affect land and resource management. These include the federal Clean Air and Clean Water Acts, and the Idaho Forest Practices Act which is part of the state's program to implement the federal Clean Water Act. The cornerstone for the nation's environmental laws is the National Environmental Policy Act.

4.1.1. National Environmental Policy Act. The National Environmental Policy Act of 1969 (NEPA) created and codified

> a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation (42 U.S.C. § 4231).

NEPA declares that the federal government is responsible for

[a] coordinating programs and plans regarding environmental protection,

[b] using an interdisciplinary approach to decision making,

[c] developing methods to ensure that non-quantifiable amenity values are included in economic analyses, and

[d] including in every recommendation, report on proposals for legislation, or other major federal actions significantly affecting the quality of the environment a detailed statement on the environmental impacts of the proposed action (Cubbage et al. 1993).

This last provision, the environmental impact statement (EIS), is probably the most well-known feature of NEPA. The Council on Environmental Quality (CEQ) was created by NEPA in part to develop implementing regulations for the act. Regulations require that whenever a federal action is proposed, an environmental assessment (EA) must be undertaken. The EA must include a brief discussion of the need for the proposed action, alternatives to the action, and their environmental impacts (Cubbage et al. 1993). If the EA finds that there will be significant impact on the human environment from the proposed action, then a more detailed and thorough EIS is required. An EIS includes a summary, a statement of purpose and need, alternatives including the proposed action, environmental consequences, cost-benefit analyses, invitations for comments, and a schedule for agency actions (Cubbage et al. 1993). At the time of its passage, no one envisioned the thousands of lawsuits NEPA has launched (Rodgers 1994).

The purpose of NEPA is to insure that federal agencies consider the potential environmental consequences before deciding to proceed with a proposal, and it serves as an environmental full disclosure law (Coggins and Glicksman 1996). The NEPA statute requires the responsible federal agency to obtain and publish the comments of various federal, state and local agencies, and to make the impact statement available to the public through the Freedom of Information Act (42 U.S.C. § 4332(c)(v)). Through the CEQ regulations, the agency proposing the activity is to obtain comments from the public and interested and affected persons and organizations (40 C.F.R. § 1503.1(a)(3)(4)). NEPA allows those who disagree with an agency's decision to seek a remedy in court, but oversight by the courts is limited almost exclusively to the procedural requirements of NEPA (Coggins and Glicksman 1996). All forest management plans and activities on federal lands must meet the requirements of the NEPA statute and CEQ regulations.

Sustainability concepts are supported by NEPA. The statute recognizes the interrelationship of the environment, social, and economic dimensions (42 U.S.C. § 4331(a)). Furthermore, NEPA sets for the federal government goals to "fulfill the responsibilities of each generation as trustee of the environment for succeeding generations" (42 U.S.C. § 4331(b)(1)), "attain the widest range of beneficial uses of the environment without degradation" (42 U.S.C. § 4331(b)(3)), and "enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources" (42 U.S.C. § 4331(b)(6)).

Congress recognized individual responsibility for sustainability in NEPA and wrote "that each person has a responsibility to contribute to the preservation and enhancement of the environment" (42 U.S.C. § 4331(c)). However, the courts could not enforce the personal nor the intergenerational responsibilities even if they were willing to do so (Coggins and Glicksman 1996).

4.1.2. Clean Air Act. The federal Clean Air Act, first passed in 1963 but amended numerous times since, is the primary legal instrument for air resource management. Among other things, the act requires the U.S. Environmental Protection Agency (EPA) to identify and publish a list of "criteria pollutants," or common air pollutants that could endanger public health or welfare. For each criteria pollutant the EPA designates a concentration above which the pollutant would be a danger. These levels are called the National Ambient Air Quality Standards. The act requires each state to develop and implement a state plan to ensure that the standards are attained and maintained for each criteria pollutant (see Idaho Code § 39-118B, § 39-118C and IDAPA § 16.01.01). Federal agencies must comply with all federal, state, and local air pollution requirements (ICBEMP 1997). The act also requires that more stringent air quality standards be maintained in Class I federal areas, which are primarily wilderness areas.

Particulate matter, ozone, and carbon monoxide are the three primary criteria pollutants associated with forest management (Rolston and Coufal 1991, ICBEMP 1997). Fire is the main activity that affects these criteria pollutants.

The Clean Air Act requirement to maintain air quality standards has not been a major consideration in policies concerning forest management and timber harvest; however, they may become so, particularly if silvicultural prescriptions involving more prescribed burning are implemented. Although increased levels of prescribed burning can have temporary negative effects on air quality, the more acute effects to air quality from wildfires can be reduced in the long term (ICBEMP 1997). Prescribed fires can be used when fuel moisture and weather conditions are optimal for minimizing the impacts on air quality, whereas wildfires may occur when conditions are at their worst, such as in the summer during inversion conditions that tend to keep smoke nearer to the ground.

4.1.3. Clean Water Act. In 1977, the Federal Water Pollution Control Act was amended under the name the Clean Water Act. The Clean Water Act established a national objective "to restore and maintain the chemical, physical, and biological integrity of the nation's waters." The act called for all of the Nation's waters to be "fishable and swimmable" and the elimination of pollutant discharge into navigable waters. The act was amended in 1987 to include increased attention on nonpoint sources of pollution as well as point sources because a large portion of the nation's rivers, lakes, and streams have experienced some amount of impairment due to nonpoint pollution sources (EPA 1991).

The Clean Water Act gives states the primary responsibility for achieving the act's goals. The federal government provides minimum standards for water quality management programs and provides some funding to implement those programs. If states do not maintain a program that meets minimum standards for water quality, then the federal government has the authority to assume responsibility for water quality management in that state.

The Clean Water Act requires states to identify nonpoint sources of water pollution from a considerable range of activities including, but not limited to, agriculture, grazing, recreation, mining, and forestry. States are required to develop management programs for controlling nonpoint sources of pollution.

Through the federal regulations implementing the Clean Water Act, states are also required to adopt an "antidegradation policy." This means that states must adopt as part of their water quality standards a policy stating that existing water quality shall be maintained and protected (O'Laughlin 1996*b*).

Idaho implements the Clean Water Act for forestry activities through the **Idaho Forest Practices Act**, described below. A more complete analysis of the nonpoint source pollution provisions of the federal Clean Water Act and its implications for Idaho was completed by the Policy Analysis Group in 1996 (see PAG Report #14, O'Laughlin 1996*b*).

4.1.4. Idaho Forest Practices Act. The Idaho Forest Practices Act applies to state and private forest land, and, through a Memorandum of Agreement, to federal forest lands in Idaho. The act recognizes that "federal, state, and private forest lands make a vital contribution to Idaho by providing jobs, products, tax base, and other social and economic benefits, by helping to maintain forest tree species, soil, air and water resources, and by providing a habitat for wildlife and aquatic life" (Idaho Code § 38-1302(1)). The act also says that "it is the public policy of the state to encourage forest practices on these lands that maintain and enhance those benefits and resources for the people of the state of Idaho" (Idaho Code § 38-1302(1)).

Forest practices include the harvesting of trees, road construction associated with harvesting, reforestation, the use of chemicals and fertilizers in forest management, the management of slashings, and the salvage of dead or dying timber that is threatened by insects, disease, windthrow, fire or extremes of weather (Idaho Code § 38-1303(1)).

The act instructs the Idaho State Board of Land Commissioners to establish standards for the conduct of forest practices that will:

(a) Provide for harvesting that will maintain the productivity of the forest land, minimize soil and debris entering streams and protect wildlife and fish habitat.

(b) Provide for road construction that will insure protection and maintenance of forest productivity, water quality and fish and wildlife habitat during construction and maintenance.

(c) Provide for reforestation that will maintain a continuous growing and harvesting of trees, and requiring stabilization of soils which have become exposed as a result of harvesting;

(d) Provide for the use of chemicals or fertilizers in such a manner that the public health and aquatic and wildlife habitat will not be endangered from their handling, storage and application.

(e) Provide for management of slashings in that manner necessary to protect reproduction and residual stands, to reduce risk from fire and insects and disease, to optimize the conditions for future regeneration of forest tree species, and to maintain air and water quality and fish and wildlife habitat.

(f) Provide for the timely salvage logging on all forest lands of dead or dying timber or timber that is threatened by various physical elements (Idaho Code 38-1304).

The Idaho Department of Lands (IDL) is responsible for administering the forest practices act on state and private lands. A landowner, timber owner, or operator must notify the IDL before undertaking a forest practice (Idaho Code § 38-1306).

Idaho requires best management practices (BMPs) to protect water quality during timber harvesting and other forestry operations in order to meet the requirements of the federal Clean Water Act (O'Laughlin 1996*b*). BMPs are discussed in more detail in **Chapter 5**.

4.2. National Forest Land-Use Policies

National forests in Idaho are almost 39 percent of the land area in the state and 73 percent of the timberland base. The National Forest System lands are managed by the U.S. Forest Service (USFS), an agency within the U.S. Department of Agriculture. It would be difficult to cover all of the policies that affect national forest management. The most recent version of *The Principal Laws Relating to Forest Service Activities* (USFS 1993*b*) describes 200 laws. There are also regulations and management guidelines that the Forest Service has adopted as policies. Only the major laws and policies are described here.

4.2.1. Organic Act. The authority for the president to create forest reserves, now called national forests, was granted in 1891, but no management direction for these lands was provided until 1897, when a law now referred to as the Organic Administration Act, or Organic Act, set out the purposes for which this system of national lands were established. The purposes are "to improve and protect the forest within the boundaries, or for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States" (16 U.S.C. § 475).

4.2.2. Multiple-Use Sustained-Yield Act. The secretary of agriculture is directed to "develop and administer the renewable surface resources of the national forests for multiple-use and sustained-yield" according to the Multiple-Use Sustained-Yield Act of 1960 (16 U.S.C. § 529). This statute codified the policy that "national forests are established and shall be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes" (16 U.S.C. § 528). Congress declared these purposes were "supplemental to, but not in derogation of" the purposes listed in the 1897 Organic Act; however, they have come to be considered the primary purposes for which national forests are managed.

Although Congress' definition of "multiple use" is long, it is worth repeating in its entirety. Multiple use is defined as

> the management of all of the various renewable surface resources of the national forests so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some land will be used for less than all of the resources; and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output (16 U.S.C. § 531(a)).

This definition allows for wide management latitude, but it also lays down three somewhat concrete guidelines (Coggins and Glicksman 1996). First, by cautioning the Forest Service to consider the relative values of the resources and not necessarily the greatest economic return, Congress rejected economic optimality as the governing criteria. Congress' second guideline is in the form of a substantive provision against any of the multiple uses that would permanently impair land productivity. Third, the statute clearly contemplates a mix of uses. Turning a large area over to a single dominant use arguably would run counter to the basic multiple-use philosophy embodied in the statute (Coggins and Glicksman 1996).

"Sustained yield" is defined as "the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the national forests without impairment of the productivity of the land" (16 U.S.C. § 531(b)). Congress did not define "high-level," a term that continues to spur much debate.

Although this law was passed many years before the term "sustainability" became popular, it includes many of the concepts embodied in "sustainability." As we discussed in **Chapter 1**, sustainability is a much broader concept than sustained yield, but the explicit recognition that the use of resources should not impair productivity now, because of subsequent effects on outputs in the future, is fundamental to the concept of sustainability. Congress also recognized that changes in resource uses over time and area would be necessary as peoples' needs and resource conditions changed.

4.2.3. Forest and Rangeland Renewable Resources Planning Act. The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) requires the Forest Service periodically to prepare three planning documents: (1) every ten years an assessment describing the renewable resources of all the nation's forest and range lands; (2) every five years a program proposing long-range objectives, with a planning horizon of at least forty-five years, for all Forest Service activities; and (3) an annual report evaluating Forest Service activities in comparison with the objectives proposed in the program (Wilkinson and Anderson 1985). The minimum content of the assessment includes (a) an analysis of present and anticipated demand and supply of renewable resources, (b) an inventory of present and potential renewable resources, (c) a description of Forest Service programs and responsibilities, and (d) a discussion of policy considerations, laws, and regulations affecting forest management. The program document includes alternatives for the protection, management, and development of the national forest system (Cubbage et al. 1993). In addition, the RPA requires the President to submit two documents: (1) every five years a statement of policy to be used in framing budget requests for Forest Service activities; and (2) an explanation accompanying each budget that does not request funds necessary to achieve the objectives of the statement of policy (Wilkinson and Anderson 1985).

4.2.4. National Forest Management Act. The National Forest Management Act of 1976 (NFMA) amends RPA by requiring land and resource management planning for units within the National Forest System and additional regulation of timber harvesting on national forests. The major provisions of NFMA require (a) public participation in the planning process, (b) regulations for the preparation and revisions of the management plans, (c) resource management guidelines for controversial management activities such as clearcutting, and (d) economic analysis of management alternatives. A primary focus of NFMA and the implementing regulations is on where timber may be harvested, how much may be cut, and how harvesting is to be carried out (Coggins and Glicksman 1996).

The NFMA and its guidelines represent an ecological approach to sustainability more than any other law (Noss 1993). New regulations for implementing the NFMA emphasize ecological sustainability above all else (65 *Federal Register* 67514 [November 9, 2000]), which seems to be a new management objective for national forests (see **4.4. Ecosystem Management**).

The NFMA is a comprehensive land-use planning law for the National Forest System, and requires the development of a management plan for each national forest. Regulations governing the planning process attempt to insure that forest plans comply with NEPA and conform to multiple-use and sustained-yield principles (Coggins and Glicksman 1996). The regulations provide guidelines for classifying land suitability, inventorying resources, and identifying hazards to resources. Like the Multiple-Use Sustained-Yield Act, the NFMA states that management plans must consider outdoor recreation (including wilderness), range, timber, watershed, wildlife, and fish. Monitoring and evaluation of planning effects to avoid impairment of land productivity is required.

Public participation is required at all stages of planning and management. Administrative appeal processes are included in regulations implementing NFMA, and challengers to forest plans must exhaust the administrative appeal processes before courts will entertain their lawsuits (Coggins and Glicksman 1996).

The NFMA requires that forest plans be updated when there has been significant change in the conditions on a forest, but at least every 15 years. Regulations allow local personnel to amend plans without going through all the procedures in NFMA if the change to the plan is not significant (Coggins and Glicksman 1996).

The NFMA explicitly addresses a number of timber management issues, including which national forest lands are "suitable" for timber harvesting, clearcutting, forest maturity, and departures from sustained yield.

Timber Suitability. In developing forest plans under NFMA, the Forest Service must identify areas "which are not suited for timber production, considering physical, economic, and other pertinent factors to the extent feasible" (15 U.S.C. § 1604(k)). Lands unsuitable for timber production are to continue to be treated for reforestation purposes and other multiple-use values are to be protected. The classification of lands as not suited for timber production is to be reviewed at least every 10 years to see if conditions have changed such that they have become suitable for timber production.

NFMA provides guidelines for forest management plans that address the physical suitability of lands for timber harvesting. Timber is supposed to be harvested only where

> (i) soil, slope, or other watershed conditions will not be irreversibly damaged; (ii) there is assurance that such lands can be adequately restocked within five years after harvest; (iii) protection is provided for streams, streambanks, shorelines,

> lakes, wetlands, and other bodies of water from detrimental changes in water temperatures, blockages of water courses, and deposits of sediment, where harvests are likely to seriously and adversely affect water conditions or fish habitat; and (iv) the harvesting system to be used is not selected primarily because it will give the greatest dollar return or the greatest unit output of timber (16 U.S.C. § 1604(g)(3)(E)).

Forest plans also must examine the economic suitability of management for timber production (16 U.S.C. § 1604 (g)(3)(A)). The NFMA implementation regulations state that "the formulation and evaluation of each alternative shall consider the costs and benefits of alternative management intensities for timber production" (C.F.R. § 219.14(c)). The NFMA does not explicitly require the Forest Service to realize a profit on any individual timber sale or on its annual sales overall (Coggins and Glicksman 1996).

***Clearcutting*.** NFMA sets out conditions that must be met before the Forest Service can authorize clearcutting on a tract of timber (16 U.S.C. § 1604(g)(3)(F)). Clearcutting cannot be selected as a harvesting method solely because it may produce the greatest amount of timber or monetary return. To authorize a clearcut, the Forest Service must determine, after an interdisciplinary review of effects, that clearcutting is the "optimum method" as judged by the standards in the land use plan. Clearcuts must be limited in size, shaped to blend with the terrain, and carried out in a manner that protects all other resources and allows timber regeneration (Coggins and Glicksman 1996).

Maturity. NFMA requires that standards are established to ensure that timber "shall generally have reached the culmination of mean annual increment of growth" before harvest (16 U.S.C. § 1604(m)). However, salvage, thinning, and other timber stand improvement techniques are allowed. Exceptions to these standards are also allowed "for the harvest of particular species of trees in management units after consideration has been given to the multiple use of the forest."

Sustained Yield and Departures. NFMA reaffirms that timber is to be managed on a sustained yield basis; however, departures are allowed under certain conditions. Departures must be consistent with the multiple-use objectives of the forest plan, must be made with public participation, and sale quantities averaged over a decade cannot exceed the quantity determined to be sustained yield (16 U.S.C. § 1611(a)). Increases in harvest levels based on intensified management practices, such as reforestation, thinning, and tree improvement are allowed provided that funds are available to continue such practices (16 U.S.C. § 1604 (g)(2)(D)). Salvage of dead timber does not have to be included in the sustained yield volume (16 U.S.C. § 1611(b)).

Problems with NFMA. Numerous analysts have identified problems with NFMA and its planning processes (e.g., Wilkinson and Anderson 1985; Baltic et al. 1989; Larsen et al. 1990; Sample 1990; Office of Technology Assessment 1992; O'Laughlin 1993; Coggins and Glicksman 1996; Jenkins 1996; Floyd 1999). It is beyond the scope of this report to enumerate the findings of all of these analysts; however, a brief summary follows.

The Office of Technology Assessment (1992) identified four major findings on forest planning:

1. Plan development emphasized timber and other physical outputs,
2. Monitoring of forest management activities was inadequate,
3. Budget decisions overwhelmed planning decisions,
4. National targets could nullify local decisions.

A team from the Forest Service (Larsen et al. 1990), with help from other organizations, concluded that adjustments were needed in the following areas:

1. The expectations of planning on the part of citizens, lawmakers, and the Forest Service,
2. The Forest Service's attitude toward and conduct of public involvement,
3. How the Forest Service conducts planning,
4. The simplification and clarification of planning procedures,
5. The implementation of plans, particularly to ensure that they are followed and used.
6. The connection between appropriations and forest plans.

4.2.5. Road Management and Roadless Area Protection Policies. Idaho's national forests contain about 14,000 miles of inventoried roads, most of which were built to access areas for timber harvest. In January 1998, the Forest Service announced its intention to revamp its policies on road development (63 *Federal Register* 4349 [January 28, 1998]). Some existing roads have unintended negative ecological impacts such as causing increased frequency of flooding and landslides, increased stream sedimentation, and associated reductions in fish habitat productivity. There are also concerns associated with fragmentation and degradation of habitat for some wildlife species and the introduction of exotic plant species. The Forest Service is also concerned because as federal budgets and timber harvest levels have decreased so has funding for road maintenance.

The Forest Service was to develop "an improved analysis process that assures that the ecological, social, and economic impacts of proposed construction and reconstruction of National Forest System roads are objectively evaluated" (63 *Federal Register* 4350 [January 28, 1998]). That analysis process was released in August 1999 (USFS 1999*b*). Administrative rules for implementing it were finalized in January 2001(66 *Federal Register* 3205 [January 12, 2001]). The rule shifts the emphasis of road management from transportation development to managing environmentally sound access. The strategy includes new analytical decision tools, aggressive decommissioning of nonbeneficial roads, and maintenance and improvement of important roads. It is not clear exactly how this strategy will affect timber harvest levels on Idaho's national forests; however, it is clear that road building associated with timber harvesting will be more closely scrutinized.

Also in January 1998, the U.S. Forest Service proposed a moratorium on building new roads into roadless areas of national forests for 18 months or until the new process for analysis of roading was completed and adopted (63 *Fed. Reg.* 4352). This moratorium went into effect in February 1999 and has affected timber harvesting on national forests in Idaho.

In October 1999, President Clinton directed the U.S. Forest Service to develop regulations that would "provide appropriate long-term protection" for some 40-50 million acres of roadless areas nationwide. The management of over nine million acres of roadless areas in Idaho's national forests have long been contentious (see MacCracken et al. 1993). The final environmental impact statement for roadless area conservation nationwide was released November 9, 2000 (USFS 2000*c*), and the record of decision was published in January 2001(66 *Federal Register* 3243 [January 12, 2001]).

The preferred alternative in the final environmental impact statement (Alternative 3) would prohibit road construction, reconstruction, and timber harvest except for stewardship purposes within inventoried roadless areas, while excepting road reconstruction needed for road safety improvements and federal highway aid projects (USFS 2000*c*). About 5.7 million of the 9.3 million acres (61%) of inventoried roadless areas in Idaho are currently allocated to management that allows road construction and reconstruction.

The final environmental impact statement (USFS 2000*c*) estimates that timber harvests planned in inventoried roadless areas from FY 2000 to FY 2004 in Idaho's national forests are almost 159 million board feet. About 72 million board feet of that total (45%) are in areas that will require road construction or reconstruction and thus subject to reduction. Almost 84 million board feet of the planned sales can be harvested using helicopters, cable and ground-based systems that do not require road construction or reconstruction. More than 76 million board feet of those sales (91%) are for stewardship purposes (USFS 2000*c*).

Although the policies associated with road management, roadless areas, and timber harvesting on national forests are in flux, it appears the results will be reductions in the amount of land where timber management activities take place and in the amount of timber harvested from national forests in Idaho.

4.3. Laws Protecting Wilderness and Biodiversity

Congress has enacted several statutes in the recognition that development of lands and resources to meet human purposes can diminish other values. Wilderness values and the values associated with biological diversity have been recognized as important by Congress. These two areas of the law have impacts on timber harvesting because the Wilderness Act reserves federal land from timber harvesting, and biodiversity protection law, especially the Endangered Species Act (ESA), tempers the use of land and resources for economic purposes by requiring adequate concern and conservation of threatened and endangered species. The "diversity" mandate of the National Forest Management Act (NFMA) also protects biodiversity on National Forest System lands.

4.3.1. Wilderness Act. The Wilderness Act of 1964 creates statutory wilderness. Congress gave itself the authority to create the National Wilderness Preservation System from lands already administered by federal agencies. The purpose of the act is to "secure for the American people of present and future generations the benefits of an enduring resource of wilderness...to be administered for the use and enjoyment of the American people in such a manner as will leave them unimpaired." The act defines wilderness as "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor and does not remain." Idaho has about 4 million acres in the National Wilderness Preservation System.

Congress defined the purposes of wilderness as recreational, scenic, scientific, educational, conservation, and historic use. Timber harvesting in wilderness areas is generally prohibited by the act and Forest Service regulations.

4.3.2. Wild and Scenic Rivers Act. In 1968, Congress passed the Wild and Scenic Rivers Act, creating the National Wild and Scenic Rivers System. The purpose of the system is to preserve sections of free-flowing rivers and their immediate environments for scenic, recreational, fish and wildlife, and other similar values (16 U.S.C. § 1271). Idaho has 574 miles of rivers designated within the system, including portions of the Clearwater, Salmon, Snake, Rapid, and St. Joe Rivers. All rivers in the system in Idaho are managed by the Forest Service.

The act protects not only the river course, but also a corridor of land on each side along it's length. The corridor for designated rivers cannot exceed 320 acres per mile without Congressional approval (16 U.S.C. § 1274(b)). If applied uniformly along a designated stretch, the corridor cannot exceed one-quarter mile on each side of the river; however, corridors are not usually uniform in width.

Timber harvesting practices on federal lands located within the corridor must be designed to help achieve land management objectives consistent with the protection and enhancement of the values which caused the river to be added to the system. Designation is not likely to significantly affect timber harvesting beyond existing limitations to protect riparian zones and wetlands which are guided by other legal mandates and planning directions (see, e.g., ***4.3.3. Endangered Species Act***) (Interagency Wild and Scenic Rivers Coordinating Council 1999). Federal timber harvesting activities outside the corridor cannot adversely affect the values which caused the river to be designated. Under the act, the only way the federal government can restrict private timber harvesting is through the purchase of timber rights or under cooperative agreement (Interagency Wild and Scenic Rivers Coordinating Council 1999).

4.3.3. Endangered Species Act. The Endangered Species Act (ESA) is a federal law that applies to all land ownerships, public or private. The ESA provides for the protection and recovery of plant and animal species that are identified as being threatened or endangered with extinction (see PAG Report #13, O'Laughlin and Cook 1995).

Identification of Imperiled Species. The ESA gives two agencies, the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), the responsibility for identifying, protecting, and recovering threatened or endangered species. The identification process is called "listing." Idaho has 22 listed species (Table 4-1). In Idaho, the USFWS is responsible for all the listed species, except salmon and steelhead which are the responsibility of the NMFS because these fish are anadromous, spending a portion of their lives in the ocean.

Habitat alteration and destruction are recognized as being the largest causes of endangerment for many species. "Critical habitat" is the specific geographic area essential for the conservation of a protected species and may require special management considerations or protection.

ESA Protection: Section *7*. The ESA protects species through several different mechanisms. The first group of protections are in section 7 of the ESA. Even though these provisions apply only to federal actions by federal agencies, they can affect private interests as well, particularly in Idaho. Because these restrictions apply to any action that involves federal authorization, private individuals may be involved because of leases, permits, or cost-sharing funds from federal agencies. Also, in Idaho over 60 percent of the land base is managed by the federal government, so the potential for federal actions to affect private individuals is large.

Section 7 says an agency's actions cannot "jeopardize" a listed species. "Jeopardize" is defined by federal regulation as "actions that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, number, or distribution of the species." Section 7 also says that an agency's actions cannot "result in the destruction or adverse modification of the species critical habitat."

Federal land management agencies (e.g., the Forest Service and the Bureau of Land Management) must consult with the USFWS or the NMFS to determine whether their proposed actions will jeopardize a listed species. Few proposed projects are terminated because of consultation; however, projects often must be modified to avoid jeopardizing listed species, and many projects are delayed by

Table 4-1. Endangered and threatened species protected in Idaho by the Endangered Species Act.

	Endangered	**Threatened**
Mammals	Gray wolf Woodland caribou	Grizzly bear Canada lynx Northern Idaho ground squirrel
Birds	Whooping crane	Bald eagle
Fishes	Kootenai River white sturgeon Snake River sockeye salmon	Snake River chinook salmon (spring/summer & fall runs) Snake River steelhead Bull trout
Snails	Utah valvata snail Idaho springsnail Snake River physa snail Banbury Springs limpet Bruneau Hot Springsnail	Bliss Rapids snail
Plants		MacFarlane's four-o'clock Water howellia Ute ladies'-tresses
Total	**10**	**12**

the consultation process (O'Laughlin and Cook 1995).

ESA Protection: Section 9. The second set of protections are in Section 9 of the ESA and apply to any individual. Section 9 prevents the "take" of endangered animals. "Take" is defined in the ESA as "harass, harm, pursue, hunt, shoot, kill, trap, capture, or collect, or attempt to engage in any such conduct." This definition has been interpreted broadly to include not only actions towards individual animals, but significant modification or degradation of their habitats (O'Laughlin and Cook 1995).

Recovery of Imperiled Species. The ultimate goal of the ESA is to recover species to the point where the protections of the act are no longer necessary. The services must develop a recovery plan for each species that identifies measures that will resolve the threats to the species, the time and costs associated with those measures, and objective quantifiable criteria for determining when the species has recovered sufficiently to be delisted, or removed from the list of protected species.

ESA and Forest Management. The ESA affects forest management and timber harvesting in Idaho because many listed species depend on forests as part of their habitat. For example, grizzly bears require large areas of forested habitat where the incidence of human contact is low. Timber harvesting and other activities continue to occur in grizzly bear habitat in Idaho, but the levels of these activities are probably lower than if grizzlies were not present or not managed under the mandates of the ESA (PAG Report #12, MacCracken et al. 1994). However, it is extremely difficult to differentiate the impacts of grizzly bear conservation from those associated with dispersed recreation goals, maintaining old-growth forests, the needs of other wildlife species, and maintaining water quality (MacCracken et al. 1994).

The listed runs of Snake River salmon and steelhead also have impacts on forest management (see ***PACFISH*** and ***INFISH*** sections below). Forest managers in Idaho foresaw the largest impacts on decreased levels of timber harvest in the state from restrictions under the ESA (Haminishi et al. 1995).

The ESA is a straightforward law in design, but quite difficult to implement. The law has several other provisions and consequences not described here. A complete analysis of the ESA by the Policy Analysis Group was completed in 1995 (see PAG Report #13, O'Laughlin and Cook 1995).

4.3.4. NFMA Diversity Mandate. The National Forest Management Act (NFMA) says that guidelines in individual forest plans for national forests should "provide for diversity of plant and animal communities based on the suitability and capability of the specific land area to meet overall multiple-use objectives" and "where appropriate, to the degree practicable for steps to be taken to preserve the diversity of tree species similar to that existing in the region" (16 U.S.C. § 1604(g)(2)(B)). The wording in this section of NFMA incorporates fudge factors not found in other sections and thus is likely less of a restriction on Forest Service discretion to sell timber than other sections. Most of the court decisions interpreting the diversity requirement have exhibited considerable deference to Forest Service choices (Coggins and Glicksman 1996). However, there is little doubt that a principal reason for the recent revisions to NFMA regulations is implementation of the species diversity mandate (see further discussion in ***4.5.1. National Forest Lands***).

4.3.5. PACFISH. In 1991, three runs of Snake River salmon in Idaho were listed under the ESA. In 1992, the Forest Service began working on conservation strategies for managing anadromous fish-producing watersheds, an effort known as PACFISH, for Pacific Anadromous Fish Strategy (USFS & BLM 1994*b*). In 1993 the BLM joined the PACFISH effort, and in February 1995 PACFISH was adopted by both agencies. Seven of ten national forests in Idaho and two of three BLM districts have portions of their land in anadromous fish habitat and thus are covered by PACFISH provisions.

Under PACFISH, interim buffer zones, or Riparian Habitat Conservation Areas (RHCAs), have been created for all riparian areas on Forest Service and BLM lands in the range of anadromous fish. On fish-bearing streams, the RHCA extends for at least 300 feet on either side of the stream channel. On permanently flowing non-fish-bearing streams, the RHCA extends for at least 150 feet on either side of the stream channel. For seasonally flowing or intermittent streams the RHCA extends for at least 100 feet on either side of the stream channel in Key Watersheds and 50 feet in non-Key Watersheds. Key Watersheds are a) those identified as having stocks of fish listed under ESA, b) watersheds that contain excellent habitat for mixed salmonid assemblages, and c) degraded watersheds with a high restoration potential. Interim Riparian Management Objectives (RMOs) have been established for the RHCAs and include pool frequency, water temperature, large woody debris, bank stability, lower bank angle, and width/depth ratio.

Timber harvest, including fuelwood cutting, is prohibited in RHCAs except for salvaging of trees in riparian areas that are degraded by catastrophic events such as fire, flooding, wind, and insects, and where salvaging impacts are consistent with RMOs. Other silvicultural practices that are consistent with RMOs also can take place in RHCAs.

PACFISH interim standards for RHCAs and RMOs apply until a more site-specific, watershed analysis is completed. **Chapter 6** of this report examines watershed analysis in detail.

PACFISH was developed as a temporary strategy until more long-term direction is provided in the Upper Columbia River Basin Environmental Impact Statement (UCRB EIS) (see ***4.4.2. Interior Columbia Basin Ecosystem Management Project***). PACFISH was originally supposed to last 18 months, ending in September 1996. However, because of delays in the development and release of the UCRB EIS, PACFISH standards are still in force. The draft of UCRB EIS was released in May 1997, a supplemental UCRB EIS was released in April 2000, and a final EIS and Record of Decision in December 2000.

Impact of PACFISH on Timber Harvest Levels. PACFISH has had an impact on timber harvest levels on federal lands in Idaho. The Environmental Assessment for PACFISH estimated its restrictions would reduce harvest in the entire action area, including Idaho, Washington, Oregon, and northern California, by 58 million board feet. The Clearwater and Nez Perce National Forests and the Coeur d'Alene BLM District were expected to cancel some timber sales, with the Clearwater National Forest accounting for about 90 percent of the volume lost for the entire action area (USFS & BLM 1994*b*).

However, in a subsequent analysis, Forest Service analysts found the Environmental Assessment's estimates to be low (Bolon et al. 1995). Most national forests and BLM districts within Idaho reported that timber harvest volumes would decline due to PACFISH (Table 4-2). ESA consultation, other special management considerations, and underfunding had already dropped timber harvest levels 38% from planned national forest and BLM timber sales volumes. PACFISH was estimated to drop timber harvest levels 11% from the 1993 levels

Table 4-2. Impact of applying PACFISH strategy on Idaho federal lands, average annual data, 1994-2003.

Forest or district	Percent of area within the range of anadromous fish	Allowable timber harvest* from plan (level 1) [mmbf]	Actual allowable timber harvest with constraints (level 2) [mmbf]	Change from level 1 to level 2	Allowable timber harvest with PACFISH strategy mitigation (level 3) [mmbf]	Change from level 1 to level 3	Change from level 2 to level 3	Cost to apply the PACFISH strategy (with mitigation)
BLM district								
Salmon	83%	1.85	1.54	-17%	1.47	-21%	-5%	$19,000
Coeur d'Alene	52%	5.70	5.70	0%	5.40	-5%	-5%	$47,360
Total BLM		7.55	7.24	-4%	6.87	-9%	-5%	$66,360
National forest								
Boise	17%	85.00	83.90	-1%	83.40	-2%	-1%	$292,800
Challis	83%	3.00	0.00	-100%	82.30	-100%	0%	$25,000
Payette	77%	86.00	86.00	0%	82.30	-4%	-4%	$228,000
Salmon	98%	21.10	17.70	-16%	17.70	-16%	-0%	$18,600
Sawtooth	80%	1.50	1.50	0%	0.75	-50%	-50%	$27,560
Nez Perce	100%	108.00	45.00	-59%	38.00	-65%	-16%	$173,000
Clearwater	45%	173.30	60.00	-65%	40.00	-77%	-33%	$108,000
Total national forest		477.90	294.10	-38%	262.15	-45%	-11%	$872,960
Total BLM and national forest		485.45	301.34	-38%	269.02	-45%	-11%	$939,320

* Allowable timber harvest for national forests is the average annual ASQ, or allowable sale quantity; for BLM lands it is the average annual DSHL, or decadal sustainable harvest level.

Source: Bolon et al. (1995).

(Bolon et al. 1995). Actual timber harvest levels from Idaho's national forests dropped 60% between 1990 and 1995 (Keegan et al. 1997).

4.3.6. INFISH. In July 1995, the Forest Service undertook the Inland Native Fish Strategy (INFISH) in an effort similar to PACFISH, but designed to protect inland native fish communities, particularly those of bull trout (*Salvelinus confluentus*). INFISH applies to all watersheds on national forests in Idaho not covered by the PACFISH agreement. INFISH uses RHCAs and RMOs similar to those in PACFISH (USFS 1995*a*). INFISH is also a temporary strategy that will remain in place until a record of decision is reached on the UCRB EIS.

4.4. Ecosystem Management

Since the late 1980s, federal land and resource management agencies have been struggling to broaden the scope of management considerations from a focus on individual resources and outputs to a more comprehensive or holistic approach to planning and managing lands. The driving forces behind this are environmental laws, and especially the laws protecting biodiversity. The most widely used term for this new approach to planning and management is "ecosystem management" (see Agee and Johnson 1988). We will call it EM for short. The term "ecosystem-based management" is also used herein to mean the same thing.

EM has been described as a "fuzzy" concept (More 1996) and has not been expressly sanctioned in any of the governing natural resource or public land management laws (Keiter 1994). However, because of its increasing use as a means of managing natural resources in both the public and private sector, EM affects timber harvesting in Idaho.

4.4.1. Ecosystem Management as Policy. In June 1992, Dale Robertson was Chief of the Forest Service. He sent a memo to agency officials stating "that the U.S. Forest Service is committed to using an ecological approach in the future management of the National Forests and Grasslands." This approach has become known as ecosystem management, or EM. Since Chief Robertson's 1992 announcement, EM has become one of the most widely used terms in resource management. Literally hundreds of articles, books, symposia, and other written materials have been devoted to defining and implementing it. It would be impossible to review all the literature here, but we provide a short discussion.

There is no widely accepted definition of EM, but Moote et al. (1994) provide an overview of five principles common to many views of the concept (Table 4-3). Some have criticized the concept because it lacks precise definition (e.g., More 1996, Christensen et al. 1996, Fitzsimmons 1996). The U.S. Congress has yet to create a statutory definition for EM. Some observers feel a statutory definition would add legitimacy to the EM concept as a federal land management direction (Keiter 1994, Keiter 1996). Other observers, including Yaffee (1996), insist that there is ample statutory authority already in place for federal agencies to undertake EM. Different and opposing interests are competing to give EM a substantive content consistent with their particular view of appropriate natural resource policy (CRS 1994). Although unsettling, this process may actually reflect a familiar evolutionary pattern for the transformation of a new experimental policy into a legal imperative (Keiter 1996).

Despite lack of statutory definition, EM is setting the agenda for environmental policy (Haeuber 1996). At least 18 federal agencies have explored the EM concept and its implications for their various activities (Haeuber and Franklin 1996). Each of the land and resource management agencies has drafted policy guidance for EM approaches to their missions. Other agencies have created partnerships to launch EM projects around the country. Similar activities are occurring at state and local government levels, and in the non-governmental sector (Haeuber and Franklin 1996).

Why has the use of EM grown despite lacking a statutory definition? One explanation is that management at an ecosystem scale makes scientific sense and offers some hope of improving today's complex natural resource controversies (Keiter 1996).

Some EM concepts can be traced back to the 1930s (Grumbine 1994). Aldo Leopold's (1949) classic *A Sand County Almanac* is given credit by many, including former Chief Robertson, for many of the concepts embodied in EM.

Two basic EM concepts or viewpoints are in use today (Stanley 1995). One view entails a fundamental reframing of how humans value nature and represents a shift from anthropocentric values toward biocentric values (see **Chapter 2**). The other view retains anthropocentric values—focusing on forest outputs—but gives more attention to ecological and social values (Stanley 1995).

To some people EM is a profoundly new approach to land and resource management; to others, it is simply a new term for what resource managers have always been doing (Irland 1994). To others, EM is a green codeword, emphasizing the protection and restoration of ecological structure, function, and process while de-emphasizing the development of economic resources (see Grumbine 1994).

Ecosystem management involves key differences from traditional forest management (Table 4-4). Although there is not yet consensus on how to implement ecosystem management (Montgomery et al. 1995), implementing it will require adjustments to policies and institutions that affect forests (Cortner et al. 1996). Timber harvesting methods and levels are likely to change as ecosystem management policies are implemented on the national forests.

4.4.2. Interior Columbia Basin Ecosystem Management Project. One of the first efforts that attempts to apply ecosystem management at a large, regional scale is the Interior Columbia Basin Ecosystem Management Project (ICBEMP). The definition of ecosystem-based management use in the ICBEMP (1997) is: "Scientifically based land and resource management that integrates ecological capabilities with social values and economic relationships, to produce, restore, or sustain ecosystem integrity and desired conditions, uses, products, values, and services over the long term."

Table 4-3. Principles of ecosystem management.
Ecosystem management is a management philosophy that [a] focuses on desired conditions, rather than system outputs, and [b] recognizes the need to protect or restore critical ecological components, functions, and structures in order to sustain resources in perpetuity.
Five principles characterize ecosystem management: ***1. Socially Defined Goals and Management Objectives***. Desired conditions and the means by which we choose to achieve these conditions are social values. Therefore, ecosystem management, like all forms of management, is a socially defined process. Nevertheless, human society needs to adapt its activities to protect crucial ecological processes. ***2. Integrated, Holistic Science.*** Ecosystem management uses a holistic approach, rather than focusing on specific system outputs. It attempts to conserve biodiversity from the genetic to the community level. Ecosystems are recognized as open, changing, complex systems. Ecosystem management focuses on the dynamic interrelations of system components—including social, political, economic, biological, and physical features—and requires a better understanding of each of these components and their interrelations. Humans are recognized as a part of ecosystems. ***3. Broad Spatial and Temporal Scales***. Specific scales of management will be determined individually for each system, based on societal values and goals. In general, however, ecosystem management must work over larger spatial and longer temporal scales than has been the norm in resource management. It requires management across ecological, political , generational, and ownership boundaries. ***4. Collaborative Decision Building***. Successful planning for ecosystem management must be sensitive to the different mandates, objectives, and constituencies of agencies and landowners. Therefore, there is a need for cooperative, integrated data collection and planning, characterized by open communication among scientists, resource management agencies, and private interests. Participants should strive for joint organizational and community learning that acknowledges the values and expertise each participant brings to the planning process. ***5. Adaptable institutions***. Institutions for ecosystem management must reflect its experimental nature. Organizations, laws, policies, and management practices need to be flexible, so that they may adapt to changes in social values, environmental conditions, political pressures, available data, and knowledge. Adaptable institutions treat management as a learning process in which decisions are continuously reviewed and revised, and therefore allow planning and decision-making to go forward in the face of uncertainty. At the same time, it is recognized that institutional decision-making is bounded by the currently defined limits of planning and management and by socio-political factors.

Source: Moote et al. (1994).

The ICBEMP project area includes all the land area in the Columbia River drainage east of the crest of the Cascade Mountains. This area includes all of Idaho, except the Bear Valley in southeastern corner of the state, eastern Washington and Oregon, and western Montana. The ICBEMP project area is approximately 144 million acres, of which 72 million acres are public lands administered by the U.S. Forest Service or the BLM.

The ICBEMP was initiated for the following reasons:

[1] To identify existing or emerging resource problems that transcend jurisdictional boundaries, such as forest health problems and declining salmon populations, and to propose potential solutions that can best be addressed on a large scale;

Table 4-4. Key differences between traditional forest management and forest ecosystem management.

	Traditional forest management	**Forest ecosystem management**
Philosophical base	• Utilitarian	• Environmental ethic, based on Aldo Leopold (1949)
Objectives	• Maximize commodity production • Maximize net present value	• Maintain the forest ecosystem as an interconnected whole, while allowing for sustainable commodity production • Maintain future options
Constraints	• Sustained yield—periodic harvest or use of outputs must be less than or equal to their periodic growth or capacity (e.g., allowable timber cut, or recreation carrying capacity)	• Long-term ecosystem sustainability • Maintain forest aesthetics • Social acceptability of management practices
Role of science	• View of forest management as applied science	• View of forest management as combining scientific and social considerations
Value	• Forest valued as a resource—instrumental value only • Singular-focused valuation	• Forest valued instrumentally and intrinsically • Pluralistic valuation
Major themes	• Focuses on outputs—goods and services demanded by people (e.g., timber, recreation, wildlife, and forage) • Management that fits industrial production processes (the "regulated forest") • Timber is the most important forest output ("timber primacy") • Impending timber shortage/famine • Mechanistic, reductionist view of forests • Scale—typically stand-level • Planning/management unit—political or ownership boundaries • Economic efficiency	• Focuses on inputs and processes (e.g., soil, natural capital, biological diversity, and ecological processes) • Management that mimics natural processes • All species—plant and animal—are important • Biodiversity loss • Systems view of forests—the forest is more than the sum of its individual parts • Scale—ecosystem- and landscape-level • Planning/management unit— ecosystems • Cost-effectiveness, social acceptability

Source: Bengston (1994).

[2] To develop management strategies using a comprehensive, “big picture” approach, and disclose interrelated actions and cumulative effects using scientific methods in an open public process;

[3] To address certain large-scale issues, such as species viability and biodiversity, from a larger context using an interagency team. This method is more cost-effective than each Bureau of Land Management (BLM) District and National Forest conducting independent efforts;

[4] To respond to President Clinton’s July 1993 direction to develop a scientifically sound, ecosystem-based management strategy for lands administered by the BLM or U.S. Forest Service in the upper Columbia River Basin; and

[5] To replace interim management strategies (PACFISH and Inland Native Fish Strategy) with a consistent long-term management strategy (ICBEMP 1997).

The design of the management strategies proposed as a result of the ICBEMP were driven by the need to: (1) “restore and maintain long-term ecosystem health and integrity,” and (2) “support, within the capacity of the land, the economic and/or social needs of people, cultures, and communities, and provide sustainable and predictable levels of products and services from U.S. Forest Service and BLM-administered lands” (ICBEMP 1997).

Work on the ICBEMP project was divided into two major efforts: the scientific assessment (Quigley et al. 1997) and the management strategy (ICBEMP 1997). The management strategy is contained in two environmental impact statements (EIS), one for the east side of Oregon and Washington and one for the Upper Columbia River Basin, which includes Idaho and western Montana. Drafts of these EISs were released in May 1997. They were subjected to constructive criticism by professional foresters (see Hill 1998, O’Laughlin et al. 1998). The two analysis areas were combined into one, called the Interior Columbia Basin, and in December 2000, Final Environmental Impact Statement and Proposed Decision documents were released for public review (ICBEMP 2000). If the Record of Decision is signed, all land-use plans currently in effect on Forest Service and BLM lands in the region will be amended. Two additional levels of analysis will be required before management activities can be conducted. One of them is subbasin review, the other is watershed analysis. Interim Riparian Conservation Areas (RCAs) and Riparian Management Objectives (RMOs) similar to PACFISH apply until watershed analysis is performed. We discuss watershed analysis thoroughly in **Chapter 6**.

The proposed decision alternative promotes broad-scale restoration and maintenance of ecosystems. Timber harvesting would increase by 21% over what a continuation of current PACFISH/INFISH guidelines would allow. The size and quality of logs produced would decrease because thinning and harvest activities would be guided by objectives to restore stands to conditions within the historic range of variability. It is expected that employment levels within the basin would increase by 3,900 jobs; 35-40% of them in stewardship timber harvesting and 60-65% associated with prescribed fire and fuels management (ICBEMP 2000). In the ICBEMP final EIS document, it is not possible to separate out projected effects on Idaho from those in Washington, Oregon, and Montana. However, from responses to comments in the document, it appears that Idaho harvest levels were pegged at the 1995-1997 average of 300 million board feet per year, and a 21% increase can be expected if the proposed alternative is adopted in the final Record of Decision.

4.5. Management Objectives

Each owner of forest land has a unique set of management objectives or goals that, in part, are policies for determining how that land is managed. Within the sideboards or constraints of federal and state laws, the management objectives of Idaho landowners will determine whether or not timber harvesting is an appropriate activity and will determine how sustainability is incorporated into management of the land.

4.5.1. National Forest Lands. As previously indicated, the basic management objective for the national forests as stated in law is found in the Multiple-Use Sustained-Yield Act. The U.S. Forest Service is to manage national forests for outdoor recreation, range, timber, watershed, and wildlife and fish purposes in the combination that will best meet the needs of the American people. However, management objectives arising from the implementation of ecosystem management also affect the national forests.

National Forest Management Act planning regulations make sustainability the overall goal of national forest management (65 *Federal Register* 67514 [November 9, 2000]. According to these new regulations, the first priority is to maintain or restore ecological sustainability of national forests. Economic and social sustainability are secondary goals after ecological sustainability. Although some people feel that the regulations have changed the management objectives of national forests without the necessary changes in laws, the planning regulations are now final. Whether they will be challenged in the court system remains to be seen.

4.5.2. State Endowment Lands. The purpose of Idaho's endowment lands as set forth in the Idaho Constitution is to manage the lands "in such manner as will secure the maximum long term financial return to the beneficiary." These lands were granted to the state of Idaho by the federal government at the time statehood in 1890. These lands include almost one million acres of timberlands that are managed as a trust for the benefit of the beneficiary, which are common or public schools within the state and the other specifically designated beneficiaries of the land grants. The land was given only for specific purposes defined in statutory law and the state constitution and is now firmly supported by case law (see O'Laughlin 1990). In FY 1997, timber sales contributed $55.2 million to the state endowment fund.

4.5.3. Forest Industry Lands. Forest lands owned by forest industry companies are managed for a variety of reasons. The primary reason is to ensure that the manufacturing facilities of the firm have a continuous supply of wood. These lands have been an insurance policy more than a profit center (O'Laughlin and Ellefson 1982).

These lands tend to be managed more intensively for the production of timber than lands in other ownerships. The mission of these companies is often expressed as providing financial return to shareholders. For example, two of the largest forest products firms operating in Idaho are Boise-Cascade Corporation and Potlatch Corporation. Boise Cascade states its mission as

> to continuously improve the company's long-term value to customers, employees, shareholders and society... Our goal is to achieve a return on invested capital over the course of each business cycle that exceeds the company's cost of capital.

Potlatch Corporation says its

> business philosophy is committed to increased earnings and superior rate of return, achieved by talented, well-trained and highly motivated people who are properly support by a sound financial structure and a keen sense of responsibility for the environment and to all the publics with whom the company has contact...Our goal at Potlatch is to earn a superior rate of return for our shareholders over the long term. In the end we should not measure ourselves in any other way.

These overall corporate objectives do not imply that private industrial forest landowners do not care about the land that they manage. The long-term financial health of private companies partially depends on the ability of lands to continue to produce timber in the future. Boise Cascade states: "We manage our forests to provide the wood fiber our mills need and to ensure that supply is always available."

4.5.4. Non-Industrial Private Forest (NIPF) Lands. Non-industrial private landowners own forest land for many reasons. Their management objectives influence their forest management and timber harvesting decisions. In a survey of non-industrial private forest (NIPF) owners in Idaho, Force and Lee (1991) found that wood for domestic use, esthetic enjoyment, and wildlife appreciation were the three major benefits from forest ownership. The most important reason for owning forest land was "to preserve natural beauty and wildlife." This was followed by four other nonmonetary related reasons before the sixth-ranked reason of "to obtain income from timber." Owners of larger forest acreages tended to place more emphasis on timber.

Fifty-six percent of all Idaho NIPF owners reported that they had harvested timber in the past (Force and Lee 1991). One-fourth said they would not harvest timber in the future, one-fifth said they would do so in the next five years, one-tenth in the next 6-10 years, and the remaining 45% were uncertain about harvest plans. Small landowners were more likely to say they would not harvest timber, and timber prices were more important in the decision of when to harvest for large landowners.

4.5.5. American Indian Tribal Lands. Timber inventory statistics compiled by the U.S. Forest Service (e.g., Brown and Chojnacky 1996) include tribal lands with non-industrial private forests. Indian tribes are sovereign nations. In Idaho, Indian nations own about 94,000 acres of timberland. Many tribal issues related to resource management in Idaho are described and discussed further in ICBEMP (1997). Tribes tend to have different management objectives for their lands than other owners. Their objectives are based on their worldview (see **Chapter 2**).

Today, American Indians continue to actively manage their forest resources for economic development and subsistence use. In Idaho, for example, the Coeur d'Alene Tribe manages about 27,000 acres of forest. The tribal council approves logging of about 6.5 million board feet from tribal forests each year. However, inherent in this timber management program is an attempt to balance economic gain and conservation for future generations. The Coeur d'Alene logging operations rarely use clearcutting methods, have an extensive replanting and restoration program and follow best management practices (BMPs) when harvesting (Roesler 1995).

4.6. Forest Certification

"Certification" is a new, rapidly developing area of forest management policy. It is the focal point of **Part I** of this analysis, available separately (PAG Report #18, Cook and O'Laughlin 1999). Certification promotes sustainable forest management by assessing forest management practices and/or forest management systems based on a set of standards (SAF 1995). Most of the industrial forest lands in Idaho are either in the process of being certified, or have been certified by a third party.

Our discussion of policies affecting timber harvesting has concentrated on only domestic policies. However, certification provides an opportunity to broaden the discussion to issues that cross national boundaries. The following review raises a few of the global issues that emerge with a movement towards certification of sustainable forest management.

In most temperate forest countries and in many tropical countries, forest policies have been changing to address forest sustainability issues (Sedjo et al. 1998). Certification may play a role in such policy changes. Even if a forestry management policy such as certification cannot by itself assure sustainability, it can be argued that certification could be a catalyst for management changes (Viana 1997). There are several dimensions of these potential policy changes that need to be addressed in the context of certification programs. They are forest management, costs, and wood supplies.

4.6.1. Forest Management Changes. Individual countries have responded to international and domestic concerns with changes in their domestic laws and policies to improve water quality, protect biological diversity, and implement silvicultural treatments that are more sensitive to public acceptance. Some of these policies are regulatory in nature, while others rely on tax or other incentives (Sedjo et al. 1998).

A great deal of the willingness of firms to change land management procedures appears to be driven by concerns about the acceptability of their product today and in the future in foreign markets, especially some European markets that are expected to become increasingly "green" in the future, such as the United Kingdom and Germany. The Canadians, in particular, seem to be very sensitive to this issue (Sedjo et al. 1998).

Of the eight temperate forest countries selected for analysis by the Resources for the Future study team of Sedjo et al. (1998), all but the United States have instituted major new forest laws or national policies within the past few years, mostly since the 1992 Earth Summit. These countries—Canada, Chile, Finland, Sweden, France, Germany, and New Zealand—appear to have anticipated the evolving reality that includes sustainable forestry and have attempted to update their laws and policies accordingly. In the U.S., although new laws have not been enacted, forest management has been affected by recent litigation and court interpretations of existing statutes. For example, the Endangered Species Act, as now interpreted, provides substantial protection for threatened and endangered species and includes provisions regarding habitat that affect both private and public lands (Sedjo et al. 1998).

The impacts of proposed sustainable forestry policies varies greatly among different countries. For example, the potential impacts of proposed changes in the U.S., Canada, and Sweden would be quite different (Table 4-5). Because of land ownership patterns and other factors, the U.S. faces higher impacts in more categories than do other countries. In general, a low impact rating implies that a policy is likely to have little disruptive effect on forest production and that the costs of accommodating this policy would be modest. A high rating implies just the opposite: the disruption of harvests would likely be large as would be the cost of implementing the policy. (See Sedjo et al. 1998, pp.54-57, for specific examples, and for analyses of 5 other countries not illustrated in Table 4-5.)

Table 4-5. Relative impacts of proposed sustainable forestry policies on selected countries.

Sustainable Forestry Approach	Canada	Sweden	United States
Placing limits on harvests from primary or old-growth forests	High	Low	Low
Discouraging conversion of natural forests to plantations	Low	Low	High
Restricting conversion of forests to other land uses	Low	Low	Low
Limiting use of genetically improved stock or exotic species	Low	Medium	High
Restricting clear cutting	High	High	High
Restricting use of chemical treatments	Low	Medium	High
Requiring chain-of-custody tracking	Low	Medium	High

NOTE: These impacts are based on existing practices, land ownership patterns, and forest conditions.

Source: Sedjo et al. (1998)

4.6.2. Costs of Certification. Forest products firms have concerns about higher costs of adapting to changes in forest policies and industry practices and about their ability to compete internationally (Sedjo et al. 1998). Most studies suggest cost increases associated with new on-the-ground sustainable practices of at least 5% and often 20%. This does not include the costs of maintaining a "chain-of-custody" control. Increases in management costs will vary widely depending on the conditions of the site (Sedjo et al. 1998).

In general, other things being equal, the types of sustainability criteria that are emerging appear to make it easier and less costly (per unit of output) for large ownerships to adapt than for small ownerships, and less costly for government-owned forests to adapt than for privately owned forests. For example, it would almost certainly be easier for Canada, with the vast majority of its lands in public ownership, to implement uniform sustainability standards and chain-of-custody tracking than for the U.S., with its millions of forest owners. The chain-of-custody issue is likely to be difficult and costly where small ownerships prevail and if many in the area choose not to undertake the new practices. This situation could occur in the U.S. South (Sedjo et al. 1998).

4.6.3. World Markets: Where will the wood come from? The market for certified wood products is currently modest and limited, but is growing (see Cook and O'Laughlin 1999). However, there will almost certainly be a very large market for noncertified wood-based products into the foreseeable future, especially if noncertified wood is less expensive. It would not be surprising if much of the world's industrial roundwood continued to be produced by firms practicing "traditional" forestry that does not incur the higher costs associated with certification (Sedjo et al. 1998). The relationship between the markets for certified and non-certified timber in world trade is yet unclear.

As Figure 2-1 illustrates, demand for wood products in the U.S. is expected to continue to increase, yet policies, particularly for publicly-owned forests, are tending to restrict timber production to protect other forest values. Certification represents a policy that may lower the amount of timber coming from a forest. If forest policies are tending toward reducing timber production, then how will the increasing demand for wood products be met?

Some authors suggest that tree plantations following an agricultural model offer great promise for fulfilling the world's demand for wood (see Sedjo and Botkin 1997, Binkley 1999), but plantations are at odds with some forest certification programs. For example, the Forest Stewardship Council (FSC) administers one of the major forest certification programs. FSC certification promotes natural and native forests and discourages intensively managed forests that utilize fertilization, genetically improved stock, and biotechnically improved pesticides (Sedjo et al. 1998). The end result of certification that rejects intensive management may bestow a comparative timber production advantage on countries with low forest productivity potential, while leaving at a competitive disadvantage the countries blessed with a high productivity potential (Sedjo et al. 1998). The upshot may be that more native and natural forests will be subjected to industrial exploitation than would be if tree plantations were used more extensively for wood production (Binkley 1999). When examined across the globe, two to five fold increases in specific timber yields appear generally to be technically feasible and economically attractive with tree plantations (Binkley 1999). More widespread plantation forestry has a large capacity to free natural forests from intensive exploitation for industrial purposes (see Sedjo and Botkin 1997).

4.7. Conclusions. Many policies affect timber harvesting in Idaho. These range from federal environmental laws to the state Idaho Forest Practices Act to individual landowner's management objectives. Most federal and state policies affecting private lands have been in effect for several decades and their impacts are well known or predictable. Policies affecting federal lands, however, are in flux, and the future of national forest timber harvesting is uncertain. New planning guidelines, new roadless area policy, new road management policy, and perhaps a forthcoming record of decision from the Interior Columbia Basin Ecosystem Management Project have the potential to dramatically alter the national forest policy landscape. Other policies such as voluntary certification of sustainable forest management have the potential to further change the timber harvesting picture in Idaho.

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Chapter 5. What are timber harvesting's effects on other resources?

Forests are complex systems in which multiple dynamic relationships exist between their various living and non-living components. Therefore, it would be impossible for us to examine all the effects of timber harvesting on all other resources. Instead, we have chosen to look at four resources that are affected by timber harvesting and provide some insight into sustainability. The first resource we examine is timber itself and the ability of a site to produce timber again after harvesting takes place. The other three resources we examine are water, wildlife, and scenery.

Obviously, timber is the primary resource obtained directly from the harvesting of trees. Will the land from which timber is harvested be able to produce the same quantity of timber in the future? Will the quality of timber be the same? Will it take the same amount of time to grow? These questions address long-term site productivity, and the replies depend on many factors. Soil is a key determinant, and the focus of the discussion herein.

Water is a resource we cannot live without. Forests contribute significantly to the quantity and quality of water that flows through them. Water quality is important for fish habitat within forested watersheds as well as for human uses downstream. Timber harvesting can affect water quality, but the effects can be reduced and mitigated through a variety of best management practices.

Some types of wildlife are dependent on forests. How does timber harvesting affect the wildlife that inhabit forests? The answer depends on the type of wildlife. We examine two species—elk and northern goshawk—for which the effects of timber harvesting are not the same.

Scenery, or visual quality, is a resource that many people value from forested watersheds. While scenic beauty may be a less tangible resource than others, changes to it may be what people notice most when timber harvesting occurs.

In this chapter, we concentrate on the physical relationships between timber harvesting and other resources. For three of the resources—timber, water, and wildlife—this puts our discussion primarily in the dimension of ecological sustainability. Scenery and its management, however, falls within the realm of social sustainability.

5.1. Variability of Harvesting's Effects

For several reasons, there is no simple answer to the question of what timber harvesting's effects are on other resources. Each resource is affected differently by timber harvesting. What may be beneficial for one resource may be harmful to another.

Timber harvesting is a part of forest management as a whole, so it is difficult to talk about only those effects that are related to timber harvesting. For example, roads are built for a variety of management activities, including accessing timber, and road building activity may affect other resources. The secondary effects of roads and road building can affect site conditions more than the cutting and removal of trees.

The effects of timber harvesting vary by the way in which harvesting is done. Factors such as the percentage of trees removed during harvest and the mechanical means of removing the trees affect results. Lastly, and probably most importantly, the effects of timber harvesting vary because of the diversity of ecosystems in which trees and timber harvesting occur.

5.1.1. Diversity of Ecosystems. The effects of timber harvesting on other resources vary depending on the ecological conditions of the site where harvesting takes place. Ecological conditions are described by the biological and physical ("biophysical") characteristics of an area. These components include such things as climate, landforms, geologic materials, vegetation, land use, and soils (Jensen et al. 1997). An ecological region ("ecoregion") is one way of describing a contiguous area with similar characteristics. Ecoregions can be further subdivided as the scale and similarity of characteristics become more refined. Idaho has been classified into 13 sections of ecoregions, each with a distinct set of biophysical characteristics (Figure 5-1 and Table 5-1). Some of these ecoregion sections support extensive forests, and others do not.

Idaho's climatic and physical features are diverse. Broad-scale landforms present in Idaho include foothills, mountains, glaciated mountains, breaks, plateaus, intermontane basins, till plains, plains, and valleys (Hann et al. 1997). Elevations range from less than 1,000 feet above sea level to almost 13,000 feet. Mean annual temperatures range from 28°F to 58°F (McNab and Avers 1994). Precipitation ranges from about 8 inches per year with very little snow along the Snake River south of

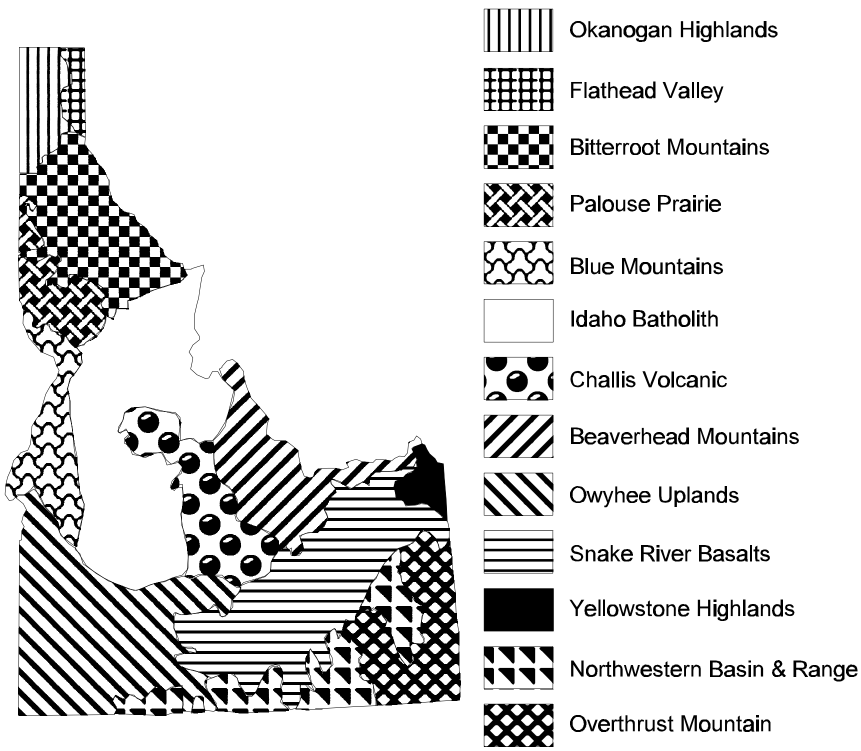

Figure 5-1. Ecoregion sections of Idaho.

Source: Adapted from Hann et al. (1997).

Boise, to over 60 inches with many feet of snowfall in the higher elevations of northern Idaho (Barker et al. 1983). In some places the climate changes dramatically within very short distances. This is especially true with an abrupt rise in elevation in the mountains. Aspect, or the direction a land surface faces, also affects climate; climates of north-facing slopes tend to be more moist and cooler than south-facing slopes.

Idaho also has diverse soil types. Geologic events over millions of years have created many different types of parent material—granite, gneiss, schist, limestone, basalt, volcanic ash—which separately or in combination contribute different physical and chemical characteristics to soil. The variety of soils found across the landscape has been affected by the variety of climates that affect soil formation processes (see Barker et al. 1983).

All of the diversity in the physical environment, particularly topography, leads to diversity in the types of trees and other vegetation that are present. Steele et al. (1981) identified 51 different "habitat types" for the forests of central Idaho. Cooper et al. (1991) identified 46 habitat types for northern Idaho forests.

Habitat types can be aggregated into three potential vegetation groups (PVGs) for forests—either cold, dry, or moist—and two PVGs for woodlands—riparian and other (Hann et al. 1997). Dry forests are typical on lower elevation sites with low levels of precipitation and are generally more dominant in southern Idaho. Moist forests are

Table 5-1. Description of ecoregion sections of Idaho.

Section	**Geo-morphology**	**Potential natural vegetation**	**Elev. (ft.)**	**Precip. (in.)**	**Temp. (°F)**	**Disturbance**
Okanogan Highlands	Glaciated mountains with moraines	Douglas-fir forest, Cedar-hemlock-pine forest	2500 to 7000	30 to 80	36 to 46	Fire
Flathead Valley	Glaciated mountains with moraines	Douglas-fir forest, W. ponderosa forest	2000 to 7000	18 to 100	36 to 45	Fire
Bitterroot Mountains	Steep, dissected mountains	Cedar-hemlock-pine forest	1200 to 7000	40 to 80	36 to 45	Fire
Palouse Prairie	Loess plains and hills	Fescue-wheatgrass, W. ponderosa forest	1200 to 6000	10 to 30	45 to 54	Wind
Blue Mountains	Mountains and lava plains	Grand fir, Lodgepole pine, Ponderosa pine series	2700 to 10000	12 to 50	28 to 52	Fire, insects
Idaho Batholith	Glaciated mountains with ridges, cirques	Grand fir-Douglas-fir, W. spruce-fir, W. ponderosa forests	3000 to 10000	20 to 80	35 to 46	Fire, insects
Challis Volcanic	Mountains and valleys	W. spruce-fir, Sagebrush steppe	4000 to 1000	11 to 45	34 to 50	Insects, fire
Beaverhead Mountains	Complex of mountainous landforms	Sagebrush steppe, Douglas-fir forest	2500 to 6500	10 to 50	36 to 46	Fire, insects
Owyhee Uplands	Intermontane plateau, mountains	Sagebrush steppe, Artemisia-agropyron	4000 to 8000	7 to 15	35 to 45	Fire
Snake River Basalts	Plateau and plains	Sagebrush steppe, Artemisia-agropyron	3000 to 6000	5 to 12	40 to 58	Fire
Yellowstone Highlands	Glaciated volcanic mountains, plateaus	Douglas-fir forest, Wheatgrass-needle-grass shrubsteppe	6000 to 13000	20 to 45	35 to 47	Fire
Northwestern Basin & Range	Sert plain with isolated mountains	Big sagebrush, Low sagebrush, Shadscale	4000 to 7200	4 to 20	41 to 50	Fire
Overthrust Mountain	Mountain ranges and valleys	Lodgepole pine-Subalpline fir, Sagebrush steppe	5000 to 13000	16 to 40	35 to 45	Fire

Elev.—Mean range of land heights above sea level; Precip.—Mean annual precipitation range; Temp.—Mean annual temperature range.

Source: McNab and Avers (1994).

typical of mid-elevation areas with higher levels of precipitation. Moist forests are more typical of northern Idaho. Cold forest types are typical of higher elevation areas throughout Idaho.

This diversity in forest vegetation, along with the diversity in the other elements of the biophysical environment, create variation in the effects of timber harvesting on other resources. Due to such diversity, for every generalization we make about timber harvesting's effects on another resource, there will be cases where the generalization does not apply. This diversity, along with our incomplete understanding of the ways in which forests work, suggests that forest resource management should be approached cautiously (Kavanaugh, review comments).

5.1.2. Variability in Harvesting Methods and Machinery. Timber harvesting's effects on other resources also will vary by how the harvesting is done; i.e., the proportion of trees removed from a site, and the machinery that is used. The choice of harvesting method and machinery often depends on land management objectives, site characteristics, and financial considerations (Helms and Lotan 1987).

Timber can be harvested under even-aged or uneven-aged silvicultural systems. Three types of even-aged management systems prevail: clearcutting, seed-tree cutting, and shelterwood cutting. Clearcutting removes all trees; seed-tree cutting leaves a few vigorous trees to provide seeds for regenerating the new stand; shelterwood cutting leaves more overstory trees after the initial harvest to prevent extremes of heat and cold on the regeneration. Residual trees can be removed in seed-tree systems, and are generally removed in shelterwood systems to prevent their shade from reducing growth and vigor of the regenerating stand (Oliver et al. 1994).

In general, even-aged systems are chosen to regenerate shade-intolerant species, to reduce costs, and to lower administrative overhead. These systems raise concerns about the potential for exposure, soil erosion, logging slash, and windthrow, and are subject to criticism for being unsightly during the regeneration phase (Helms and Lotan 1987).

Uneven-aged systems leave many living trees within the harvested area while allowing regeneration of a new stand. Appropriate uneven-aged systems promote vigorous trees of a variety of ages and species by removing weakened trees—as opposed to "high grading" which removes the most vigorous or largest, highest value trees and leaves small, weak, scarred and/or diseased trees (Oliver et al. 1994). Uneven-aged management has not been practiced widely in the northern Rocky Mountain region so we do not have the knowledge base to evaluate the effectiveness of uneven-aged systems in Idaho (Helms and Lotan 1987, Naumann 1987). One exception is industrial forest management in southwestern Idaho, which allows Boise Cascade Corporation to meet its goals through uneven-aged management (O'Laughlin et al. 1993, Blatner et al. 1994).

Group selection is another alternative that generally leaves larger openings than traditional uneven-aged systems and leaves a mosaic of stands of many species and structures (Oliver et al. 1994).

Thinning is an intermediate stand treatment that removes some trees—either from upper canopy layers (high thinning) or lower canopy layers (low thinning). Thinning can be done in conjunction with both even-aged and uneven-aged systems (Oliver et al. 1994). Thinning is cutting trees and removing them from the site in order to obtain one or more of a variety of forest management objectives.

Thinning in fire-prone national forests received some attention following the extensive wildfires that affected 7.3 million acres in 2000, when more than 1 million acres of Idaho national forests burned. Congress has provided additional funds for hazardous fuel reduction in national forests. We expect implementation will include an emphasis on thinning of dense stands and prescribed burning.

A variety of machinery can be used to remove trees from the forest. The most common type of logging machinery is tractor logging in which tractors are used to drag (yard) logs from where they are cut (felled) to a road. Cable systems yard logs to a road usually by suspending part or all of the log in the air. Helicopters are also used to yard wood, but are expensive to operate. At the other end of the technology spectrum are horses or oxen that can be used for yarding.

Different yarding systems result in differing effects on other resources. For example, there is generally less disturbance to soils by yarding systems capable of suspending logs in the air (Cromack et al. 1978); therefore, in general, cable and helicopter logging result in less soil disturbance than tractor logging. Different tractor logging systems affect soil differently; tractors with treads compact soil less than tractors with round tires, such as rubber-tired skidders (Oliver et al. 1994).

5.2. Timber

A sustainable timber harvest implies that the site from which timber is harvested will be capable of producing the same amount and quality of timber again, over a similar amount of time, and can continue to do so into the future. This concept can be called long-term site productivity. Timber harvesting involves several sets of long-term productivity issues.

5.2.1. Effects of Timber Harvesting on Soil. Soil is a primary determinant of long-term site productivity, and timber harvesting can produce a variety of changes in soil properties that affect long-term site productivity. These are outlined below.

Microclimate. Timber harvesting and subsequent site preparation usually result in microclimate changes that influence subsequent biological processes. The most important of these changes include changes in light, temperature, and moisture. Soil chemistry and microbial processes can be affected in either a beneficial or detrimental manner (Harvey et al. 1989).

Organic Matter. Soil organic matter is key to maintaining site productivity because of its roles in soil water availability and nutrient cycling (Childs et al. 1989, Harvey et al. 1989). Organic matter influences soil physical properties such as water-holding capacity, aeration, drainage, and cation exchange (Jurgensen et al. 1990, Page-Dumroese et al. 1991). Organic matter also is essential to the soil microflora and microfauna that are active in nutrient cycling, soil aggregation, and disease incidence or prevention (Jurgensen et al. 1990).

Timber harvesting can cause extensive losses and disturbances of surface organic matter. This has important implications for soil chemical, biological, and physical properties (Harvey et al. 1987, Jurgensen et al. 1990). Timber harvesting reduces soil organic matter both by physical loss at time of harvesting and by increasing microbial activity caused by soil disturbance (Jurgensen et al. 1990). Site preparation techniques, particularly slash piling and windrowing, can cause productivity problems related to organic matter because of the disturbance of large areas of the forest floor (Harvey et al. 1987, 1989). Substantive losses of surface organic matter lead to declines in productivity (Powers 1991).

Although not a soil component, the quantity, quality, and disposition of woody residue, also called woody debris, can influence soils greatly (Jurgensen et al. 1990, Graham et al. 1991). Physically, woody residue protects soil from erosion, displacement, and compaction. As woody residue decays and becomes incorporated into the litter, humus, and mineral soil horizons, it releases nutrients that are vital for forest growth. Woody residue also provides a substrate for micorhizzae that cycle nutrients (Dechert, review comments). In addition, woody residue also protects regenerating forests by providing shade and protection from wind and snow.

The quantity of woody residue can vary dramatically, depending on site, forest conditions, and forest treatments. The quantity and kind of residue on a site can affect site productivity (Graham et al. 1991). Too much woody residue and organic matter can increase the risk of wildfire (Harvey et al. 1987, Jurgensen et al. 1990). The quantity of organic matter may also favor some types of diseases. The situation presents a trade-off for forest managers.

Nutrients. Many nutrients—including nitrogen, phosphorus, calcium, magnesium, potassium, and sulfur—are required for tree growth and vigor (Cole and Gessel 1992, Mandzak and Moore 1994). The relationships between nutrients and tree growth are complex. Forests derive their nutritional supply from several potential sources, including weathering of minerals, nitrogen fixation, atmospheric deposition, and decomposition of organic matter (Cole and Gessel 1992).

The cycling of nutrients between soil and tree is a key forest ecosystem process (Cole and Gessel 1992). The soil surface is rich in nutrients because it is the site of the most active nutrient cycling, and thus is particularly vulnerable to disturbance and dislocation processes that can result in outright loss or reduced capacity for replacement. Different harvesting and site preparation methods affect stand nutrient balances differently (see Brockley et al. 1992). For example, broadcast burning of slash maintains more nitrogen, phosphorus, and cations in the organic horizons of soil than does bulldozer piling (Page-Dumroese et al. 1991).

It is beyond the scope of this report to fully discuss nutrient cycling in forest ecosystems (see, e.g., Pritchett and Fisher 1987). Despite increasing knowledge about nutrient cycling in forest ecosystems, it is difficult to predict how trees on any given site will react to nutrient limitations, losses, and additions. However, most sites and soils in the Inland Northwest will experience reduced productivity if nutrient losses and associated soil degradation occur (Harvey et al. 1989).

Erosion. Erosion is a geomorphic process that is a natural component of any forest ecosystem; however, erosion rates can be accelerated by human disturbances (Megahan 1991). The relationship between soil surface horizons and tree growth leaves little doubt that removing the soil surface can significantly reduce stand productivity (Harvey et al. 1989, Megahan et al. 1995). Soil loss from erosion affects site productivity by changing soil depth. This reduces the nutrient pool and water-holding capacity of the soil and by direct damage to vegetation (Megahan 1991).

The actual impacts of different erosion processes on site productivity are influenced by several factors, including a) the depth of erosion, which determines the amount of soil components that are lost from the site; b) the areal extent of the erosion, which determines the area over which the losses occur; c) the downslope rate of movement of eroded material; and d) the probability of redeposition of the eroded material at downslope locations. Evaluation of the total effects of erosion on site productivity must consider the net effects of all these factors. Erosion can increase productivity of a site downslope, if eroded material is deposited there (Megahan 1991).

Forest management activities, especially timber harvest and road construction, have been shown to increase erosion rates on forest lands (Megahan 1991). Skid trails and other high traffic areas are particularly susceptible to erosion (Cullen et al. 1991). Debris landslides and gullying cause serious and long-term reductions in site productivity, but the areas affected are small. Surface erosion occurs over much larger areas and reduces site productivity, but the magnitude of the reduction is poorly defined because of the compounding effects of compaction on logged areas and water repellency of burned areas (Megahan 1991).

Depending on the rate of soil formation, it may take centuries to restore soils lost through erosion (Page-Dumroese et al. 1991). Caution to prevent physical losses of surface soil horizons by erosion pays large dividends in retaining forest productivity (Harvey et al. 1989).

Compaction. Forest productivity problems associated with soil compaction are well known (Cromack et al. 1978, Harvey et al. 1989, Jurgensen et al. 1990). The extent of damage from compaction due to timber harvesting is highly variable, depending on the timber type and volume, soil type, equipment type and use, and moisture conditions (Harvey et al. 1989).

Compaction alters pore size and distribution in the soil. This can affect plant-water relations, aeration, and depth of freezing, and thus may create an environment less favorable to tree growth and survival (Harvey et al. 1989). Compaction generally reduces the available water-holding capacity of soils (Cullen et al. 1991). Decreased soil-water storage is particularly important for sites with little growing-season precipitation, shallow soil profiles, or coarse-textured soils where water limitations already control productivity (Childs et al. 1989). Compaction also affects the ability of roots to penetrate the soil (Cullen et al. 1991). Possible indirect effects of soil compaction include increases in root pathogens and increases in host stress, predisposing trees to insect and disease attack (McDonald 1991).

Soil factors such as texture, water content, structure, and organic matter control, in part, the process of soil compaction (Cullen et al. 1991). Volcanic ash-influenced soils with low bulk densities and rock content, such as many of those in northern Idaho, are particularly susceptible to compaction (Page-Dumroese 1993).

The persistence and long-term impact of compaction depend on the severity of contact by harvesting vehicles, the ability of various species to cope with compacted soils, and rates of processes tending to decompact the soil (Cromack et al. 1978). Compaction can occur not only on the surface, but also at greater soil depths (Graham et al. 1991). The effects of compaction can persist for decades or longer (Page-Dumroese 1993). Natural recovery from compaction may take more than 40 years on many Inland Northwest soils (Harvey et al. 1989).

Microorganisms. A myriad of soil organisms and their interactions profoundly affect forest productivity through capture and uptake of nutrients, nitrogen fixation, protection against pathogens, maintenance of soil structure, and buffering against moisture stress. The balance of forest-soil organisms can shift dramatically in response to fluctuations of chemical, environmental, and biotic factors caused by natural disturbance or management-related activities such as timber harvest, site preparation, and fertilization. Some organisms thrive with disturbance while others are harmed. The final equilibrium of soil organisms may or may not facilitate the same productive conditions that existed previously (Amaranthus et al. 1989).

Soil nutrient status, moisture, temperature, pH, and organic matter content, litter inputs, disturbance, and species composition affect the growth and occurrence of soil organisms (Amaranthus et al. 1989). Some forest practices can reduce or eliminate beneficial soil organisms. For example, pore space is essential for movement of oxygen and water into soil and the flushing of carbon dioxide out; therefore, timber harvesting activities that compact soil may harm healthy populations of soil organisms. Also, the harvesting of host trees can eliminate the photosynthate source for dependent ectomycorrhizal fungi and associated microbes. The diversity of organisms within soil tends to buffer the impacts of disturbance on forest sites, but the proportion of each type of organism is affected (Amaranthus et al. 1989). It can take years for microbial communities to recover from disturbances due to timber harvesting (Dechert, review comments).

5.2.2. Mitigating Timber Harvesting's Effects on Soil. Many of the effects of timber harvesting on soil can be minimized or mitigated with appropriate management techniques. In most cases, appropriate mitigation of extreme changes in microclimate above and below the soil surface can be accomplished by leaving sufficient overstory, low shrub and herb layers, or surface debris to provide shade, soil organic matter, or both, to act as an environmental buffer (Harvey et al. 1989). Mitigating microclimate changes along roads is more problematic and may require closure and revegetation (Dechert, review comments).

In the past, timber removal was not considered detrimental to organic matter because of long stand rotation ages and the large amount of residue left after harvest. However, recent trends towards short stand rotations, total tree harvesting, and increased residue removal raise concerns about how such management impacts soil processes, organic matter, and site productivity (Harvey et al. 1987, Jurgensen et al. 1990, Graham et al. 1991). As a result of harvesting methods that leave branches, limbs, and other slashing in the woods, many stands in Idaho contain adequate organic reserves and wood, and may not be considered highly sensitive to soil organic matter depletion following harvest (Harvey et al. 1987, Jurgensen et al. 1990).

Site preparation techniques that cause problems related to organic matter are more difficult to deal with. Safe, effective, and economical methods for removing unwanted slash are limited. Careful prescribed burning and mechanical site preparation and spot use of herbicides are site preparation techniques that can be done with low impact on soil organic matter (Harvey et al. 1989, Jurgensen et al. 1990).

Most compaction in timber harvesting operations is a result of the vehicles used for harvesting (Cullen et al. 1991). Several techniques are available for minimizing the extent of area compacted during timber harvest and site preparation. One of the most common techniques is to designate skid trails and confine equipment to those trails. Directional felling and line pulling also can reduce the area affected. Skyline and helicopter harvesting systems also helps minimize soil compaction. Cable yarding over snowpacks during winter also helps minimize disturbance (Graham et al. 1991). In some locations during site preparation, the use of a grapple-skidder to pile logs can reduce compaction because grapple-pilers apply less pressure on the ground than crawler-tractors used for bulldozer-piling. Leaving the tops of trees and surface organic matter on site also may reduce the amount of compaction (Page-Dumroese 1993). Avoiding logging on wet soils through careful planning is also important for reducing compaction (Dechert, review comments).

To minimize long-term impacts on beneficial organisms forest managers should [1] minimize disturbance severity (i.e., intense burns, soil compaction, or erosion), [2] emphasize retention of organic matter, [3] emphasize rapid revegetation by indigenous host species and associated beneficial soil organisms, and [4] recognize that sites with harsh environments (i.e., cold or drought) are most susceptible to productivity losses (Amaranthus et al. 1989, Harvey et al. 1989).

5.2.3. Wood Quality. One aspect of timber management that is rarely considered in discussions of sustainability is wood quality. Are we managing forests so that they will produce the same quality of wood that they have previously? Traditionally, management decisions have been based primarily on wood volume with little analysis of the effects of wood quality (Fight et al. 1995, Hansen et al. 1996). Neither the conceptualization nor the measurement of quality has been adequately studied (Hansen et al. 1996).

> Growing wood in quantity without regard to quality is based upon a philosophy that one need not worry about quality; that somehow whatever is grown can be converted to usable products.

> We, in effect, lay any problems that may arise on the altar of forest-products technology. Technology can contribute a great deal to the problem of processing wood of lower quality, but usually this is done at the sacrifice of increased energy inputs, reduced yield, increased cost, or loss of quality of the final product (Kellogg 1982:254).

Numerous authors have expressed concerns about changes in the qualities of wood and wood products (e.g., Zobel 1984, Senft et al. 1985, Maeglin 1987, Briggs and Fight 1992, Briggs and Bialozynski 1995, Fight et al. 1995, Hansen and Bush 1996). Producers and consumers of wood products have recognized a decrease in quality (Willits 1994, Hansen and Bush 1996).

The types of timber being harvested are changing. Much of the slow-grown, mature timber resource has been harvested and is being replaced by harvests of younger and faster-grown trees. The current emphasis on forest health in the interior western U.S., with an emphasis on thinning dense forest stands, seems likely to increase the proportion of total timber harvest that is made up of smaller trees. Harvesting reductions from federal lands also may make it more difficult to obtain wood of desired quality (Briggs and Bialozynski 1995).

The primary quality concern is that smaller trees and fast-grown trees have a higher proportion of juvenile wood than more mature trees (Briggs 1996). Juvenile wood is not necessarily "bad wood" and functions well in certain products (Zobel 1984), but it has different properties than mature wood. Juvenile wood has lower strength and stiffness compared to mature wood (Barrett and Kellogg 1991, Fight et al. 1995). Lumber quality problems result from a higher proportion of juvenile wood in a tree, leading to less strength overall and drying problems (Fahey and Starostovic 1979, Maeglin 1987, Barrett and Kellogg 1991, Kennedy 1995). Lumber quality problems also result from younger trees and fast-grown trees, which tend to have more knots because of the way tree crowns develop (Zobel 1984, Briggs 1996).

Wood quality is very responsive to both silvicultural and genetic manipulation (Zobel 1984, Jozsa and Middleton 1994), but there is a general lack of information on wood strength, tree spacing and taper, and other characteristics that affect quality for many species of importance in the Inland Northwest (Kennedy 1995, DeBell and Gartner 1997). Although new manufacturing techniques are enabling production of high-quality products from low quality timber, these products are markedly different from those previously available (Zobel 1984). Tomorrow's forests will supply wood products different from those currently being used (Fahey and Starostovic 1979).

5.3. Water Resources

Water is an essential forest ecosystem element. Many organisms, including humans, depend on clean water for survival and quality of life. Timber harvesting and its associated activities can affect water quantity and quality. This section focuses only on the impacts of timber harvesting on water quality.

The extent of water quality effects depends on where timber harvesting is done and how it is managed. Policies that seek to protect water quality are a large part of the policies that affect timber harvesting (see **Chapter 4**). Our discussion focuses on moving water—streams and rivers—and in Idaho, water quality policy for most streams translates into providing habitat for aquatic species, particularly for salmon, trout, and other cold-water fish.

Like other natural systems, rivers and streams are complex and diverse. Our understanding of the hydrologic and geomorphic process and stream morphology itself, continues to advance rapidly (Moore, review comments). Reviews of the science are available (e.g., Leopold 1994). The effects of a management action on a particular stream will vary, in part, with the characteristics of the stream. Scientists have developed classification systems for streams based on similar characteristics observed across many different streams. An understanding of stream classification will help in determining the effects of management actions on fish habitat and related concerns (see Rosgen 1996).

5.3.1. Fish Habitat. Fish habitat results from a complex interaction among water, sediment, and channel structure (Chamberlin et al. 1991). Biologists describe stream habitats in terms such as pools, riffles, spawning gravel, obstructions, and side channels. Pools are areas of high water velocity during peak flows, but at low flow their depth creates a place where fine sediments are deposited. Pools are the result of the scouring action or impoundment of water and are caused by structural controls in the channel or streambank (Chamberlin et al. 1991).

Riffles are bars (sediment deposits) with water flowing over them. Because riffles represent the first material deposited after high flows, they usually contain larger particles (gravel, cobbles, and boulders) than are found elsewhere in the stream. Riffles are food producing areas, but offer few habitats to small fish (Chamberlin et al. 1991).

Spawning gravel is the sorted product of streambed scouring and redeposition from which sand and finer material has been removed and transported downstream. Abundance of potential spawning gravel is a key factor influencing redd (or nest) density of cutthroat trout (MaGee and McMahon 1996). Good fish spawning habitat also requires that the stream's normal sediment supply contain relatively low amounts of fine material, and that flow be sufficiently high to sort out the fines and keep them from accumulating in the gravel. Spawning areas are often associated with the hydraulic transition zones between pools and riffles; the more transition zones, the more spawning gravels there will be (Chamberlin et al. 1991).

Obstructions of various types are barriers to fish migration. They can be either natural, such as debris accumulations, or a dry stretch of streambed during low flow, or man-made, such as culverts and dams. Side channels occur in the stream's margin, or where water is forced out of the channel into the floodplain. Side channels have a direct hydrologic relationship to runoff from the valley walls and to the valley groundwater table and will remain stable only if their structural controls (usually tree root systems) remain intact (Chamberlin et al. 1991).

Because different species of fish have different habitat requirements throughout their changing life stages, streams that have a varied complex of structural (geomorphic) and water flow (hydrologic) conditions along their lengths provide the best habitat (Chamberlin et al. 1991).

5.3.2. Effects of Timber Harvesting on Fish Habitat. Numerous reviews of the scientific literature about the effects of timber management activities on water quality and fish habitat exist (e.g., Salo and Cundy 1987, Chamberlin et al. 1991, Meehan 1991, Lee et al. 1997). Following is a brief summary.

Timber harvesting can affect both the processes and structures that result in fish habitat (Figure 5-2). Habitat alterations can adversely affect all life-stages of fishes, including migration, spawning, incubation, emergence, and rearing (Lee et al. 1997). The effects of timber harvesting on fish habitat are likely to be varied and dynamic. The episodic nature of climatic events also makes time an important factor in the analysis of forest practices (Chamberlin et al. 1991, Lee et al. 1997). Many of the events that occur as a result of timber harvesting would occur without timber harvesting, but timber harvesting affects the frequency, timing, or severity of their occurrence (Table 5-2). The mechanical processes involved in timber harvesting and associated road construction, in conjunction with natural conditions, influence the level of disruption or disturbance within watersheds (Lee et al. 1997).

Importance of Small Streams. Most spawning and rearing of salmonids in forested watersheds takes place in small streams (Chamberlin et al. 1991, MaGee and McMahon 1996). Small streams are also the streams most easily altered by forest management activities. Because small streams depend largely on litter fall for organic energy input, any manipulation of the canopy or streambank vegetation will influence the stream's energy supply. Small streams are particularly vulnerable to temperature changes resulting from timber harvesting activities (Dechert, review comments). Likewise road building and other activities that increase sediment supplies or modify local runoff have greater effects on smaller streams than they would on larger systems (Chamberlin et al. 1991).

Even small streams that are not accessible to migrating fish because of barriers or steep gradients are important to the quality of downstream habitats. The channels of these streams carry water, sediment, nutrients, and wood debris from upper portions of the watershed. The quality of downstream habitats is determined, in part, by how fast and at what time these organic and inorganic materials are transported (Chamberlin et al. 1991).

Effects on Structure. Four major effects of timber harvesting on stream structures can be summarized as follows (Chamberlin et al. 1991):

- Increases in peak flows or the frequency of channel-modifying flows from increased snowmelt or rain-on-snow events can increase bed scour or accelerate bank erosion.
- Increases in sediment supply from mass movements or surface erosion, bank destabilization, or instream storage losses can cause aggradation, pool filling, and a reduction in gravel quality.

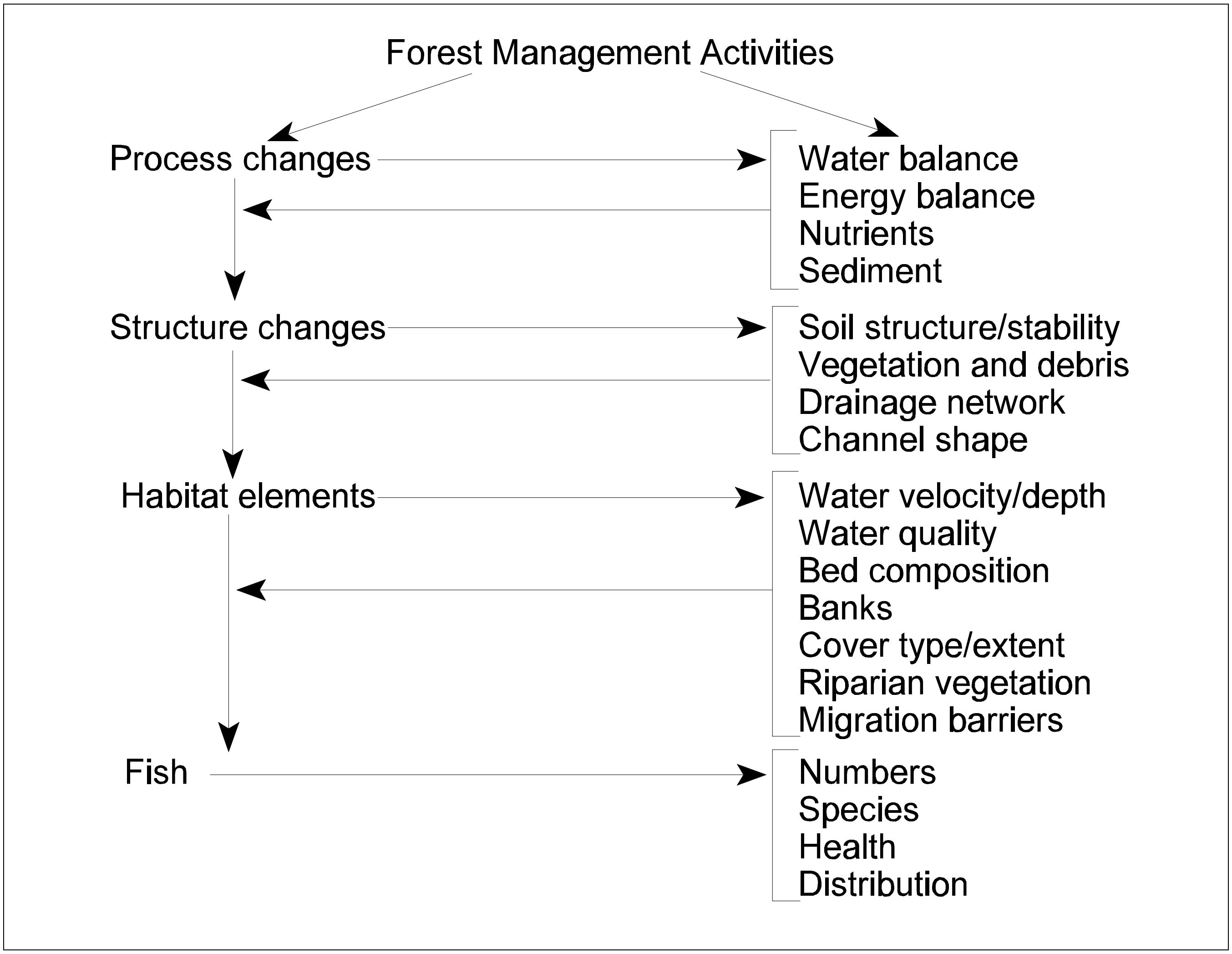

Figure 5-2. Linkages between timber management activities and fish production.

Source: Chamberlin et al. (1991).

- Streambank destabilization from vegetation removal, physical breakdown, or channel aggradation adds to sediment supply and generally results in a loss of the channel structures that confine flow and promote the habitat diversity required by fish populations.
- Loss of stable instream woody debris by direct removal, debris torrents, or gradual attrition as streamside forests are converted to managed stands of smaller trees will contribute to loss of sediment storage sites, fewer and shallower scour pools, and less effective cover for rearing fish (Chamberlain et al. 1991).

The structural features of fish habitat are selectively influenced by different harvesting activities. For example, if timber harvesting increases the supply of fine sediments, these sediments settle preferentially in pools, which become less useful to fish. Similarly, if the structural element causing the pool to exist (such as a log or tree root) is removed, the pool will disappear after the next flood flow. Pools are thus susceptible to falling and yarding operations that influence the availability of large woody debris in or near stream channel margins (Chamberlin et al. 1991).

Harvesting activities can increase sediment supplies that in turn increase the extent and number of riffles. Removal of instream woody structure steepens the gradient and hence increases the average size of particles in the substrate (Chamberlin et al. 1991). Harvesting activities that maximize the

Table 5-2. Approximate ranges of recurrence of major disrupting events and the effects of those events on channel and habitat conditions in streams.

Event	Range of recurrence (years)	Channel changes	Habitat effects
Daily to weekly precipitation and discharge	0.01-0.1	Channel width and depth; movement and deposition of fine woody debris; fine sediment transport and deposition	Minor siltation of spawning gravels; minor variation in spawning and rearing habitat; increased temperature during summer low flows
Seasonal precipitation and discharge; moderate storms; freezing and ice formation	0.1-1.0	Increased flow to bank-full width; moderate channel erosion; high base-flow erosion; increased mobility of in-channel sediment and debris; local damming and flooding; sediment transport by anchor ice; gouging of channel bed; reduced winter flows	Changes in pool:riffle ratio; siltation of spawning gravels; increased channel area; increased access to spawning sites; flooding of side-channel areas; amelioration of temperatures at high flows; decreased temperatures during freezing; dewatering of gravels during freezing; gravel disturbance by gouging and anchor ice
Major storms; floods; rain-on-snow events	1.0-10	Increased movement of sediment and woody debris of channels; flood flows; local channel scour; movement and redistribution of coarse sediments; flushing of fine sediments; movement and redistribution of large woody debris	Changes in pool:riffle ratio; shifting of spawning gravels; increased large woody debris jams; siltation of spawning gravels; disturbance of side-channel rearing areas; increased rearing and overwintering habitat; local blockage of fish access; filling and scouring of pools and riffles
Debris avalanches and debris torrents	5.0-100	Large, short-term increases in sediment and large woody debris contributions to channel; channel scour; large-scale movement and redistribution of bed-load gravels and large woody debris; damming and obstruction of channels; accelerated bank erosion and undercutting; alteration of channel shape by flow obstruction; flooding	Changes in pool:riffle ratio; shifting of spawning gravels; siltation of spawning gravels; disturbance of side-channel rearing areas; blockage of fish access; filling and scouring of pools and riffles; formation of new rearing and overwintering habitat
Activities of beavers	5.0-100	Channel damming; obstruction and redirection of channel flow; flooding of bank and side channels; ponding of streamflow; siltation of gravels behind dams	Improved rearing and overwintering habitat; increased water volumes during low flows; slack-water and back-water refuge areas during floods; refuge from reduced habitat quality in adjoining areas; limitation on fish migration; elevated water temperatures; local reductions in dissolved oxygen

(continued)

Table 5-2. (continued)

Event	Range of recurrence (years)	Channel changes	Habitat effects
Major disturbances to vegetation	10-100		
Windthrow		Increased sediment delivery to channels; decreased litterfall; increased large woody debris in channel; loss of riparian cover	Increased sedimentation of spawning and rearing habitat; increased summer temperatures; decreased winter temperatures; increased rearing and overwintering habitat; decreased fine organic debris
Wildfire		Increased sediment delivery to channels; increased large woody debris in channels; loss of riparian vegetation cover; decreased litterfall; increased channel flows; increased nutrient levels in streams	Increased sedimentation of spawning and rearing habitat; increased summer temperatures; decreased winter temperatures; increased rearing and overwintering habitat; decreased availability of fine woody debris; increased availability of food organisms
Insects and disease		Increased sediment delivery to channels; loss of riparian vegetation cover; increased large woody debris in channels; decreased litterfall	Increased sedimentation of spawning and rearing habitat; increased summer temperatures; decreased winter temperatures; increased rearing and overwintering habitat
Slumps and earthflows	100-1,000	Low-level, long-term contributions of sediment and large woody debris to stream channels; partial blockage of channel; local baselevel constriction below point of entry; shifts on channel configuration	Siltation of spawning gravels; scour of channel below point of entry; accumulation of gravels behind obstructions; partial blockage of fish passage; local flooding and disturbance of side-channel rearing areas
Climatic change	1,000-100,000	Major changes in channel direction; major changes in channel grade and configuration; valley broadening or downcutting; alteration of flow regime	Changes in type and distribution of spawning gravels; changes in frequency and timing of disturbing events; shifts in species composition and diversity

Source: Swanston (1991).

number of pool-forming structural elements and minimize the influx of fine sediments will favor the maintenance of spawning gravel (Chamberlin et al. 1991).

Obstructions are most often associated with roads that accompany timber harvesting. Culverts or bridges can cause water velocities to be greater than the swimming ability of fish. Side channels are vulnerable to effects from timber harvesting in the riparian zone because they can easily be isolated without adequate culverts (Chamberlin et al. 1991).

Effects on Streamflow. The hydrologic effects of timber management activities vary with many environmental factors, but Chamberlin (1991) suggests the following broad generalizations apply:

- Harvesting activities such as roadbuilding, falling, yarding, and burning can affect watershed hydrology and streamflow much more than can other management activities such as planting and thinning.
- Clearcutting causes increased snow deposition in the openings and advances the timing and rate

of snowmelt. The effect lasts several decades until stand aerodynamics approach those of the surrounding forest. Snowmelt can be accelerated by large wind-borne energy inputs of warm rain falling on snow.

- Harvested areas contain wetter soils than unlogged areas during periods of evapotranspiration and hence higher groundwater levels and more potential late-summer runoff. The effects last 3-5 years until new root systems occupy the soil.
- Road systems, skid trails, and landings accelerate slope runoff, concentrate drainage below them, and can increase soil water content (Chamberlain et al. 1991).

Water defines fish habitat more than any other factor, so changes in the quantity, quality, or timing of streamflow caused by timber harvesting and other silvicultural activities are a primary focus for timber-fish interaction (Chamberlin et al. 1991). Timber management activities do not normally change the total amount of precipitation entering a watershed; however, timber management activities can affect streamflow by altering the water balance or by affecting the rate at which water moves from hillsides to stream channels. The more severe the alteration of the hydrologic cycle is, the greater the effects on streamflow and fish habitats will be. Harvesting may substantially alter the spatial distribution of water and snow on the ground, the amount intercepted or evaporated by foliage, the rate of snowmelt or evaporation of snow, the amount of water that can be stored in soil or transpired from the soil by vegetation, and the physical structure of the soil that governs the rate and pathways by which water moves to stream channels (Chamberlin et al. 1991).

Not all of the effects of timber harvesting on streamflow negatively affect fish habitat. For example, higher groundwater levels after harvesting may expand the area of floodplain habitats accessible to fish, particularly during summer low-flow periods, and may moderate the increases in stream temperature that result from removal of shade vegetation (Chamberlin et al. 1991).

Effects on Water Quality. Water temperature, dissolved oxygen, and nutrient concentrations can be altered by timber harvest activities (Chamberlin et al. 1991, Lee et al. 1997). Stream temperature is affected by eliminating stream-side shading, disrupted subsurface flows, reduced stream flows, elevated sediments, and morphological shifts toward wider and shallower channels with fewer deep pools (Lee et al. 1997). When streamside vegetation is removed, summer water temperatures usually increase in direct proportion to the increase in sunlight that reaches the water surface. Water has a high heat capacity, so a stream's volume, depth, and turbulence affect the actual temperature at any point in the water column. Timber harvesting can cause stream temperatures to increase, but specific stream and watershed conditions cause wide variation in the processes affecting temperature increases (Chamberlin et al. 1991).

Dissolved oxygen can be reduced by low stream flows, elevated temperatures, and increased fine inorganic and organic materials that have infiltrated into stream gravels slowing intergravel flows (Chamberlin et al. 1991, Lee et al. 1997). In summer, high temperatures both accelerate respiration and lower the solubility of oxygen. In winter, ice cover may prevent diffusion of oxygen from air to water. Harvest activities that impose large oxygen demands on streams exacerbate the normal stresses that low flows place on fish (Chamberlin et al. 1991).

The high chemical and biological oxygen demands of organic debris and the bacteria on it may persist for long periods until the bottom material is removed by high flows. Clogging of surface gravels by fine inorganic sediments enough to lower dissolved oxygen concentrations usually occurs only when large or persistent volumes of sediment emanate from active road systems, mass soil movements, bank slumps, or destabilized upstream channels (Chamberlin et al. 1991).

Concentrations of nutrients (e.g., N, P, K, Ca) in streams may increase after logging, but usually by moderate amounts and for short periods (Chamberlin et al. 1991, Lee et al. 1997). Likewise, increases in nutrient releases after slash burning can be expected to return to earlier levels (DeByle and Packer 1972). The mobilization of nutrients is tempered by their adsorption onto soil particles and by their uptake by microorganisms that decompose stream detritus (Chamberlin et al. 1991).

Effects on Sediment. Sediments entering stream channels can affect channel shape and form, stream substrates, the structure of fish habitats, and the structure and abundance of fish populations (Chamberlin et al. 1991). Increased deposition of fine sediments in salmonid spawning habitat increases mortality of embryos, alevins, and fry (Chamberlin et al. 1991, MaGee and McMahon

1996, Lee et al. 1997). Winter survival is reduced by fine sediments because juvenile fish can survive harsh icing conditions by entering substrate crevices, but refuges are lost if filled with sediment (MaGee and McMahon 1996, Hillman et al. 1987). Fine sediments affect the rearing potential of streams by altering substrate particle-size composition, riffle-pool ratios, macroinvertebrate production, and pool area (Hillman et al. 1987, Chamberlin et al. 1991).

The chief variables that affect sedimentation through surface erosion are the inherent erodibility of the soil, slope steepness, surface runoff, slope length, and ground cover (Furniss et al. 1991, Lee et al. 1997). Erosion potential is greatly increased by reduction in vegetation, compaction of soils, and disruption of natural surface and subsurface drainage patterns (Chamberlin et al. 1991, Lee et al. 1997). Accelerated surface erosion and increased levels of sedimentation can decrease after initial disturbance but may remain above historic levels for many years (Lee et al. 1997).

The degree of influence timber harvesting has on sediment in streams varies with geology, climate, vegetation, dominant geomorphic processes, and land uses. Timber harvesting can influence both upland erosional processes and the way that forest streams process sediment in their channels. Forest management activities that substantially change the magnitude, timing, or duration of sediment transport and overwhelm the ability of fish to cope with or avoid resulting stress are of most concern (Chamberlin et al. 1991).

Roads and mass movements associated with roads are the largest sources of sediment production associated with timber harvesting activities (Dechert, review comments); each is addressed specifically in subsequent sections. However, other silvicultural activities that require scarifying the ground or burning can increase sediment production if buffer strips are not left between treated areas and stream channels. Even when burns do not expose mineral soil, a water-repellent layer can form and reduce the ability of water to infiltrate into the soil, increasing runoff available for surface erosion (Chamberlin et al. 1991). However, the degree of water repellency and its return to normal levels is dependent on soil texture, parent material, and intensity of the burn (McNabb et al. 1989). An indirect effect of burning is loss of the insulating layer of organic matter. In areas where soils freeze, modifying the freeze-thaw relationship can have serious and long-lasting effects on soil structure and sediment production (Chamberlin et al. 1991).

Concern for soil erosion on granitic soils is especially high in the Idaho Batholith, where serious sedimentation damage to valuable salmon and steelhead fishery resources has been documented (Megahan and Ketcheson 1996). To illustrate, Megahan et al. (1995) found that streamflow parameters showed little change in response to clearcutting using helicopter logging followed by broadcast burning on a south-facing slope in the Idaho Batholith. However, total annual sediment yields increased an average of 97% in the 10 years following logging, with the largest increases occurring in years of highest sediment yields. Increased sediment yields did not appear to result from accelerated channel erosion; rather, about 94% was attributed to accelerated surface erosion on cutting units, and 6% was contributed by a single mass erosion site. The accelerated surface erosion occurred primarily as a result of the prescribed burning (rather than the helicopter logging); surface erosion rates on the burned areas were about 66 times greater than those on undisturbed slopes. Accelerated sedimentation showed no signs of abating 10 years after disturbance (Megahan et al. 1995).

Mass Movement. The frequency of mass erosion events in forested watersheds is strongly linked to the type and intensity of land treatment (Rice et al. 1972). Although most mass movements are associated with roads and their drainage systems, increases in mass soil movement can occur after harvesting due to many factors (Table 5-3) (Swanston 1978, Chamberlin et al. 1991).

When soils from mass movements are deposited into stream channels, effects on fish habitats depend on the sediment-processing capability of the stream. Sediment transport in forest streams involves the detachment and entrainment of sediment particles, their transport, and their deposition. The process repeats whenever flow velocities are high enough to move the stream's available material. Forest harvesting directly affects these processes when it increases or decreases the supply of sediment, when it alters the peak flow or the frequency of high flows, and when it changes structure of the channel by removing the supply of large woody debris that forms sediment storage sites. Bank erosion and lateral channel migration also contribute sediments if protective vegetation and living root systems are removed (Chamberlin et al. 1991).

Table 5-3. Impacts of timber harvest activities on factors that influence slope stability in steep forest lands.

Factors	Activities (and impacts)[1]	
	Tree removal	Roading
I. Hydrologic influences		
A. Water movement by vegetation	Reduce evapotranspiration (-)	Eliminate evapotranspiration (-)
B. Surface movement by vegetation	Alter snowmelt hydrology (- or +)	Alter snowmelt hydrology (- or +)
	Alter concentration of unstable debris in channels (-)	Alter surface drainage network (-)
		Intercept subsurface water at bank cuts and alter subsurface drainage (-)
II. Physical influences		
A. Vegetation		
1. Roots	Reduce rooting strength (-)	Eliminate rooting strength (-)
2. Bole and crown	Reduce medium for transfer of wind stress to soil mantle (+)	Eliminate medium for transfer of wind stress to soil mantle (+)
B. Slope		
1. Slope angle		Increase slope angle at cut and fill slopes (-)
2. Mass on slope	Reduce mass of vegetation on slope (+)	Eliminate mass of vegetation on slope (+)
		Cut and fill construction redistributes mass of soil and rock on slope (- or +)
C. Soil properties		Reduce compaction and apparent cohesion of soil used as road fill (-)

[1]Influence that usually increases slope stability denoted by (+) impact; influence that usually decreases stability denoted by (-) impact.

Source: adapted from Swanston (1978).

Mass movements may be beneficial if they bring stable rubble and woody debris complexes to "sediment-poor" channels. Many mass movements bring soil to higher-gradient reaches, however, and the sediment is carried downstream to a deposition zone where it severely impairs the stream's ability to support fish rearing and spawning (Chamberlin et al. 1991).

Soils. Much of the information about soils was reviewed in the preceding section on timber. When surface soils are exposed, their pores can be clogged by fine sediment and their structure can be broken down by the energy of falling raindrops. If the infiltration capacity of the soil is sufficiently reduced, water runs off over rather than through the soil. Higher peak flows and increased sediment transport result. Internal changes in soil structure also take place after logging. As tree roots die, sediment fills soil pores, and compaction occurs. The collapse or blockage of these "macropores" forces water to flow over the surface, which may accelerate erosion. Soils can be compacted by logging equipment or by logs dragged over the ground during yarding and site preparation (Chamberlin et al. 1991).

In general, yarding exposes the least amount of soil when it is done with balloons or helicopters, and the most when logs are skidded with tractors. Snow cover and flat terrain tend to lessen impacts of tractor skidding. Soil disturbance will be minimized when the harvesting system is well matched to particular site characteristics (Chamberlin et al. 1991).

Large Woody Debris. It should be noted that the term "large woody debris" is being replaced in some recent literature by terms such as "large wood" (Kavanaugh, review comments). This is because of the negative connotations associated with "debris." We use the terminology in the literature reviewed. In both alluvial and bedrock-controlled channels, large woody debris and tree roots can be secondary controlling structures (Chamberlin et al. 1991). Because the supply of large woody debris to stream channels is typically a function of the size and number of trees in riparian areas, it can be profoundly affected by timber harvest. Shifts in the composition and size of trees within the riparian area affect recruitment potential and longevity of large woody debris within the stream channel. Large woody debris influences channel morphology, especially in forming pools and instream cover, retention of nutrients, and storage and buffering of sediment. Any reduction in the amount of large woody debris within streams, or within the distance equal to one site-potential tree height from the stream, can reduce instream complexity. Large woody debris increases the quality of pools by providing hiding cover, slow water refuges, shade, and deep water areas (Maser et al. 1988). The size of large woody debris in a logged watershed in Idaho was smaller than that found in a relatively undisturbed watershed (Lee et al. 1997).

5.3.3. Roads. By far the greatest concerns about timber harvesting and water quality result from the issue of roads. Serious degradation of fish habitat can result from poorly planned, designed, located, constructed, or maintained roads. Roads directly affect natural sediment and hydrologic regimes by altering streamflow, sediment loading, sediment transport and deposition, channel morphology, channel stability, substrate composition, stream temperatures, water quality, and riparian conditions within a watershed (Chamberlin et al. 1991, Furniss et al. 1991, Lee et al. 1997).

It is beyond the scope of this report to provide a complete review of the large body of literature that exists on the relationship between forest roads and water quality. For example, the scientific bases for many of Idaho's best management practices for forestry are related to roads and water quality and are well known (see Seyedbagheri 1996). We briefly discuss the two major issues associated with roads and water quality: sediments and mass movements.

Sediments. Sedimentation is by far the largest concern with roads. The sediment contribution per unit area of roads is often much greater and longer-lasting than that from all other land management activities combined, including log skidding and yarding (Furniss et al. 1991, Megahan and Ketcheson 1996, Lee et al. 1997). For example, 91 percent of the annual sediment production by land use activities in the South Fork of the Salmon River has been attributed to roads and skid trails (Lee et al. 1997).

Sediment loss from road surfaces is partially a function of traffic, surface composition, and road maintenance (Reid and Dunne 1984, Furniss et al. 1991). In granitic landtypes common in central Idaho, sedimentation tends to be directly proportional to the amount of road mileage (Lee et al. 1997). However, sediment production is likely to increase with increasing volumes of traffic (Reid and Dunne 1984). Sediment production is likely to be greater from gravel surfaces than from paved surfaces. Erosion of gravel road surfaces is of particular concern both because a high proportion of the eroded sediment is introduced directly to streams and because most sediment from this source is finer than 2mm; this fine-grained material is the size most harmful to fish and water quality (Reid and Dunne 1984).

Mass Movements. Erosion in the form of landslides is called mass movement or mass wasting. Roads can cause mass movements. Where forests occur on steep terrain, mass soil movement is often the primary mode of erosion and sediment delivery to streams from roads (Furniss et al. 1991, Lee et al. 1997). The increase in frequency of slope failures due to road construction depends on such variables as soil type, slope steepness, bedrock type and structure, and presence of subsurface water. Road location is the most important factor because it affects how much all of these variables will contribute to surface failure (Furniss et al. 1991).

The most common causes of road-related mass movements are improper placement and construction of road fills, inadequate road maintenance, insufficient culvert sizes, very steep hillslope gradient, placement or sidecast of excess materials, poor road location, removal of slope support by undercutting, and alteration of slope drainage by interception and concentration of surface and subsurface water (Furniss et al. 1991). Road-related mass soil movements can continue for decades after the roads have been constructed (Furniss et al. 1991, Lee et al. 1997).

On Idaho's Clearwater National Forest 58% of landslides that occurred during winter of 1995-96 were associated with roads (McClelland et al. 1997). Fillslope failures were the dominant cause of road failures both in numbers of landslides and volume of material produced.

5.3.4. Mitigating Timber Harvesting's Effects on Water Quality. Under most circumstances, timber and fish can be successfully managed together in the same watershed if measures to protect water quality and fish habitat are carefully planned and coordinated with timber management operations (Chamberlin et al. 1991). Forest practices that affect water quality have improved over the last 30 years (Rice 1992), and present day practices, properly implemented, have the potential of reducing detrimental effects (Megahan et al. 1992). However, some effects are unavoidable even using the most cautious logging and roading methods (Furniss et al. 1991).

Best Management Practices. Implementation of best management practices, or BMPs, is one way to reduce timber harvesting's effects on water quality. BMPs are specifically related to nonpoint sources of water pollution, or the polluted runoff that comes not from one specific location, but is discharged over a wide land area from activities such as timber harvesting (O'Laughlin 1996*b*). The U.S. Environmental Protection Agency's water quality management regulations define BMPs as

> methods, measures or practices selected by an agency to meet its nonpoint source control needs. BMPs include but are not limited to structural and non-structural controls and operation and maintenance procedures. BMPs can be applied before, during and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters (40 C.F.R. 130.6(c)(4)).

Specific to forestry, the Idaho Forest Practices Act defines a BMP as

> a practice or combination of practices determined by the [Idaho Land Board], in consultation with the [Idaho Department of Lands] and the forest practices advisory committee, to be the most effective and practical means of preventing or reducing the amount of nonpoint pollution generated by forest practices (Idaho Code 38-1303(15)).

Idaho law requires BMPs for all forest practices on all forests. All forest landowners are required by the Idaho Forest Practice Act to implement BMPs. Forestry BMPs in Idaho include: road design, construction, and maintenance; streamside protection zones; logging unit design; slash treatment and site preparation; winter harvesting; hazardous substances; and stream crossings. These individual forestry BMPs in Idaho have been described elsewhere (see Almas et al. 1996). The effectiveness of BMPs at controlling nonpoint source pollution and improving water quality is discussed below.

The effectiveness of BMPs at reducing nonpoint source pollution and protecting water quality is a subject of continuing debate. The question of effectiveness has at least two dimensions: [1] effectiveness of individual BMPs on site, and [2] effectiveness of BMPs programs at protecting water quality over an entire watershed. Research has found that BMPs for forestry reduce nonpoint source pollution on individual sites to acceptable levels (Lynch and Corbett 1990; Binkley and Brown 1993*a,* 1993*b*; Ice et al. 1997). However, the record for program effectiveness at the watershed scale is mixed (Brown et al. 1993*b*, Floyd and MacLeod 1993, Ice et al. 1997).

The effectiveness of individual BMPs can vary considerably. Differences in climatic and hydrologic conditions can cause a BMP to be effective at one site but not at another (Novotny and Olem 1994). To be effective, BMPs must be tailored for specific sites (Mosley et al. 1997). Individual BMP effectiveness also varies because of differences in operator's motivation, understanding of regulations and practices, monitoring, and maintenance (Rice 1992, Mosley et al. 1997).

Determinations of BMP effectiveness can be inferred from scientific data. Seyedbagheri (1996) compiled an extensive review of literature specifically related in Idaho forestry BMPs. While most BMPs had at least some supporting scientific literature, there were some that did not. Scientific evidence can be inconclusive. For example, the protection of watercourses from sediment is the objective of some BMPs, specifically buffer zones, which are designated setback distances from streams where special management activities are specified. There is widespread recognition of the need for buffer zones but little agreement regarding the designated setback distance and activities allowed therein (Belt et al. 1992, Megahan and Ketcheson 1996).

Effectiveness of BMP programs over entire watersheds tends to be a function of operator participation, monitoring, and enforcement. Regulatory approaches, such as Idaho's, tend to be more effective than voluntary programs (Floyd and MacLeod 1993).

The 1988 Forest Practices Water Quality Management Plan for Idaho requires that an audit of forest practice BMP implementation be conducted every fourth year by the Idaho Department of Environmental Quality (IDEQ) and by the Idaho Department of Lands in intervening years. Results from the 2000 audit by IDEQ are not yet available. During the 1996 audit by the IDEQ, the audit team inspected 42 timber sales where over 1900 rules were applicable (1996 Forest Practices Audit Team 1997).

In 1996, the implementation rate of Idaho forest practices rules ranged from 93% to 100% across the four land ownership categories (federal, state, industrial, non-industrial) and the rate of implementation in each land ownership category improved from the 1988 and 1992 audit results (Table 5-4). Road maintenance and construction accounted for 67% of the incidences where BMPs were not implemented fully. Where BMP rules were implemented, they were determined to be 98 to 99% effective across all ownerships (1996 Forest Practices Audit Team 1997).

The most recent audit by the Idaho Department of Lands was completed in 1999 (Colla and DuPont 2000). The audit team inspected 26 timber sales, including 11 on industry-owned lands, 8 on private non-industrial lands, and 7 on state lands. The team did not calculate overall compliance rates. Rather they evaluated compliance by noting deficiencies, describing the qualitative impacts, and determining what actions could be taken to prevent a similar problem from occurring elsewhere. The team found 20 of the 26 (77%) inspected timber sales to be in full compliance with the Idaho Forest Practices Act (Colla and DuPont 2000).

BMPs are designed to be technically and economically feasible and socially acceptable; as such, they result from political compromises (Rice 1992). Some researchers feel these compromises lead to ineffectiveness in protecting some aspects of water quality in Idaho. For example, BMPs have been criticized on the Clearwater National Forest for not adequately protecting salmon habitat because they "are habitually diluted or dropped" in order to be economically feasible (Espinosa et al. 1997). Furthermore, these critics say BMPs do not adequately consider past and cumulative impacts of land management activities, and characterize BMPs as "merely a means to reduce level of impact given a decision to proceed with development" (Espinosa et al. 1997:225).

Criticism has also been levied at the way in which BMP effectiveness is measured. One approach used by many states, including Idaho, is to assemble groups of professional hydrologists, biologists, engineers, silviculturalists, and foresters to audit BMPs as they relate to observed, but not empirically quantified, impacts on water quality. Specific sites are visited, each person provides his or her qualitative judgment as to whether the BMP is effective, and an effectiveness rating is assigned via team consensus (Stanford and Ward 1992). Such methods have been criticized as "subjective, qualitative, and cryptic" (Espinosa et al. 1997)

In Idaho, the 1996 audit team was made up of representatives of the Idaho Division of Environmental Quality, Idaho Department of Lands, U.S. Forest Service, Idaho Department of Fish and Game, U.S. Bureau of Land Management, Plum Creek Timber Company, Lukens Tree Farm, and the Idaho Forest Owners Association. All audit assessments were strictly visual with the exception of gradient, where hand-held clinometers were used to estimate stream, road, and skid trail gradients. The conclusions and recommendations of the audit report represent consensus opinion of the audit team (1996 Forest Practices Audit Team 1997).

Critics of BMPs say that subjective assessment methods are often never verified in terms of actual impact measured *in situ* (e.g., increase in fine sediments, decrease in fish production), and inferences and recommendations can be misleading (Stanford and Ward 1992). Furthermore, they say these methods will identify pervasive effects, such as severe sedimentation resulting from roads collapsed into streams or skid crossings that are not bridged, but it is virtually impossible to detect chronic effects (e.g., accelerated water yield and bank erosion, slow reduction in woody debris accumulation, changes in water chemistry and bioproduction, fish habitat alteration) via non-empirical audits. The value of the judgment is lost in formalization of the approach

Table 5-4. Comparison of Idaho forest practices rule implementation rates by ownership categories, as determined by 1988, 1992, and 1996 audits of BMPs.

Ownership	1988 Audit	1992 Audit	1996 Audit	
Federal	94%	93%	100%	(529/530)
State	97%	96%	98%	(548/560)
Industrial	95%	94%	95%	(427/450)
Non-industrial	86%	89%	93%	(336/360)

Source: 1996 Forest Practice Audit Team (1997).

unless the audit result can be verified by temporal and spatial ecological measures obtained with appropriate experimental designs (Stanford and Ward 1992).

The methods for measuring BMP effectiveness in Idaho are changing and may address many of these criticisms. The 1999 Idaho Department of Lands audit was designed to be "more objective and statistical in nature" than previous audits (Colla and DuPont 2000). Although the field procedures and assessment remained basically the same as in 1996 for addressing Forest Practices Act rule implementation and effectiveness, a new objective was added to assess whether the Forest Practices Act protects bull trout spawning and early rearing habitat. New data collection included quantity of organic debris, substrate composition, canopy cover, pool frequency, percent occurrence of raw banks, and potential for recruitment of large organic debris. Data were collected on 26 stream reaches within timber sales areas and 36 reference stream reaches outside timber sale areas.

The 1999 audit findings suggest that the quality of bull trout habitat in logged stream reaches is less than that on reference reaches; however, it is not apparent that Forest Practice Act rules are responsible for the differences. Most of the logged reaches that had low quantities of large woody debris and pools and a high occurrence of raw banks had been previously logged. Many were logged prior to passage of the Forest Practices Act in 1974, and many were influenced by factors beyond control of the Forest Practices Act, including urbanization, loss of beaver, and the long-abandoned practice of driving logs down stream and river channels through a series of splash dams (Colla and DuPont 2000).

In addition to moving BMP audits toward more quantitative measures, the Idaho Department of Lands now administers a cumulative watershed effects (CWE) program (see ***6.1.1. Idaho's Cumulative Watershed Effects (CWE) Process***). CWE assessment has been completed on approximately 150 watersheds across the state, resulting in a significant increase in the amount of data that can be used to evaluate BMP effectiveness (Dechert, review comments). Information about BMP effectiveness, both from CWE and audits, is fed back to the Forest Practices Act Advisory Committee, which recommends changes to BMPs. New issues associated with BMP effectiveness are continually being brought to the table and addressed through this feedback process (Dechert, review comments).

5.4. Wildlife

Wildlife are an integral part of any forest. Forests are not static, and changes in forest structure and vegetative species composition will favor certain species of wildlife and deprive others of some elements necessary for reproduction and survival. Timber harvesting can have positive, negative, and neutral effects on wildlife habitat depending on the life requirements of the species inhabiting the area. This makes general discussions of the effects of timber harvesting on wildlife difficult (Patton 1992, O'Connell et al. 1993); therefore, after a brief introduction, we focus our discussion on two species: Rocky Mountain elk and northern goshawk.

Plant succession determines animal succession (Patton 1992). While the species might differ in any particular geographic area the process is the same in every forest ecosystem. Successive seral stages occurring during the process of ecological succession. At different stages, wildlife food and cover change, accompanied by a change in wildlife species able to use that tract of land. In the forest ecosystem, timber harvesting sets back succession to early seral stages. Theoretically, present forest conditions can be duplicated in the future if the appropriate silviculture prescriptions are applied when harvesting and regenerating a stand of trees (Patton 1992).

One important aspect of the relationship between wildlife and timber harvesting is not how many trees are removed, but how much vegetation remains for food and cover for the species inhabiting the area. Populations of animals of low mobility and specific habitat requirements—amphibians, reptiles, small birds, and small mammals—can be adversely affected at the time of a timber harvest even if the cut is limited to a small area or to a single tree. Highly mobile animals—large birds and mammals—are less affected. The age and size classes of trees that remain after harvesting and their spatial relationship is important (Patton 1992).

The literature provides some general guidelines for benefitting or minimizing the negative effects of timber harvesting on wildlife (Table 5-5). More specific guidelines depend on which species inhabit an area and are the objective of management activity.

5.4.1. Management Indicator Species. Forest Service regulations for implementing the mandates of the National Forest Management Act of 1976 directed that individual national forests identify management indicator species (MIS) to facilitate forest planning and management (Wilkinson and Anderson 1985). The indicator species concept is a transitional phase from single-species to multiple-species approaches to wildlife management. Although a single species is emphasized, this species is used to index or represent specific environmental conditions or the population status of other ecologically similar species (Block et al. 1995). Each national forest in Idaho has identified a set of MIS (wildlife, fish, and plants) with descriptions of what the species are supposed to indicate (Table 5-6).

Four broad categories of MIS are commonly used: [1] recovery species, [2] featured species, [3] specific habitat indicators, and [4] ecological indicators. Recovery species are those that are managed to increase their populations because they are recognized as threatened or endangered. Featured species are those managed for consumptive purposes or those that are valued for nonconsumptive recreational use. Specific habitat indicator species are those with potentially limited habitat needs that might be affected adversely by land management practices. Ecological indicators are those whose populations can be used to index habitat quality and population status of other species (Block et al. 1995).

There is considerable debate concerning the validity and usefulness of the indicator species concept (Landres et al. 1988, O'Laughlin et al. 1993, Block et al. 1995). Many of the criticisms of the indicator species concept are evident in Table 5-6, including: [1] vague definitions of what the species are supposed to indicate, including such things as population trends in other wildlife species or habitat abundance and quality; [2] selection of species that are too general; and [3] the inclusion of threatened and endangered species based only on that special protected status. The major problems with the use of indicator species are the lack of rigorous and consistent selection criteria, the failure to address management goals as related to MIS and the lack of empirical data supporting the assumptions concerning MIS (Landres et al. 1988). In most instances, there is no evidence that a particular MIS actually reflects trends in the populations of other species or habitat quality and abundance. In addition to conceptual questions, the MIS program on national forests may not be working because of programmatic problems, particularly the lack of monitoring (Yanishevsky 1994, Knowles and Knowles 1994).

Although the application of the MIS concept has problems, managing for wildlife habitat diversity by maintaining well distributed, viable populations of wildlife is a formidable task. Given the complexity of wildlife habitat relationships and population dynamics, and the richness of wildlife species on the national forests, the MIS concept was deemed the only feasible alternative (O'Laughlin et al. 1993). The following sections focus on two management indicator species used in the national forests of Idaho: elk and northern goshawk.

5.4.2. Elk. Rocky Mountain elk (*Cervus elephus*) is a wildlife species familiar to most Idahoans. Whether it is the personal enjoyment to residents that comes from the opportunity to view or hunt these large ungulates, or the economic impacts of out-of-state hunters, the people of Idaho treasure the state's elk populations.

Table 5-5. Examples of timber management techniques that positively benefit or reduce negative effects on wildlife.

1. Locate timber roads and skid trails to eliminate or minimize siltation of streams.
2. Reserve, in connection with tree planting and regeneration, natural openings, access ways, and brush areas for food and cover.
3. Plant or reserve groups of trees for cover (thermal, escape, hiding, etc.).
4. Reserve and release fruit and nut trees and shrubs to increase food production.
5. Retain den and roost trees.
6. Create openings by harvesting in dense timber stands. One of the most common techniques to benefit deer, elk, and turkey as well as many species of small mammals and birds.
7. Retain tree buffer areas or riparian vegetation along streams and lakeshores.
8. Adjust slash disposal plans to include requirements of wildlife species; slash piles benefit small mammals and birds.
9. Prevent logging skidding across meadows, along streambanks or through food, escape, nesting, or roosting cover. Areas must be identified before timber sale.
10. Reserve cover adjacent to seeps and stringer meadows in cut areas. Areas must be identified before timber sale.
11. Withhold from tree planting special areas needed for food and cover plantings.
12. In releasing coniferous timber species, leave hardwoods in strips or patches to provide a mast crop.
13. Scatter the location of small timber sales to break up large areas of a single age class. Provides diversity of food and cover for many species.
14. In large clearcuts, leave small scattered plots uncut for cover.
15. Seed skidways, roadsides, and landings on sale areas with wildlife food mixtures of forbs, grasses, and shrubs. Provides food for many species.
16. Burn slash away from water so ash will not enter streams or lakes.
17. Provide for juxtaposition of stands in different vegetation types.
18. Provide for interspersion of habitat units throughout the vegetation type.
19. Thin dense stands of trees to stimulate understory growth.
20. Close permanent and seasonal logging roads when necessary to protect a species during all or part of a year.
21. Mark and save a given number of snags per acre for cavity nesting birds.

Source: Patton (1992).

Table 5-6. Wildlife management indicator species in Idaho, what the species is an indicator of, and associated national forest in Idaho.

Species	Indicator of ... [1]	National Forest
Birds		
Bald eagle [2]	Large rivers and lakes	Panhandle, Clearwater, Payette, Nez Perce, Caribou, Targhee
Goshawk	Old-growth, multi-layered mature stands on north slopes for nests, seral habitats for foraging	Panhandle, Clearwater, Nez Perce, Caribou, Targhee
Peregrine falcon [3]	N/A	Payette, Nez Perce, Clearwater
Great gray owl	Mature sub-alpine fir and Douglas-fir forests	Salmon
Sage grouse	Sagebrush habitats, range condition	Sawtooth, Caribou
Sharp-tailed grouse	Grass-shrub habitats, range condition	Sawtooth
Pileated woodpecker	Large snags, old-growth forests, old-growth species, cavity nesters	Panhandle, Clearwater, Nez Perce, Payette, Sawtooth, Boise, Salmon
Hairy woodpecker	Snags	Caribou
Lewis woodpecker	Riparian woodlands, large snags	Sawtooth
Williamson's sapsucker	Cavity dependent species, mature forest snags	Payette, Targhee
Yellow-bellied sapsucker	Cavity nesters, aspen	Caribou, Salmon
Belted kingfisher	Riparian habitat	Clearwater
Vesper sparrow	Non-forests, early succession species, sagebrush habitat	Payette, Salmon
Brewer's sparrow	Sagebrush habitats, mid-seral sagebrush	Sawtooth, Targhee
Yellow warbler	Riparian willow habitat	Challis, Boise
Pygmy warbler	Cavity nesters, old-growth ponderosa pine forests	Salmon

(continued)

Table 5-6. (continued).		
Species	**Indicator of ...** [1]	**National Forest**
Birds (continued)		
Brown creeper	Cavity nesters, mature sub-alpine fir and lodgepole forests	Salmon
Mountain bluebird	Cavity nesters, ecotones	Salmon
Mountain chickadee	Smaller snags and insects	Boise
Mammals		
Grizzly bear [2]	Large undisturbed areas	Panhandle, Clearwater, Nez Perce, Payette, Targhee
Gray wolf [2]	Human disturbance	Clearwater, Payette, Nez Perce
Woodland caribou [2]	Climax forest vegetation	Panhandle
Elk	General forest seral species, habitat interspersion, coniferous forests, riparian forests, wet meadows, sagebrush-grass habitats, savanna forests, spruce-fir forest, sub-alpine fir-Douglas fir forest, summer range	Panhandle, Clearwater, Nez Perce, Payette, Sawtooth, Challis, Salmon, Boise, Targhee
Moose	Mature timber stands, pacific yew	Panhandle, Clearwater, Nez Perce
White-tailed deer	Interspersion of cover and forage, mature and old-growth, winter range	Panhandle, Clearwater
Bighorn sheep	Alpine, subalpine, rock-scree, open timber, rock outcrop habitats	Nez Perce, Challis, Targhee
Antelope	Sagebrush habitats	Targhee
Mule deer	Conifer forest, mountain brush, sagebrush-grass, savanna forest, riparian subalpine, Douglas-fir habitats, successional summer and winter range	Sawtooth, Challis, Salmon, Boise, Caribou
Mountain goat	High elevation, alpine, subalpine, rock-scree, open-timber, cliff habitats	Sawtooth, Challis, Salmon, Targhee

(continued)

Table 5-6. (continued).

Species	Indicator of ... [1]	National Forest
Mammals (continued)		
Pine marten	Mid-to high-elevation mature forests, ecosystem health, old-growth sub-alpine fir and lodgepole forests	Clearwater, Salmon
Beaver	Riparian habitat	Targhee
Pika	Alpine, talus habitats	Targhee
Red squirrel	Climax or mature conifer forests	Challis
Red-backed vole	Old-growth forests	Boise
Aquatic insects	Water quality, litterfall and sedimentation	Challis, Targhee
Fish		
Cutthroat and rainbow trout; Bull trout [2]	Water quality: cool, clear, sediment free, streamside cover, instream flows	Panhandle, Clearwater, Challis, Salmon, Caribou, Targhee, Boise
Steelhead [2]	Open channels, spawning gravels	Clearwater, Challis, Salmon, Boise
Chinook salmon [2]	Same as steelhead	Clearwater, Challis, Salmon, Boise

[1] Many of the National Forests have the same species listed as an MIS. However, that species may indicate different things on different forests. This column lists those indicator attributes as identified in the forest plans, but does not associate each attribute with each individual forest.

[2] Designated a threatened or endangered species under the Endangered Species Act. NFMA regulations automatically make threatened and endangered species MIS's.

[3] Removed from federal endangered species list in 1999.

Source: O'Laughlin et al. (1993).

Historically, elk populations in northern and central Idaho were small and widely dispersed. In 1805 and 1806, the Lewis and Clark expedition crossed Idaho through the Clearwater River drainage and did not report seeing elk. In the early 1900s, wildfires burned much of northern Idaho, and as a consequence vegetation that favored elk became more abundant. Because of increased forage, hunting restrictions, predator control, and supplementing native herds with elk from Yellowstone Park, elk populations in the Clearwater and Spokane River drainages increased to high levels between 1935 and 1965 (Servheen 1997). Elk populations peaked in the late 1950s and generally have declined since that time. Increased access brought about by roads built for timber harvest activities, lenient hunting seasons and bag limits, increased hunter numbers, increased numbers of predators, and natural plant succession in forage and cover areas are all suggested as factors causing the decline (Lyon and Ward 1982, Leege 1984, O'Neil and Witmer 1991, IDFG 1998*b*).

Many wildlife and land management agencies are working to better understand factors affecting elk populations. For example, the Idaho Department of Fish and Game is currently conducting a project in two contrasting areas in north-central Idaho. The area in the Lochsa River drainage was subjected to large wildfires in the early 1900s and is characterized by bull ratios that are satisfactory, poor calf recruitment, and apparently high predator densities. The South Fork of the Clearwater River area, on the other hand, has less fire influence but more logging, has poor bull ratios, satisfactory calf recruitment, good access, and relatively lower predator densities (IDFG 1998*b*). The department hopes to determine more precisely the causes of elk decline and implement management strategies that will help maintain populations at acceptable levels. This is just one of many efforts aimed at managing Idaho's elk populations.

Elk Habitat Requirements. Elk are tolerant of diverse environments; however, they exhibit preferences for specific vegetation and terrain within areas they occupy (Servheen 1997). Elk habitat selection and use have been studied extensively in forested ecosystems of the northern Rocky Mountains (Edge et al. 1987). Elk habitat selection is a multidimensional concept including behavior, topography, weather, food, and cover factors as well as interactions among those factors (Table 5-7).

Elk use a variety of habitats daily, seasonally, and from year to year (Irwin and Peek 1983, Pedersen 1985, Edge et al. 1988, O'Connell et al. 1993). Elk habitat requirements in Idaho are well known (Servheen 1997).

Elk Management. Elk management focuses on two separate issues: elk habitat effectiveness and elk vulnerability (Servheen 1997). Elk habitat effectiveness focuses on providing elk with areas for foraging, calving, nursing, security, and "gaining body condition." Elk vulnerability focuses on elk mortality rates as a function of hunter and motorized route densities (Servheen 1997). Timber harvesting can affect both issues of elk management.

Effects of Timber Harvesting on Elk. The relationship between elk and timber harvesting activities in the northern Rocky Mountains has been studied extensively (e.g., Hieb 1976). Forest management, including timber harvesting, probably has the greatest potential for either negative or positive influences on elk populations than does any other land management activity (Lyon and Ward 1982). Timber harvesting activities have the potential for altering the amount and distribution of cover and forage areas and changing elk movements, distribution, and habitat utilization. In addition to vegetation changes caused by timber removal, the effects of logging slash, and the timing, pattern, and duration of logging activity are important considerations (Servheen 1997).

Timber harvesting activities have two general effects on elk: [1] during the logging operation there is a direct and substantial disturbance of animals and their habitat; and [2] in the long term there is a modification of habitat structure than can either improve or downgrade conditions for elk (Lyon and Ward 1982).

Elk reaction to the noise and activity of timber harvesting varies widely, depending on season of year, cover, topography, the kinds of equipment used, and the type and duration of activity (Lyon and Ward 1982). Displaced elk often remain within undisturbed portions of their home ranges, moving only as far as necessary to place a topographic barrier between themselves and the disturbance (Lyon and Ward 1982, Servheen 1997).

The long term effects of timber harvesting on elk habitat are varied. Prior to the late 1960s, it was widely presumed that timber harvest might be a logical alternative to fire-created seral habitats that favored elk, but successful improvement of a productive elk range following timber harvest has been harder to document than some of the concurrent, apparently adverse effects (Lyon and Ward 1982).

Table 5-7. Factors that influence habitat selection by elk.[1]

Topographic	***Food***
A. Elevation	A. Availability
B. Slope	B. Quality
1. gradient	***Cover***
2. position on slope	A. Cover type
3. aspect	1. thermal
C. Land features	2. hiding
Meteorologic	B. Density
A. Precipitation—snow	C. Composition
1. depth	D. Site productivity
2. condition	E. Structure
B. Temperature	F. Successional stage
1. solar radiation	G. Configuration
a. radiation	***Space***
b. convection	***Water and salt***
C. Humidity	***Specialized habitats***
D. Barometric pressure	A. Calving
E. Wind	B. Wallows
1. velocity	C. Trails
2. direction	

[1]Escape from predators, insects, and humans may override elk use of suitable habitat in a given situation.

Source: Skovlin (1982).

Elk response to habitat manipulation is more complex than is indicated by the uncritical assumption that food is a limiting factor (Lyon and Ward 1982). Forests commonly have micro-openings in the canopy that allow sunlight needed for growth of elk forage. In these situations, creation of additional openings through timber harvesting may not provide forage benefits to elk. However, beneficial forage can result from timber harvesting in elk home ranges that have dense canopies and limited understory of shrubs, grasses, and forbs (Leege 1984).

Different types of silvicultural and harvesting systems produce different effects on elk habitat. Disturbance by clearcutting has three major effects on forage plants in the forest: a change in plant species composition, an increase in forage production, and changes in nutrient quality. Although the composition of the plant community growing within a clearcut area depends on the composition of the understory before disturbance, it is also affected by soil disturbance during logging, methods of slash disposal, fire, and herbicide treatment (O'Connell et al. 1993).

Cover, forage quality, and roads also have been found to determine elk use of clearcuts (Lyon and Ward 1982). Forest edges between early and late seral stage forest communities can be used heavily by elk (O'Connell et al. 1993), so the size and shape of a clearcut unit affects its use (Leege 1984).

Partial cuts tend to be less optimal for both forage and cover and are further disadvantaged because they require multiple logging entries that cause more disturbance (Leege 1984, O'Connell et al. 1993). Selective cutting, if it involves more roads and systems that cause repeated disturbance, also will have more detrimental effects on elk habitat than clearcutting (Lyon and Ward 1982).

Thinnings may have favorable results for elk, as long as slash is removed or is not large enough to be a barrier. If thinning increases the structural diversity of an otherwise homogenous forest it may benefit elk. However, thinning to densities often recommended for timber growth may increase forage, but produce neither security nor thermal cover (Lyon and Ward 1982). A literature review concluded that thinning practices produce only negligible forage benefits for elk (O'Connell et al. 1993).

Logging slash has the potential to affect elk behavior and movement in both the cut area and adjoining uncut area. Slash, when piled, may provide cover (Lyon and Wood 1982), but if slash is deeper than 1.5 feet, elk use the area less. Broadcast burning of slash encourages forage used by elk (Leege 1984).

Although Lyon and Ward (1982) concluded that it seems unlikely that any one silvicultural system is intrinsically more desirable than any other for management of elk habitat, they did express concern that the shift in timber management from clearcutting toward partial cutting, and the increasing emphasis on intensive management of more productive timber sites, could produce negative changes to elk habitat and populations.

Roads. The development and use of roads has the potential to affect elk behavior adversely, reduce habitat effectiveness, and increase elk vulnerability (O'Neil and Witmer 1991, Servheen 1997). In the short term, road construction results in disturbances that may result in temporary abandonment of portions of previously secure habitat. In the long term, roads that are not closed and re-contoured forever alter the terrain, with fills blocking historic travel routes, and road grades establishing new routes across the landscape. The area of the road bed is removed from the portion of the landscape that can provide elk forage (Toweill, review comments; Skovlin 1982; Lyon and Ward 1982; Leege 1984; Pederson 1985; Servheen 1997). Roads substantially reduce elk use in adjacent habitat (Edge et al. 1987).

Roads used by elk increase elk vulnerability to hunters, because hunters typically use the same roads to access hunting areas. Roads increase the ability of hunters to access formerly remote portions of habitat, and to do so at relatively high rates of speed in either motorized or non-motorized vehicles. (Toweill, review comments; Lyon and Ward 1982; Leege 1984; Edge et al. 1987; Unsworth et al. 1993).

Mitigating Timber Harvesting's Effects on Elk. Managing elk involves managing both habitat effectiveness and vulnerability (Marcot et al. 1994, Servheen 1997). With proper planning, timber harvest can often be conducted with minimal detrimental, and sometimes positive, impacts on elk habitat. However, access associated with timber harvest often has negative impacts that are impossible to completely mitigate (Leege 1984, Servheen 1997).

Timber harvesting and associated road construction on elk range initiates a long period of elk responses to immediate environmental changes, to successional changes as the forest returns to maturity, and to any intermediate cuttings required. Also, habitat quality for elk is influenced by the relationship of various forest stands at any one time (Lyon and Ward 1982). The amount and juxtaposition of habitat types required to maintain elk populations are usually found in a landscape matrix or patchwork (O'Connell et al. 1993).

Elk are considered generalist herbivores and their distribution and success in a variety of habitats supports this notion. This variability makes site- or area-specific recommendations for habitat modification difficult (Lyon and Ward 1982, Edge et al. 1988). This variation also suggests that concern over forage production should be secondary to reducing disturbance and providing secure habitat during fall hunting season (Unsworth et al. 1998). In Idaho, elk are more likely limited by hunting than lack of appropriate habitat (Unsworth et al. 1993).

Advancing forest succession can produce declines in habitat quality in terms of both forage and cover (Irwin and Peek 1983). As discussed previously, removal of the overstory promotes growth of many herbaceous forage species, resulting in excellent forage opportunities for elk; however, the value of any increase in forage production depends on whether food is limiting and whether additional forage actually is available (Lyon and Ward 1982).

Hiding cover is particularly important when there is motor vehicle access to an area, and timber harvesting reduces the amount of cover available to elk in the short term, but can eventually lead to beneficial results. Young stands are used for hiding cover by elk (O'Connell et al. 1993). One study in Idaho found that pole timber stands provide better escape cover than mature/old-growth due to the presence of lower limbs and greater tree density (Irwin and Peek 1983). However, the relationship between tree size and hiding cover is complicated by topography. The same height or density of trees on flat terrain does not provide the same amount of hiding cover in steep terrain because of the viewing angles. Habitat management guidelines need to take topography into account (Canfield et al. 1986).

The appropriate management of timber harvesting and elk habitat depends on what the limiting factors are and achieving a balance between habitat elements (Lyon and Ward 1982). To reduce stress on elk, timber harvesting activities need to be designed and scheduled so that elk are provided adequate security and feeding areas protected from disturbance during active logging. For migratory elk herds, logging activity might be scheduled during seasons when elk are on other ranges. Another option is to plan timber harvest activities that can be completed in short time periods, with a minimum amount and time of disturbance. The size of the harvest area may not be as important as the proportion of the total habitat being disturbed at any one time (Lyon and Ward 1982).

A study by the Idaho Department of Fish and Game stated that premier summer elk habitat would consist of a roadless area, with no cattle use, at least 40% cover, and with adequate forage areas that are less than 1000 feet wide (Leege 1984, Unsworth et al. 1998). Researchers have recommended that at least 50% of roaded habitats be maintained in vegetation that meets requirements of cover (Unsworth et al. 1998). Maintenance of early to mid-seral stage habitat will provide long term benefits for elk on winter ranges by providing more forage, but reductions in cover and the increased access associated with timber harvest on summer and fall ranges will likely be more detrimental in terms of security than beneficial in terms of forage production (Unsworth et al. 1993). Researchers have recommended large portions of managed areas be maintained in cover and more aggressive access management than was being practice on most national forests (Unsworth et al. 1998).

Elk Management Guidelines. The Idaho Department of Fish and Game published guidelines for forest managers in north-central Idaho to assess and mitigate the effects of roads and logging activities (Servheen 1997). They were designed to: [1] identify existing elk summer habitat quality, [2] evaluate the effects (improvement or degradation) a proposed activity might have on habitat quality, [3] specify which factor(s) are the primary agents affecting summer habitat quality, and [4] provide recommendations and methods for minimizing negative effects on elk summer habitat (Servheen 1997). The Idaho Department of Fish and Game's recommendations for minimizing the adverse effects of timber harvesting on elk are:

1. Silvicultural methods that change the vegetation so that it no longer meets the definition of hiding cover (see **Glossary**) should be confined to an area with a maximum width of 1,000 ft. and should be bordered on all sides by cover of not less than 800 ft. width.
2. Maintain slash depth at less than 1.5 ft. to minimize impact on elk movements, distribution and habitat use.
3. When promoting increases in shrub cover and/or forage using burning and silviculture methods, do so without new road construction.
4. Plan timber sales so maximum duration of disturbance in any one are is two years in succession and the period of non-disturbance after post-sale activities is at least 3 years. Eliminate random logging and disturbance over the entire sale area. Use smaller sales or sequencing of larger sales through contract stipulations.
5. When feasible, refrain from road construction and logging in areas when elk would normally be using them. For example, do not log important summer habitat during summer if a viable option is to log during the winter.
6. If summer logging is planned on elk summer range, provide adjacent security areas at least as large as the areas being disturbed to provide elk security during periods of timber harvest and/or road building activity. This may be accomplished by scheduling of sale subdivisions so that one or more subdivisions are closed to all human activity including log hauling at one time. Try to provide a ridge line between the disturbed area and security area. It is preferred to have more than one security area adjacent to the sale area.

7. When feasible, utilize alternative logging systems such as log forwarders, helicopters, or long span skyline to reduce the amount of road construction and reconstruction required.
8. Protect major elk travel routes with buffer strips on either side for at least two sight distances (see **Glossary**)(Servheen 1997).

The Idaho Department of Fish and Game provides additional recommendations for managing access roads that influence elk habitat effectiveness and vulnerability (see Servheen 1997).

5.4.3. Northern Goshawk. The northern goshawk (*Accipiter gentilis*) is a bird widely distributed in temperate and boreal forests throughout the higher latitudes of the northern hemisphere (USFWS 1997, 1998). It inhabits coniferous, deciduous, and mixed forests, and shows morphological adaptations (short, rounded wings and long tails) for maneuverability in forest habitats (Patla et al. 1995). It preys on small- to medium-sized birds and mammals, which it captures on the ground, in trees, or in the air (Reynolds et al. 1992).

There is concern that changes occurring in goshawk nesting and foraging habitat, particularly reduction, fragmentation, and deterioration of mature conifer habitat, may be adversely affecting goshawk populations in Idaho and elsewhere in the western states. Habitat changes are due, in part, to the management of forests for timber production (Reynolds et al. 1992, Patla et al. 1995).

On several occasions the U.S. Fish and Wildlife Service has been petitioned to protect the northern goshawk under the Endangered Species Act (see Peck 2000). The most recent finding was that listing is unwarranted because recent survey efforts have resulted in discovery of more goshawks and habitat does not appear to be limiting (USFWS 1998). However, this does not mean that goshawks are not affected by forest conditions and harvesting activities or that there is no reason for concern. Goshawks remain classified as a "species of special concern" by the Idaho Department of Fish and Game (IDFG 1998*a*) and as a "sensitive species" by the U.S. Forest Service Region 4 (south and central Idaho).

Because they occur in fairly low densities in areas remote from human habitation, goshawks are rarely encountered by the casual observer (Patla et al. 1995). Due to concern about their status, monitoring efforts in Idaho have increased, and researchers are attempting to gain a better understanding of goshawk habitat characteristics and how land management activities affect them (IDFG 1998*a*).

Northern Goshawk Habitat. Goshawks use a variety of forest types, forest ages, structural conditions, and successional stages (Reynolds et al. 1992); however, mature or old-growth forests with large trees and high canopy closure are especially important habitat in the western states (Iverson et al. 1996, Beier and Drennan 1997, Daw et al. 1998). Goshawks are found in most types of forests in Idaho (Hejl et al. 1995). The structure of the forest, not the species of trees, appears to be the important factor (Siders and Kennedy 1996).

The nesting home range of goshawks contains three components: the nest area, the post-fledging family area, and the foraging area, each with specific characteristics and management requirements (Graham et al. 1994). The nest area includes one or more forest stands, several nests, and several landform characteristics. The size and shape of nest areas depend on topography and the availability of dense patches of large trees. Nest areas range in size from 20 to 30 acres (Graham et al. 1994).

The critical characteristics of nest sites are structural features associated with the successional stage of the nesting stands (Moore and Henny 1983). Most studies have found that goshawks prefer to nest in stands with older, larger trees and high canopy closure (Reynolds et al. 1982, Moore and Henny 1983, Reynolds 1983, Hayward and Escano 1989, Crocker-Bedford 1990, Siders and Kennedy 1996, Squires and Ruggiero 1996, Beier and Drennan 1997, Daw et al. 1998).

Within a given forest type, characteristics of nest areas can vary depending on forest productivity. Nest areas within highly productive forests have more trees and denser canopies than nest areas in less productive forests. Similarly, tree ages in a nest area can be highly variable, depending on forest type (Graham et al. 1994).

There has been debate over the accuracy of nest site descriptions for northern goshawks. In some cases search methods have not been documented and many nest sites have been discovered either opportunistically or by use of a priori knowledge of habitat structure to direct decisions on where to search for nests (Siders and Kennedy 1996, Squires and Ruggiero 1996, Daw et al. 1998).

The post-fledgling family area is the area surrounding the nest that is used by fledglings until they are no longer dependent on the adults for food.

It is a 300 to 600 acre mosaic of large trees, large snags, mid-aged forests, and small openings with a herbaceous understory, and large, downed logs (Graham et al. 1994).

The foraging area is 5,000 to 6,000 acres of forest that provides the food base for nesting goshawks. This area contains the habitat for larger birds and mammals that serve as prey. More than 50 species of goshawk prey have been identified, but few studies have examined the structure and composition of habitats preferred by foraging goshawks (Patla et al. 1995, Beier and Drennan 1997). Some studies have shown that goshawks use closed canopy forests more than open woodlands or meadows (Crocker-Bedford 1990, Patla et al. 1995), but goshawks have been observed hunting in many forest types and other habitats (Reynolds 1983, Graham et al. 1994, Patla et al. 1995, Iverson et al. 1996). Several studies suggest that foraging habitat may be as closely tied to prey availability as to particular habitat composition or structure (Reynold et al. 1992, Graham et al. 1994, Brier and Drennan 1997).

Hayward and Escano (1989) described typical northern goshawk habitat in northern Idaho. They found preferred nesting habitat to be mature to overmature conifer forest with a closed canopy (75-85% cover) on a moderate (15-35%) slope, facing north at or near the bottom of the hillside. Nest sites often occupied one of the older stands in the area. Relatively large diameter trees and wide spacing of trees and foliage allowed flight beneath the upper canopy. The typical nest was placed next to the bole of a live conifer in the lower one-third of the living crown. The nest tree had a whirl of large branches supporting the nest and an open canopy structure to allow nest access. Water and large forest openings were both generally within three-tenths of a mile of the nest (Hayward and Escano 1989).

Effects of Timber Harvesting on Northern Goshawks. Many authors who have studied goshawks in the western states have suggested that timber harvesting may result in reductions in goshawk abundance (e.g., Reynolds 1983, Patla et al. 1995). However, the mechanisms for inferred impacts of timber harvest on goshawks have not been well established (USFWS 1998). Several factors may contribute to decreased productivity and density in goshawk populations following particular changes in forest structure and composition, including: [1] increased predation on adults and young goshawks as hiding cover is reduced and potential predator populations increase; [2] loss of cool thermal conditions at nest sites; [3] reduced prey abundance or availability or both; [4] increased competition as predators that are adapted to more open forests become abundant; and [5] increased disturbance and human-caused mortality due to increased access from timber harvest road network (Iverson et al. 1996).

Effects of timber harvesting are difficult to quantify, as reoccupancy of nest sites is not guaranteed even at undisturbed sites. If other suitable sites were available, harvesting may only cause a relocation of nest sites. However, if nesting sites are limited, harvesting could result in local reduction in the breeding population (Moore and Henny 1983). Structure, age, and patch size of remaining forest habitat may be a factor in determining whether goshawks continue to use modified nesting territories over time. Prey abundance, diversity, and accessibility are also affected by changes in the composition and structure (Reynolds et al. 1992, Patla et al. 1995).

Effects of timber harvesting on northern goshawks vary by the silvicultural system and harvesting techniques employed. Direct disturbance during harvest operations does not appear to be a problem (Crocker-Bedford 1990, Grubb et al. 1998).

Clearcutting eliminates a preferred habitat type for northern goshawks and creates one that goshawks avoid (Iverson et al. 1996). One study found that goshawks appeared to be negatively affected by clearcuts in some studies but not in others (Hejl et al. 1995). A researcher speculates that such results are observed because goshawks are more easily seen in open areas, such as clearcuts (Crocker-Bedford 1990). Shelterwood treatment, even with reserve trees, is considered among the least valuable for nesting or foraging because of inadequate forest structure remaining in the stand (Iverson et al. 1996).

Uneven-aged silviculture that emulates natural disturbance patterns has a high likelihood of sustaining suitable goshawk habitat (Reynolds et al. 1992, Iverson et al. 1996). Group selection may not provide nesting habitat equivalent to mature/old-growth forest because of the degree of increased patchiness that will result over time; however, the value for nesting likely would remain adequate over the entire area throughout the rotation. Light, single-tree selection can retain high-value nesting habitat as long as large, old trees remain on the site through time. Group selection or single-tree selection also maintains relatively high-value foraging habitat throughout the management cycle (Iverson et al. 1996).

Intermediate silvicultural treatments, such as precommercial and commercial thinnings that open the canopy, can theoretically enhance stand suitability for goshawk use. The greatest benefits would not be in direct habitat improvement, but rather in reducing the time to develop stand structural characteristics necessary to provide suitable goshawk nesting and foraging habitat (Iverson et al. 1996).

Mitigating Timber Harvesting's Effects on Northern Goshawks. Numerous sets of recommendations and guidelines for management of timber harvesting and northern goshawk habitat have been developed (e.g, Jones 1974, Reynolds et al. 1992, Lilieholm et al. 1993, Patla et al. 1995, Iverson et al. 1996, Graham et al. 1999), but they tend to be regional in nature. In attempting to develop guidelines for Idaho, Patla et al. (1995) determined that more and better data were needed specific to the forest types of Idaho. They suggested that historical data be searched more thoroughly, monitoring of nest sites be increased, and survey methods be standardized. They suggested that until such time as guidelines specific to Idaho are developed, the guidelines developed for the southwestern states by Reynolds et al. (1992) should be used (Patla et al. 1995).

Northern Goshawk Management Guidelines. Forest structure influences the abundance and accessibility of prey, and in the long term, vegetation condition at the landscape scale will influence goshawk populations (Reynolds et al. 1992). Guidelines based on these accepted concepts focus on desired forest conditions and the link between forest structure and prey availability (Iverson et al. 1996). The guidelines are summarized in the following paragraphs.

Nest areas (30 acres each). Three suitable nest areas should be maintained per home range. In addition, three replacement nest areas per home range should be in a development phase, using intermediate treatment and prescribed fire. Nest areas are typified by one or more stands of mature or old trees and dense forest canopies. No adverse management activities should occur at any time in suitable nest areas (Reynolds et al. 1992).

Post Fledging-Family Areas (PFA) (420 acres). The PFA contains a variety of forest conditions and prey habitat attributes. Interspersed small openings, snags, downed logs, and woody debris are critical PFA attributes. To sustain desired canopy cover, size of trees, and the specified portions of different forest ages within the PFA, regeneration of 10 percent of the PFA may be required every 20 years. Other management tools, such as prescribed fire and removing understory trees, are suggested for sustaining other critical elements of goshawk habitat.

All management activities in the PFA should be limited to the period from October through February. Prescribed burning is the preferred method for management of woody debris. Thinning from below (removing understory trees) is preferred for maintaining desired forest structures, and a variable spacing is preferred for developing groups of trees with interlocking crowns. Road densities should be minimized, and permanent skid trails should be used in lieu of permanent roads (Reynolds et al. 1992).

Foraging Area (5,400 acres). Both the desired conditions and the management recommendations for the foraging area are similar to the PFA. The distribution and proportion of vegetative structural stages and the requirements for habitat attributes such as reserve trees, snags, and downed logs are the same as the PFA (Reynolds et al. 1992).

5.5. Scenery

Scenery may be one of the most common, yet often under-appreciated, resources that humans obtain from forests. High scenic quality fosters psychological and physiological benefits to individuals, and thus benefits communities and society at large (Galliano and Loeffler 1995). Beautiful scenery can attract people to visit and live in an area, which can encourage economic and social development (Power 1996).

Many people may believe the old adage that "beauty is in the eye of the beholder," but over the last two decades, much research has found that there are many common elements in what people find visually attractive about landscapes (McCool et al. 1997). Landscapes with a high degree of natural appearing character are most attractive (Galliano and Loeffler 1995). Timber harvesting and other timber management activities influence the scenic character of landscapes, and the scenic impacts of timber management influence public perceptions of forestry (Brunson and Reiter 1996).

Scenery is defined as the general appearance of a place and the features of its views or landscapes—the arrangement of predominantly natural features of the landscapes we see. Scenery consists of two components. First, are biophysical elements such as landforms, water, and vegetation. Second are cultural elements, which are positive features resulting from human activities in the landscape. The adjective "scenic" is defined as having to do with natural scenery that affords beautiful views (Galliano and Loeffler 1995).

Methods for studying and inventorying scenic beauty in forested areas have focused on either "near-view" or "vista" scenes. Near-view scenes focus on forest characteristics generally within 100 yards of the viewer and do not include distant elements. Near-view forest scenes are incurred when the viewer is "in the forest" as opposed to viewing the forest from afar. The near view is important for hikers, campers, and other recreationists (Schroeder and Daniel 1981). Vista scenes emphasize more distant landscape features, although they may include some near-view features (Brown and Daniel 1986).

During the 1970s public land management agencies, particularly the U.S. Forest Service, led the research and planning effort into visual resource management. Although their methods were somewhat dissimilar, each agency developed a systematic approach to inventorying, evaluating, and predicting scenic values. For example, the U.S. Forest Service developed the Visual Management System, which has evolved into the Scenery Management System (Galliano and Loeffler 1995). The basic premise of these models is that on public lands people expect natural appearing scenery to visually dominate cultural or human activities, especially in forested landscapes (Galliano and Loeffler 1995).

5.5.1. Idaho's Scenery. The most recent scenic assessment for all of Idaho was conducted as part of the Interior Columbia Basin Ecosystem Management Project (ICBEMP). The visual environment, particularly that on public lands, is important to people of the basin (McCool et al. 1997). Galliano and Loeffler (1995) used a large-scale "vista" approach for assessing the entire basin. They used a concept called "landscape character" to describe ecoregion-based areas, defining landscape character as the overall impression created by scenery resulting from both natural processes and positive human influences. They described landscape character using four primary attributes: landforms, vegetation, water forms, and cultural forms. These attributes served as a frame of reference for inventorying "scenic integrity."

Galliano and Loeffler (1995) define scenic integrity as the present condition or level of visual wholeness or intactness of landscape. Landscapes with high scenic integrity have virtually no discordant elements and contain only positive human alterations. In ICBEMP, scenic integrity was evaluated for all Ecological Reporting Units (ERUs). (Eight ERUs lie entirely or partially within Idaho.) Four ERUs in Idaho (Central Idaho Mountains, Snake Headwaters, Owyhee Uplands, and Upper Snake) have more than half their total lands within the Very High and High scenic integrity categories (Table 5-8). In total, nearly two-thirds of the federal lands in Idaho and western Montana are currently rated within the Very High and High scenic integrity categories, distinguishing them as some of the most scenic areas in the U.S. (Galliano and Loeffler 1995, Quigley et al. 1997).

5.5.2. Scenic Beauty and Forest Management Research. Literally dozens of research efforts have focused on evaluating scenic beauty and forest management. Rosenberger (1998) provided an up-to-date review of the literature, and we rely heavily on his work here. (For another review see Ribe 1989).

Much of the work on forest management and scenic beauty has focused on the near view of forest stands. Researchers have found that scenic beauty, particularly for the near view, can be evaluated using the same management units (i.e., timber stands) and variables (e.g., tree diameter, tree age, stand density) that are used for timber management (Arthur 1977, Brown and Daniel 1986). Therefore, data is usually readily available for evaluating the effects of timber management practices on scenic beauty.

Certain forest characteristics have produced consistent results across many forest types and geographic regions. Tree size is a significant variable of scenic beauty explanation in most models (Rosenberger 1998). The presence and dominance of larger diameter trees in a forest stand has a strong, positive effect on scenic beauty (Arthur 1977; Brown and Daniel 1984, 1986; Ribe 1989; Rosenberger 1998). The presence of large trees is most important in stands with fewer trees per acre (Rosenberger 1998). Scenic beauty increases with decreases in the presence of sapling- and pole-sized trees (Brown and Daniel 1984, Brown 1987).

Tree density effects on scenic beauty are more complex. For instance, at the sapling stage, more trees per acre has a negative effect (Brown 1987), whereas with large trees, as tree density increases per acre, the effect grows more positive (Rosenberger 1998). However, more open and park-

Table 5-8. Existing scenic integrity by ICBEMP Ecological Reporting Unit (ERU), for ERUs that include lands in Idaho.

Scenic Integrity by ERU	Percent of acres in category				
	Very High	**High**	**Moderately High**	**Moderately Low**	**Low**
Columbia Plateau	2	19	42	37	0
Blue Mountains	10	21	55	14	0
N. Glaciated Mtns.	25	9	63	3	0
Lower Clark Fork	14	8	75	3	0
Owyhee Uplands	2	50	44	4	0
Upper Snake	3	64	17	16	0
Snake Headwaters	37	41	18	5	0
Central Idaho Mtns.	34	31	31	4	0

Source: Galliano and Loeffler (1995).

like stands, typical for ponderosa pine in western landscapes, are preferred over dense forest stands, whether the stand contains saplings and young trees or large trees (Rosenberger 1998). Overstory stocking affects scenic beauty with lower densities that allow more light penetration preferred (Brown and Daniel 1984, Brown 1987). Dense clumps of trees also tend to decrease scenic beauty (Brown and Daniel 1984, 1986).

Stand age has a strong, positive effect on perceived scenic beauty. This is evident from and consistent with the positive effect of large trees, and the negative effect of dense forests, small trees on scenic beauty. In some cases, mature, even-aged stands are preferred over uneven-aged stands. However, in other cases the vertical diversity in uneven-aged stands is preferred over homogenous stands (Rosenberger 1998).

A mix of tree species has a strong, positive effect on perceived scenic beauty (Ribe 1989). Several studies on ponderosa pine forests show improved scenic beauty when other species are present, including oaks, junipers, aspen, birch, and firs (Rosenberger 1998).

Understory, including seedlings and shrubs, has a varied effect on perceived scenic beauty of forest stands. It can have a negative effect on scenic beauty by reducing visual penetration when open, park-like stands are preferred. Dense shrubs can detract from scenic beauty (Ribe 1989). However, the diversity of the understory can improve the scenic beauty of some western forests. In some studies, understory is not significant in explaining scenic beauty (Rosenberger 1998).

Vegetative groundcover (grasses, forbs, and seedlings) has a positive effect on scenic beauty, especially in western forests (Brown and Daniel 1986, Brown 1987, Ribe 1989). Typically, the benefits of groundcover for increasing scenic beauty are greatest with the first few increments of groundcover, with additional increments exhibiting smaller marginal benefits (Rosenberger 1998).

Downed wood, including slash from harvesting operations, is a consistent predictor of scenic beauty. Downed wood has a negative impact on scenic beauty, but the degree of impact depends on the forest type, the size and amount of downed wood, and the vertical height of the wood (Arthur 1977; Brown and Daniel 1984, 1986; Ribe 1989; Schroeder et al. 1993; Rosenberger 1998). People do not distinguish between naturally-downed wood and logging slash in their judgments of scenic beauty (Brown 1987).

Fire damage to forest stands immediately reduces the scenic beauty of an area (Ribe 1989). The magnitude of the impact depends on the severity of the fire and the level and timing of recovery. Prescribed burns have been found to negatively impact scenic beauty in the short term, but with ground vegetation recovery, prescribed burns can enhance scenic beauty after a few years. This is primarily due to the elimination of slash after harvest or increasing visual penetration by reducing understory density. More severe prescribed burns may decrease scenic beauty, since they may leave visible scars on mature trees (Rosenberger 1998).

5.5.3. Managing Timber Harvest for Scenic Beauty. All of the relationships between perceived scenic beauty of forest stands and forest stand component variables have implications for timber management. Timber harvesting probably has the greatest potential for negatively impacting scenic beauty in the short term, and may confound all other relationships between forest characteristics and scenic beauty (Rosenberger 1998).

The effects of timber harvesting on scenic beauty will vary by the silvicultural and harvesting system employed. Clearcutting has the greatest negative impact on scenic beauty in the short run (Rosenberger 1998). The visual evidence of disturbance associated with the removal of all trees as well as the obvious presence of stumps and slash creates negative perceptions of scenic quality. Seed-tree cuts produce similar results because so few trees are left after harvest (USFS 1973*b*). The visual quality of the initial entry on a shelterwood cut varies considerably with each timber type, but the appearance after the final entry is similar to that of a clearcut because of the small size of young trees in the newly regenerated stand. Uneven-aged management and selective cutting keep visual evidence of disturbance to a minimum and create stands that have more structural diversity, thus partially mitigating overall impacts of harvesting on scenic beauty (USFS 1973*b*, Rosenberger 1998). As a generalization, the more trees per acre left standing, the higher the scenic quality of the stand (Brunson and Reiter 1996, Rosenberger 1998).

Thinning of dense stands can increase scenic beauty by increasing visual penetration, provided that slash is minimized (Ribe 1989, Rosenberger 1998). Thinning to remove dead, diseased, and damaged trees also can increase scenic beauty (Buhyoff et al. 1982, Rosenberger 1998).

The size and shape of harvested areas also affect scenic beauty at both the near-view and vista scales. Smaller clearcuts are preferred to larger ones (Schroeder et al. 1993, Gobster 1996), and straight, unnatural-appearing edges between harvested and unharvested areas decrease scenic quality (USFS 1973*b*, Ribe 1989). Harvest units can be designed with feathered edges, islands of "leave" trees, and variety in shape and size, all giving harvested stands a more natural-appearing character (USFS 1973*b*, Walters 1992).

The duration of timber harvest activity's visual impact to a landscape depends greatly on the regenerative capabilities of specific forest types, climate, management techniques, and degree or severity of impacts. The reduction of slash left after harvest leads to the quickest and most significant improvement in scenic quality (Brown and Daniel 1984, Ribe 1989). Burning, removal, lopping, and chipping and spreading are all management techniques for slash that mitigate its effects on visual quality (Rosenberger 1998). The use of fire to prepare a recently logged site for replanting has negative immediate scenic impacts, although the longer-term effect may be positive if the new stand regenerates more quickly (Brunson and Reiter 1996). Planting of new seedlings decreases the time until regeneration appears, thus reducing recovery time.

5.5.4. Scenery and Ecosystem Management. Ecosystem management is a relatively new paradigm for forest management (see **Chapter 4**), and is based on maintaining ecosystem composition, structure, and processes. It is not yet clear how compatible these goals are with scenic beauty in forested landscapes. High scenic quality may sometimes equate with high ecosystem integrity, but one does not necessarily ensure the other (Galliano and Loeffler 1995). What looks good now may be at high risk for change in the future. Rosenberger (1998) concluded that, in general, preferred characteristics for scenic beauty are not at high risk for fire or insects, but other changes that affect ecosystem integrity may occur.

Ecosystem management forestry techniques often entail leaving behind "ecological legacies"—clumps of live trees, standing dead snags, downed logs, and woody residues. Although most scenic beauty research was not done in the context of ecosystem management, the existing research tends to suggest that people may find these techniques unattractive, which may reduce support for ecosystem management overall (Brunson and Reiter 1996).

Some ecosystem management techniques may produce negative scenic beauty effects. Brunson and Reiter (1996) evaluated the scenic impacts of several ecosystem management techniques on forest stands in Oregon. Despite the presence of downed wood, people in their study rated old growth scenes highest in scenic beauty, followed by group selection, thinning, and shelterwood after the first entry. Snag retention and clearcutting ranked lowest. Topping trees to create snags also had a slight negative effect (Brunson and Reiter 1996).

By providing information about the reasons ecosystem management techniques were undertaken, Brunson and Reiter (1996) attempted to influence people's preferences. Although in other studies increased information has been shown to affect scenic beauty judgments (Anderson 1981, Buhyoff et al. 1982), in this case increased information had mixed effects on scenic evaluations (Brunson and Reiter 1996).

Biodiversity is a focus of ecosystem management, and some practices that enhance biodiversity may conflict with those that promote visual quality (Gobster 1996). For example, slash left from harvesting operations has one of the biggest impacts on near-view scenic quality. Naturally occurring downed wood is often indistinguishable from downed wood caused by logging practices, and thus natural decline in mature and old-growth stands may have similar scenic impacts. To reduce these impacts harvest prescriptions for visually scenic areas often call for removing, chipping, burning, or pulling slash from the areas. From a forest biodiversity perspective, however, downed wood can be important for maintaining site quality and sustaining soil productivity, the diversity of insects, microfauna and microflora, wildlife food and cover, and tree and groundcover regeneration. Practices that affect abundance and distribution of slash and natural downed wood thus can hinder biodiversity goals (Gobster 1996).

Visual preferences are often thought of as coinciding with the perceived degree of disruption; i.e., unmanaged forests are most preferred, and clearcuts are least preferred (Gobster 1996). Several studies, however, have shown that lightly managed stands in which dead material and low tree and shrub cover are reduced, and visual penetration increased, are often preferred over unmanaged stands. From a biodiversity standpoint, even- and uneven-aged techniques that promote a varied vertical structure may encourage higher biodiversity. In this light, techniques that reduce structural heterogeneity—such as those that produce park-like stands of mature trees with herbaceous groundcover but little midstory vegetation—may be scenically popular but compromise biodiversity goals (Gobster 1996).

5.6. Conclusions

Timber harvesting affects other forest resources, but the direction and magnitude of those effects is highly variable. The effects vary because the biotic and abiotic conditions that exist on each timber harvesting site differ. The effects also vary depending on the method of timber harvesting employed, including the proportion of stems removed, the size of trees removed, and the machinery used for removal.

Timber harvesting activities affect the soil on the timber harvesting site, and thus can affect the ability of the site to produce timber in the future. Negative effects on long-term site productivity can be mitigated by reducing minimizing soil disturbance, leaving plenty of organic matter behind, and ensuring prompt regeneration.

Water quantity and quality are also affected by timber harvesting activities. Streamflow, water temperature, dissolved oxygen, nutrient concentrations, and sediment loads can all be affected. More negative effects are associated with roads for accessing timber than with the sites where trees are removed. Best management practices (BMPs) developed under the Idaho Forest Practices Act are designed to mitigate the effects of timber harvesting on water quality by reducing impacts to acceptable levels. BMPs are mandatory for timber harvesting activities in the state of Idaho.

The responses of wildlife to timber harvesting depend on the type of wildlife, the ecological conditions on and off site before and after harvesting, the type of logging system used, and when harvesting is done. The two species we examined, Rocky Mountain elk and Northern goshawk, have varied and somewhat different responses to timber harvesting. Generalizing about effects of timber harvesting on these two species, or wildlife in general, is tenuous because of the variety of habitats used and the conditions of any particular site. Actions that affect one species positively may affect another negatively.

Timber harvesting can affect scenic beauty. The social acceptability of timber harvesting in particular areas may be dependent on people's impressions of its scenic impacts. Timber harvesting's impacts on scenic beauty can be reduced by leaving some live trees on site and providing visual penetration. Questions remain about whether ecological goals for forest management are compatible with scenic goals.

It is difficult to reach one definitive conclusion about the effects of timber harvesting on other resources, particularly at a statewide scale. Conditions vary across the state and the combinations of factors are almost endless. The importance placed on the effects of timber harvesting on other resources, and how those effects are managed will vary, too, because forests are managed under different policies and management objectives (see **Chapter 4)**.

Chapter 6. Alternative Approaches to Watershed Analysis

One of the criticisms that arises in discussions of sustainable forest management is that links from policy to implementation are missing. What on-the-ground planning and management processes are available that encourage sustainable forest management? What tools can help managers ensure that timber harvesting is sustainable?

In the past decade, "watershed analysis" has emerged as a name for a type of process that may encourage sustainable forest management. Although watershed analysis approaches are still evolving and may differ in their management objectives, the intent is basically the same: to understand the ecological processes at work in a watershed and protect some resources from detrimental effects of using other resources, including timber. The differences lie in which processes and resources are included in the analysis (Grant et al. 1994, Montgomery et al. 1995, Reid 1998).

In this chapter we look at three governmental approaches to watershed analysis. Two are state level and one is federal. The two state approaches, for Idaho and Washington, are based on a management paradigm called cumulative watershed effects (Reid 1993, Collins and Press 1997*a*), which is concerned primarily about water quality and nonpoint source pollution. The federal approach extends the cumulative watershed effects model into a planning tool for ecosystem management (USFS 1995*b*, Grant et al. 1994, Montgomery et al. 1995). It considers not only a broader range of ecological elements than those related to water quality, but also economic and social objectives.

After describing the three approaches to watershed analysis, we compare them using four resource management paradigms: cumulative effects assessment, adaptive management, restoration assessment, and ecosystem management. We then look at a methodology being developed and tested by a private timber company that builds on the Washington process for watershed analysis by developing methods for extrapolating results to a broader range of watersheds.

6.1. Cumulative Watershed Effects: State Programs

Before analyzing Idaho and Washington programs for cumulative watershed effects analysis, it is necessary to define what the term means.

6.1.1. What are cumulative impacts? In the regulations for implementing the National Environmental Policy Act (NEPA) the Council on Environmental Quality (CEQ) defines cumulative impact as:

> the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or persons undertake such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over time (40 C.F.R. § 1508.7).

In other words, the concept of cumulative impacts, or effects, encompasses those environmental changes caused by the interaction of natural ecosystem processes with the effects of land-use activities distributed through time, space, or both (Sidle and Hornbeck 1991, Reid 1993).

6.1.2. What are cumulative effects? Cumulative effects can be caused by repeated, progressive, sequential, and coexisting land-use activities (Reid 1993). They can occur because of a single type of influence on an environmental parameter. For example, many types of land use can compact soils. Effects can result from complementary influences. For example, both increased snow compaction and altered snow accumulation can affect flood peaks. Cascading influences can accumulate. For example, one type of land use can influence a second to cause an impact, as when urbanization increases recreational pressure, thus increasing trail erosion. Cumulative effects can arise from interdependent influences. For example, two introduced chemicals can react to produce a third (Reid 1993).

Cumulative effects may result from the accumulation of small effects of many forest practices that are insignificant at any one site, or they may result from a change in dominant watershed processes, even when activities triggering effects are limited (WFPB 1997). For example, sedimentation from surface erosion is incremental, whereas landslides or mass wasting are usually considered to be episodic. The manifestation of cumulative effects is complicated by lags in system response to change, geographic decoupling between cause and effect, site-specific variations in impact expression, accumulation of innocuous changes to the point that a catastrophic change is triggered, the ability of high-magnitude events to trigger delayed impacts, and interaction between changes that modify their expression (Reid 1993, Reid 1998).

Analysis of the cumulative effects of land management activities has received increasing attention in recent decades. The primary difference between research on cumulative effects and research on individual land-use effects is that research on cumulative effects focuses specifically on the interaction of processes and treatments (Sidle and Hornbeck 1991, Reid 1998). Cumulative effects analysis is likely to involve interdisciplinary work and larger temporal and spatial scales compared to analysis of individual resources (Sidle and Hornbeck 1991, Reid 1993, Reid 1998).

The legal impetus for cumulative effects analysis in forest management has come from the Multiple-Use Sustained-Yield Act, the National Environmental Policy Act (NEPA), the National Forest Management Act, and the Clean Water Act (Cobourn 1989, Sidle and Hornbeck 1991). Specifically, in addressing the proper scope of an environmental impact statement under NEPA, the CEQ regulations require that such statements consider direct impacts, indirect impacts, and cumulative impacts (Cobourn 1989). The Clean Water Act requires a process to identify silviculturally related nonpoint sources of pollution and their cumulative impacts (33 U.S.C. 1288(b)(2)(F)). Also, federal courts have set down mandates regarding cumulative effects in several cases (Cobourn 1989).

6.1.3. What are cumulative watershed effects? Much of the cumulative effects analysis in land management is done in relation to watersheds, or cumulative watershed effects (CWE). There is some disagreement about the meaning of "watershed" in the CWE context. Broad interpretations include any changes occurring within the boundaries of a drainage basin, where the watershed is simply the location of impacts and does not necessarily play a role in its generation. A narrower interpretation is that "watershed effects" include only those changes occurring to resources influenced directly or indirectly by processes affecting water quality, with water and sediment transport processes functionally linked to expression of impacts (Reid 1993). This distinction also is apparent in the interpretation of "watershed analysis." The federal process tends toward the first interpretation of the watershed as an ecological whole, whereas the state processes reflect the latter interpretation of the watershed as a fluvial system.

In the context of state water quality programs, CWE analysis is basically an advanced means of controlling nonpoint source pollution. It is a safety net for water quality, predicting impacts that might be missed if planning were carried out only at the project proposal level. By recognizing that a watershed is a fluvial system and an ecological whole, cumulative watershed effects analysis assures that hydrologic effects, erosion processes, and biologic responses are considered from the outset (Cobourn 1989). In Idaho, CWE is focused primarily on timber management practices and has wide implications for soil resources and long-term productivity (Dechert, review comments).

6.1.4. Idaho's Cumulative Watershed Effects (CWE) Process. In 1991, the Idaho Forest Practices Act was amended to include provisions to reduce the impacts of cumulative effects of multiple forest practices. The amendment defined cumulative watershed effects as:

> ... the impact on water quality and/or beneficial uses which result from the incremental impact of two (2) or more forest practices. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time (Idaho Code § 38-1308(17)).

A task force composed of representatives of large private forest owners, state and federal resource management agencies, and environmental interest groups worked to develop a cumulative watershed effects (CWE) analysis and control process to ensure that watersheds are managed to protect water quality so that beneficial uses of water bodies are supported. The *Forest Practices Cumulative Watershed Effects Process for Idaho* (IDL 1995) was the result of the task's force work. A revised process manual was released in March 2000 (IDL 2000).

The Idaho CWE process sets up a framework in which trained evaluators combine field observations and measurements with professional judgment to examine important watershed processes (see IDL 2000). With minimal specialized guidance, trained resource managers can use the procedure to determine the hazards inherent in, and the current condition of, streams and watersheds. That allows them to estimate the risks associated with planned forest practices. With this information they can determine whether a CWE problem exists. If it does, they can design prescriptions needed to control it (IDL 2000).

The CWE process consists of two basic parts: the Watershed Condition Assessment Process and the Impact Control Process (IDL 2000). First, the Watershed Condition Assessment includes modules for erosion and mass failure hazard, canopy closure/stream temperature, hydrology, sediment delivery, channel stability, beneficial use/fine sediment, and nutrients. These factors are assessed to determine if adverse conditions exist. Second, the Impact Control Process guides the resource manager to prescribe solutions to adverse CWE conditions (IDL 2000).

The CWE process leads to one of three courses of action for the forest manager:

1. Guidance for making decisions that will allow a planned forest practice to proceed without unacceptable risk of adverse CWE.
2. When the results of the evaluation indicate the existence of a CWE problem, help in redesigning forest practices, and/or correcting the identified watershed problems.
3. When the evaluation process suggests the existence of a complex CWE situation, guidance for completing additional analysis before proceeding with a forest practice. If necessary, IDL will facilitate convening an interdisciplinary team of qualified technical specialists to complete the analyses of complex situations (IDL 2000).

Resource managers and the Idaho Department of Lands, the agency responsible for implementing the Idaho Forest Practices Act (IDL) have three ways of monitoring the effectiveness of CWE management prescriptions. Those are forest practice inspections, forest practice audits, and CWE reassessments. Regular inspections of forest practices are conducted by IDL while forest operations are taking place. Annual forest practice audits by the Idaho Department of Environmental Quality (every fourth year) and IDL (in interim years) are required. (See results in *5.3.4. Mitigating Timber Harvesting's Effects on Water Quality*.) Reassessment of watersheds is to be done on a regular basis (IDL 2000).

Landowners responsibilities are highlighted in the CWE process. A watershed committee consisting of forest landowners within a watershed has the opportunity to oversee application of the process in the watershed. The committee can select evaluators from IDL's approved list, and the committee and individual landowners can develop management prescriptions based on the assessment report (IDL 2000). In practice, IDL has taken a lead role in initiating and conducting the CWE process, and it is currently being driven by the TMDL process under the federal Clean Water Act (see O'Laughlin 1996*b*) (Dechert, review comments).

The CWE process is designed to be adaptive in that the decision criteria provided in the process change as new data and information become available (IDL 1995). The differences in the assessment modules between the 1995 and 2000 editions of the CWE manual reflect this adaptive trait (see IDL 1995, 2000). IDL has developed an extensive GIS database from CWE assessments (Dechert, review comments).

Not all watersheds in the state have been assessed using the CWE process, but analyses are targeted toward the most vulnerable watersheds. In the last few years, increased appropriations to IDL specifically for CWE have allowed the department to increase training, assessment crews, data availability, and completion of watershed assessments (Dechert, review comments).

6.1.5. Washington's Watershed Analysis Program. The state of Washington's watershed analysis program grew out of concern over the cumulative effects of forest management activities. Until cumulative effects rules were adopted, forest practices were considered one activity at a time, and although the regulations provided protection on a site-by-site basis, there were concerns that the watershed as a whole might be affected by the cumulative effects of all the activities in the basin. Washington state defines cumulative effects as "the changes to the environment caused by the interaction of natural ecosystem processes with the effects of two or more forest practices." These changes include effects on water quality, wildlife, fish habitat, and other public resources (WFPB 1997).

A fundamental assumption of Washington's approach to watershed analysis is that by applying standard forest practices in less sensitive areas and managing sensitive areas appropriately, the overall watershed condition will be protected and cumulative effects will not occur (WFPB 1997). Watershed analysis is a structured approach to developing a forest practice plan for a watershed based on a biological and physical inventory. During the startup and resource assessment phases, an interdisciplinary team of scientists develops information and interpretations of resource conditions and sensitivities at a watershed scale guided by a series of key questions. The products produced by the scientists include resource condition reports describing watershed conditions, maps locating sensitive areas requiring prescriptions (which may include all or parts of the watershed), and causal mechanism reports describing the sensitive area and the nature of potential problems to public resources supported with facts and data. This information is then fed into the prescription process where local land managers and agencies develop a tailored management plan for the watershed that responds to the resource concerns identified by the scientific investigation. A team of field managers and analysts determine required and voluntary forest practices for each identified sensitive area. Once the watershed plan is developed, further forestry activities in the watershed must be conducted within the provisions of the watershed analysis prescriptions for each sensitive area, unless an alternative plan is approved, with compliance regulated by the Washington Department of Natural Resources (WFPB 1997).

In the wrap-up phase of Washington's watershed analysis, the analysis team may develop a plan to measure effectiveness of prescriptions, but this step is optional. The team can identify monitoring variables and protocols and pass on a monitoring plan to stakeholders for implementation. Monitoring is implemented as an option by landowners, agencies, tribes, and others interested in the watershed (WFPB 1997).

Washington's watershed analysis assumes that management plans should be developed by those with the skills and experience to conduct forest management activities; however, it also relies on stakeholders within each watershed to make it work (WFPB 1997). It is a collaborative process involving resource scientists and managers representing landowners, tribes, and other interested publics. A fundamental philosophy of the process is that the best solutions will result when the scientists that develop information for an area work collaboratively with the resource managers responsible for developing and implementing the plan for the area. Resource specialists provide resource condition reports, maps of sensitive areas, causal mechanism reports, and rules for standards of performance. Field managers provide prescriptions with justification for each mapped sensitive unit (WFPB 1997).

Provisions are made for public review of the findings of the watershed study and management prescriptions before final acceptance of the plan. The Washington Department of Natural Resources manages the public review (WFPB 1997).

The state of Washington has been divided into approximately 800 watersheds ranging in size from 10,000 to 50,000 acres. Total time for completion of a watershed analysis is two to five months depending on the size and complexity of the watershed and the chosen level of assessment. Products of the watershed analysis are assumed to be valid for a period of five years, at which time the process may be repeated if necessary (WFPB 1997).

The Washington watershed analysis program is designed to be adaptive. The application of the process is expected to evolve as scientific knowledge and experience with the process grows. The watershed analysis process can best be viewed as a work in progress (WFPB 1997).

6.2. Watershed Analysis by Federal Agencies

Watershed analysis as it is done by federal agencies builds on and moves beyond cumulative watershed effects analysis (USFS & BLM 1993, Grant et al. 1994, Montgomery et al. 1995). For federal agencies, watershed analysis is a vehicle for implementing ecosystem management at the watershed scale (Grant et al. 1994, RIEC 1995, Tuchmann et al. 1996, Reid 1998). It provides a process for melding social expectations with the biophysical capabilities of specific landscapes (FEMAT 1993, Fight et al. 2000).

Watershed analysis originated from a recognition that planning directed at single issues by individual agencies does not work. For example, a management plan focused only on harvesting timber may meet the silvicultural and economic objectives of one landowner, but that plan may not adequately consider the effect of that activity on other owners, values, or activities within the watershed. Watershed analysis identifies conflicting values and expectations and the social, biological, and physical processes that are important when viewed at the watershed scale (Ziemer 1997). Watershed analysis is designed to allow federal agencies to shift their focus from species and sites to the ecosystems that support them in order to understand the consequences of management actions before implementation (Montgomery et al. 1995, RIEC 1995).

Watershed analysis is designed to be an iterative, incremental process (USFS & BLM 1994*b*). Its methods and procedures are flexible and designed to be updated and revised as new information or understanding of ecosystem processes is either developed or becomes available (RIEC 1995).

Federal watershed analysis is not a decision making process; it is a stage-setting process. Watershed analysis can support any decision-making priorities; it is intended only to generate the information required to make informed choices about potential land management impacts in a spatially-distributed context. The results of watershed analyses establish the context for subsequent decision making processes, including planning, project development, and regulatory compliance (Grant et al. 1994, RIEC 1995).

Montgomery et al. (1995) suggest that incorporation of watershed analysis into land use planning offers at least five distinct advantages over more traditional approaches to land use decision-making:

1. Incorporating scientific input at the front end of the planning process can help avoid crisis management through more effective and complete use of such information in decision-making. Watershed analysis provides a framework within which to explicitly address the ecological impacts of land management decisions. This should generate the structure necessary to avoid policies inconsistent with resource-management objectives.
2. Incorporating available scientific information and theories should decrease the probability of unanticipated conflicts arising from real or perceived incompatibilities between management activity and resource objectives or laws. Decisions are likely to be more defensible if potential impacts are realistically addressed based on current knowledge. Involvement of all interested parties during the watershed analysis process also provides a more productive forum for addressing basic disputes about watershed conditions and processes.
3. By synthesizing available data on landscape history, condition, and potential future conditions, watershed analysis helps focus land use disputes on policy and prescriptions. While ecosystem response may be dauntingly complex, adversaries may be compelled to agree on basic data, thus narrowing the scope of potential differences.
4. Watershed analysis provides a framework for incorporating interdisciplinary, interagency, and multi-owner considerations and input necessary to either prevent ecosystem deterioration or restore degraded areas. Present planning procedures often provide little opportunity for interdisciplinary (as opposed to multi-disciplinary) or holistic assessments of landscape conditions and potential management options.
5. Provides a public and accountable assessment of the degree to which societal expectations are met by land managers (Montgomery et al. 1995:383).

6.2.1. History. The federal impetus for watershed analysis came out of the spotted-owl controversy in the Pacific Northwest. The Forest Ecosystem Management Team report (FEMAT 1993) and related documents (USFS & BLM 1993) first proposed the use of watershed analysis as a systematic procedure for characterizing watershed and ecological processes to meet specific management and social objectives. PACFISH (USFS & BLM 1994*b*) and INFISH (USFS 1995*a*) followed suit.

Watershed analysis was first introduced in 1994 in the Pacific Northwest forests (USFS 1995*b*). In 1994 and 1995, the USFS and BLM completed 15 pilot watershed analyses and additional watershed analyses on more than 8 million acres, which represents more than 51% of the land matrix, adaptive management areas, and late-successional reserves (including riparian reserves) in the spotted owl forests of the region. Federal agencies completed analyses on another 3.2 million acres in 1996 and planned to complete 2.5 million acres in 1997 (Tuchmann et al. 1996). Examples of early federal approaches include the Applegate Watershed Analysis in southwestern Oregon (BLM 1995) and the Nestucca Watershed Analysis on the north coast of Oregon (USFS et al. 1994).

6.2.2. Ecosystem Analysis at the Watershed Scale. The most recent federal guide for watershed analysis, *Ecosystem Analysis at the Watershed Scale* (RIEC 1995), outlines the following six-step analysis process:

1. *Characterization of the watershed*— Identify the dominant physical, biological, and human processes or features of the watershed that affect ecosystem functions or conditions. Establish the relations between these functions. Identify the important land allocations, plan objectives, and regulatory constraints that influence resource management.
2. *Identification of issues and key questions*—Focus the analysis on the key elements of the ecosystem that are most relevant to the management questions and objectives, human values, or resource conditions with the watershed.
3. *Description of current conditions*— Develop information relevant to the issues and key questions identified in step 2. Document

current range, distribution, and condition of the relevant ecosystem elements.

4. *Description of reference conditions* —Explain how ecological conditions have hanged over time as a result of human influence and natural disturbances.
5. *Synthesis and interpretation of information*—Compare existing and reference conditions of specific ecosystem elements and explain significant differences, similarities, or trends and their causes. Evaluate the capacity of the system to achieve key management-plan objectives.
6. *Recommendations*—Bring the results of steps 1 to 5 to conclusion; focus on management recommendations that are responsive to watershed processes identified in the analysis. Link issues and key questions with synthesis and interpretation of ecosystem understanding. Identify monitoring activities. (Tuchmann et al. 1996:85).

The guide proposes seven core topics that each watershed analysis should address: erosion processes, hydrology, vegetation, stream channel, water quality, species and habitats, and human uses. These represent the major and common ecological elements, and their interrelations, in all watersheds. They are purposely broad and general, to encourage a watershed-scale perspective of the system as opposed to site- or project-scale perspectives. They help ensure that analyses are sufficiently comprehensive to develop a basic understanding of ecological conditions, processes, and interactions in the watershed (RIEC 1995, Tuchmann et al. 1996).

A series of questions serves as a guide to watershed analysis teams through the core topics and six step process (RIEC 1995). For example, the core questions for water quality are:

- What beneficial uses dependent on aquatic resources occur in the watershed? Which water quality parameters are critical to these uses? (Step 1: *Characterization*)
- What are the current conditions and trends of beneficial uses and associated water quality parameters? (Step 3: *Current Conditions*)
- What were the historical water quality characteristics of the watershed? (Step 4: *Reference Conditions*)
- What are the natural and human causes of change between historical and current water quality conditions? What are the influences and relationships between water quality and other ecosystem processes in the watershed (e.g., mass wasting, fish habitat, stream reach vulnerability)? (Step 5: *Synthesis and Interpretation*) (RIEC 1995).

6.2.3. How big is a watershed? The guide does not specify the size of watersheds that should be analyzed. It suggests that the size of the area chosen for analysis depends on the purpose of the analysis, the topics to be analyzed, and the physical, biological, and social complexity of the area. With watershed analysis, the challenge is to select an area such that the data and information are useful for deciding what management activities are compatible with ecosystem goals—not so broad that the conclusions are not directly helpful to managers and not so refined or detailed that the information does not show broader ecosystem needs (RIEC 1995).

Watershed analysis guides site-level project planning and decision making by providing the watershed context. As watershed size increases, it becomes more difficult to provide meaningful information for this use (RIEC 1995). FEMAT (1993) suggested that watershed analysis applied to watersheds of approximately 20-200 square miles. This size is small enough to provide a useful level of precision, while being large enough to exhibit any of the interactions important to environmental issues (Ziemer 1997).

6.2.4 Implementation Issues. To provide accountability, watershed analysis includes a certification process through which the responsible line officer certifies that the analysis has been conducted and completed according to the expected scientific standards (USFS & BLM 1994*b*). The guide states that a qualified interagency and interdisciplinary team should be used for the analysis, and involving other agencies, tribes, state and local governments, and the public throughout the analysis is encouraged (RIEC 1995).

The federal guide does not provide a time frame for completing the analysis nor an estimate of costs. INFISH estimated that initial assessment of conditions would cost $17,000 to $25,000 per assessment, and comprehensive assessment to evaluate watershed response and recommend adjustments would cost $38,000 to $100,000 per assessment (USFS 1995*a*). However, INFISH (USFS 1995*a*) cautions that the cost estimates are speculative.

6.3. Comparing Alternative Approaches

Table 6-1 summarizes selected characteristics of the Idaho, Washington, and federal watershed analysis processes. Differences between the processes are numerous, but given that the goals for each are different, that should be expected.

We compared these processes in light of four natural resource management paradigms used by Collins and Pess (1997*a*) to critique Washington's watershed analysis program. The four paradigms are: [1] cumulative effects assessment (from Reid 1993), [2] adaptive management (from Halbert 1993), [3] restoration assessment (from Beechie et al. 1996), and [4] ecosystem management (from Grumbine 1994). The key elements of each paradigm are listed in Table 6-2.

Our analysis is general in nature because it is based only on each entity's general procedures guide for watershed analysis (i.e., IDL 2000, WFPB 1997, and RIEC 1995). Examinations of actual field procedures, reviews of completed analysis reports, and interviews with managers might have produced more detailed and different results.

6.3.1. Cumulative Effects Assessment Comparison. All three watershed analysis processes include most elements of the cumulative effects management paradigm (Table 6-2). However, none of the three processes appears to require that monitored impacts be compared to predicted impacts using statistically sound methods, nor do they address ways to assess impacts at downstream sites outside the delineated watershed.

There appears to be disparity between the processes in evaluating effects of many types of land-use activities. Idaho's and Washington's processes were designed to apply only to forest practices; the federal process was designed to apply to many types of land uses and associated activities and impacts. However, Idaho's CWE process is now being used in conjunction with TMDL development, which might address each land use in a watershed that is a pollution source (Dechert, review comments).

6.3.2. Adaptive Management Comparison. Three of the four elements of the adaptive management paradigm are included in each process. The missing element, which is one of the keys to adaptive management, is that management actions and monitoring are viewed as experiments (Table 6-2). Washington's assessment and monitoring processes are designed somewhat like experiments, but development of the monitoring component is optional and implemented at the discretion of landowners. Monitoring tends to be a weakness of many watershed analysis programs (Montgomery et al. 1995). To remain credible, however, comprehensive monitoring is required (Reid 1993).

The goals of the federal process are less clear and specific than those of the two state processes, but the federal process is designed to accomplish a broad range of tasks. Part of the federal process is to determine the issues that will make the goals of any particular watershed analysis more clear and specific.

All three processes link science and management; however, the strength of the linkage can vary. Some Idaho forestry BMPs do not have well-documented supporting scientific evidence (see Seyedbagheri 1996). In Washington, teams must document their technical rationale for selecting prescriptions, but prescriptions without an adequate scientific basis still exist (Collins and Pess 1997*b*).

6.3.3. Restoration Assessment Comparison. None of the three processes has clearly defined restoration goals, which are a component of such an assessment (Table 6-2). Restoration goals may be one of many types of management recommendations made in the federal process, but they are not required. Although restoration goals are not emphasized, each process does look at past activities to assess the causes and persistence of degraded conditions. The factors that will limit restoration, if it is set as a goal for a watershed, are identified in each process.

6.3.4. Ecosystem Management Comparison. Most of the ten elements of the ecosystem management paradigm (Table 6-2) are present in each of the three alternatives. However, those elements that focus on biological diversity tend not to be emphasized in the Idaho and Washington programs. Concerns about life forms are expressed through beneficial uses (e.g., cold water biota, warm water biota, salmonid spawning, and wildlife habitat) in the Idaho process. The Washington process similarly addresses effects on wildlife, fish habitat, and other public resources, but biodiversity is not specifically mentioned. Idaho's process does not contain an assessment of wildlife habitat, and Washington has yet to implement a wildlife habitat module.

Interagency cooperation appears to take place in all three alternatives. As previously mentioned, the Idaho Department of Lands is now cooperating with the Idaho Department of Environmental Quality to

Table 6-1. Selected characteristics of watershed analysis alternatives.

	Idaho	**Washington**	**Federal**
Objective	Develop management prescriptions for forest practices to protect water quality so that beneficial uses are supported.	Develop forest practices plan to protect public resources including water quality, wildlife, and fish habitat.	Characterize the human, aquatic, riparian and terrestrial features, conditions, processes, and interactions.
Assessment team	Evaluator(s) authorized by IDL.	Analysts and resource specialists with qualifications outlined in Washington Administrative Code § 222-22-030.	Interagency and interdisciplinary team of professionally qualified resource specialists.
Required inventories/ assessments	Erosion and mass failure hazard Canopy closure/stream temperature Hydrologic Sediment delivery Channel stability Beneficial use/fine sediment Nutrient Adverse condition	Mass wasting Surface erosion Hydrology Riparian function Fish habitat Water quality Public capital improvements	Erosion processes Hydrology Vegetation Stream channel Water quality Species and habitats Human uses
Management prescriptions	Watershed Committee, individual landowners, and IDL may develop proposed management prescriptions.	Field managers develop prescription with assistance and review of resource specialists.	No prescriptions. Not a decision-making process. General recommendations made.
Public involvement	All forest landowners within watershed are given opportunity to participate on Watershed Committee. Watershed Committee may allow ex-officio participation of others, including specialists or interest groups.	Landowners and tribes may participate on teams through qualified individuals. Observers may work under supervision of specialists. Public review of assessment and management prescriptions before acceptance of plan.	Tribes, state and local governments, and public stakeholders are encouraged to participate frequently throughout process.

(continued)

Table 6-1. (continued).

	Idaho	Washington	Federal
Approval	Idaho Department of Lands (IDL) reviews assessment and prescriptions for consistency, completeness, and compliance with Forest Practices Act.	Full report forwarded to Department of Natural Resources for review and approval as specified in Washington statute.	Responsible USFS or BLM line officers certify analysis has been conducted and completed according to expected scientific standards.
Monitoring	Through forest practices inspections and audits, and reassessments. IDL or Watershed Committee may specify additional monitoring in a watershed.	Optional monitoring module available. Recommendations passed on to watershed stakeholders.	Monitoring activities identified and recommended, but implementation is not part of process.
Reassessment period	Generally 5 to 10 years depending on planned activities in watershed	5 years	None specified.
Priority for conducting analysis	IDL, Watershed Advisory Groups, or an individual or group representing at least 25% of the forested land in a watershed may initiate the process. IDL prioritizes based on soil, hydrologic and vegetative conditions, the state of water quality and/or beneficial uses, critical habitat for sensitive species, and planned forest practice activity levels.	Department of Natural Resources regions determine priority subject to Washington Administrative Code § 222-22-040.	Under PACFISH/INFISH, Key/Priority Watersheds receive priority for analysis. PACFISH/INFISH standards for Riparian Habitat Conservation Areas and Riparian Management Objectives can be adjusted only after analysis is completed.
Time frame for completion	None specified	2 to 5 months	None specified
Size of watersheds	Up to 20,000 acres	10,000 to 50,000 acres	12,800 to 128,000 acres (20 to 200 sq.mi.)

Sources: RIEC (1995), WFPB (1997), IDL (2000).

Table 6-2. Key elements of four management paradigms.

(I) Cumulative Effects Assessment
(1) Appreciation that cumulative effects are generated by complexly interacting mechanisms.
(2) Evaluate effects from many types of land use.
(3) Address range of impacts likely at all sites downstream.
(4) Flexible methods for allowing site-specific prescriptions.
(5) Evaluate effects of past impacts.
(6) Use best available technology.
(7) Technology for tracking spatial distribution of activities, impacts, and land-use histories.
(8) Verification by statistically sound comparisons between predicted and monitored impacts.
(II) Adaptive Management
(1) Links science with management.
(2) Clear and specific goals.
(3) Implements management as an experiment, including monitoring designed as scientific experiments.
(4) Institutional learning.
(III) Restoration Assessment
(1) Clearly defined restoration goals.
(2) Assess causes and persistence of degraded conditions.
(3) Assess factors limiting restoration.
(IV) Ecosystem Management
(1) A hierarchical context that focuses on multiple levels of biodiversity.
(2) Management units having ecological boundaries.
(3) Management for ecological integrity, as variously measured by native diversity and ecological patterns and processes that maintain that diversity.
(4) Data collection, and the improved use of existing data.
(5) Monitoring of management activities.
(6) Adaptive management which focuses on continuos experimentation and learning.
(7) Interagency cooperation.
(8) Organizational change in land management agencies.
(9) A view of humans embedded in nature.
(10) A key priority placed on human values.

Source: Collins and Pess (1997*a*).

incorporate CWE information into the TMDL development process (Dechert, review comments). Washington's process encourages interagency appointments to the assessment team, and the federal process was created by an interagency team, requires an interagency analysis team, and encourages interagency cooperation throughout the process. While organizational change is not specified as a goal any of the watershed analysis alternatives, the encouragement of interagency and interdisciplinary cooperation and institutional learning may encourage organizational change.

All alternatives realize that human actions affect watersheds, but the ecosystem management view of "human embeddedness" (Table 6-2) is difficult to evaluate. Neither the Idaho or Washington processes have a separate assessment module for human activities. Instead, they are driven by human-defined beneficial uses of water bodies, as required by the federal Clean Water Act. The federal process explicitly recognizes human uses as a core topic and attempts to identify "natural" and "human" causes of all other core topics. This does not seem to support the view that humans are embedded in nature.

Implementation of ecosystem management requires recognizing and considering not only physical and biological processes but also the social context within which decisions will be made and managed (Montgomery et al. 1995). All three processes place priority on human values; the differences lie in defining what those values are. Idaho and Washington are focused on a predefined set of values (i.e., beneficial uses of water); the federal process attempts to identify watershed-specific values through the issues and key questions step in the process.

6.3.5. Time and Cost Considerations. Another way to compare the alternative approaches to watershed analysis is using practical considerations such as time and costs of completion. The Washington process is the only alternative to identify a time line for completion—two to five months. Although no time frame is specified, completion of the Idaho process would seem to take a similar amount of time. The federal process would seem to take the longest of the alternatives. A brief examination of some completed federal watershed analyses in Oregon (see BLM 2000) indicates a completion time of 18 to 48 months. The federal process is the most data intensive alternative, requires the most public involvement, and requires peer review. INFISH (USFS 1995*a*) suggests that peer review of watershed analysis requires an additional 20% time commitment.

The federal process is the only alternative for which an estimate of cost was found. INFISH (USFS 1995*a*) estimates the cost of watershed analysis at $38,000 to $100,000 per watershed, but cautions that this estimate is highly speculative.

6.4. The Watershed as a Unit and Scale of Analysis

Is the watershed an appropriate scale and unit of analysis? Researchers are not of one opinion. It depends on what is being analyzed. Watersheds are a useful unit of analysis because there is little disagreement about the definition of watersheds. A typical definition for a watershed is a topographic area within which apparent surface water runoff drains to a specific point on a stream or to a water body such as a lake. Much of the apparent usefulness of watersheds as study units comes from the general understanding that the quantity and quality of water at a point on a stream reflects the aggregate of the characteristics of the topographic area up gradient from that point (Omernik and Bailey 1997).

Many analysts (e.g., FEMAT 1993, Montgomery et al. 1995, RIEC 1995) argue that watersheds define ecologically and geomorphically relevant management units for spatially-explicit, process-oriented scientific assessment that provides information relevant to guiding management decisions. At finer scales, it becomes difficult to represent relevant processes and connect upstream causes to downstream effects; at broader scales, data interpretation and assimilation become impractical (Montgomery et al. 1995). The watershed scale makes sense because the watershed is a well-defined land area having a set of unique features, a system of recurring processes, and a collection of dependent plants and animals (RIEC 1995). FEMAT (1993) argued that watersheds also provide a rational and effective spatial scale for citizens to participate in natural resource decision making.

However, the watershed may not be the appropriate scale for every ecosystem component, and it must be placed in the hierarchical context of other scales (RIEC 1995). Regardless of the physical area selected, one analysis draws context from larger-scale analyses and provides the context for analyses at smaller scales (Montgomery et al. 1995, RIEC 1995). This relationship between scales is important. The results of watershed analyses vary depending on the scale at which it is performed, and the tools used at one scale may not be appropriate at another scale (Moore, review comments).

Some researchers (e.g., Omernik and Bailey 1997, Griffith et al. 1999) argue that watersheds are not necessarily the best units for organizing ecosystem management or water quality management. First, they note that the areas within which there is similarity in the aggregate of geographic characteristics related to the quality and quantity of environmental resources seldom if ever correspond to patterns of topographic watersheds. Second, the processes that control movement of water across drier landscapes, as in much of the western U.S., are different than those in wetter landscapes. Third, in many areas watersheds are difficult or impossible to define. Continental glaciation, deep sand, karst topography, flat plains, and dry climates all create difficulties in delineating watersheds, and more than one of these conditions occurs in many areas making the problem more complex (Omernik and Bailey 1997).

Omernik and Bailey (1997) found the watershed scale appropriate for resource management agencies to assess the relative contribution of human activities to the quality and quantity of water at specific points on streams and on particular water bodies; however, use of the framework in a social-science context is not self evident. The physical and economic conditions relative to watershed functions have little correlation with patterns of consumption or with distributions of most geographic phenomena that affect or reflect spatial differences in ecosystem health, integrity, and quality (Omernik and Bailey 1997).

These researchers also argue that watershed approaches are inappropriate to use as an extrapolation tool for assessing resource and management needs (Omernik and Bailey 1997, Griffith et al. 1999). States, regional, and national level management strategies, particularly those involving ecosystem management, require a spatial framework that considers the regional tolerances and capacities of the landscape. They argue for the use of ecological regions, or ecoregions. (See ***5.1.1. Diversity of Ecosystems*** for a description of ecoregions.) Whereas watersheds serve as the study units, ecological regions, rather than watersheds, provide the extrapolation mechanism. Ecoregions were designed to fill that need and identify areas with similarity in the combination of geographic phenomena that cause and reflect regional differences in the quality of ecosystems and ecosystem components (Omernik and Bailey 1997, Griffith et al. 1999).

6.5. A Private Sector Approach to Watershed Analysis

Private companies, in addition to the federal and state governments, are developing methods for watershed analysis. Here we briefly discuss an approach being developed by Plum Creek Timber Company. We are also aware that other forest industry companies operating in Idaho are working independently to develop analysis methods for watersheds in which they operate.

Plum Creek developed a new methodology that integrates watershed analysis and ecoclassification (Watson et al. 1998). The effort was in support of a native fish habitat conservation plan for Plum Creek's lands (Plum Creek Timber Company 2000). The company is in the business of producing timber, but must abide by laws such as the federal Endangered Species Act and state forest practices acts that protect water quality and fish habitat. One of the primary mechanisms for controlling timber harvesting's effects on water quality and fish habitat is the use of buffer zones adjacent to water bodies. The width of these buffers and the management activities allowed in them were the impetuses for the company developing the new watershed analysis methodology (Watson et al. 1998).

State and federal strategies tend to rely on fixed buffer widths that may not account for the full range of dynamic factors that vary for different stream segments. Relatively wide buffer widths are likely to account for more variability, but buffers that are larger than necessary can deprive landowners and resource dependent communities of economic benefits that could be realized through active management of the surplus buffer area unnecessary for maintaining the integrity of the aquatic ecosystem (Watson et al. 1998). Overly large and restrictive buffers also may preclude management for insect and disease control and reduction of the risk of fire. By the same token, fixed-width buffers that are too narrow may not account for enough variability in ecosystem processes and not protect water quality and fish habitat from the effects of timber management. Although regulatory targets are relatively easy to administer for regulatory compliance, they vastly over-simplify the structure and variability of streams, and are likely to prove inadequate from a scientific perspective (Watson et al. 1998).

As described in earlier sections of this chapter, watershed analysis is the process by which buffer widths and other regulatory standards can be fine-tuned to fit local conditions (USFS & BLM 1994*b*, USFS 1995*a*, WFPB 1997). Currently under both state and federal processes, watershed analysis must be completed on each watershed before site-specific buffer widths and management prescriptions can be implemented. The process that Plum Creek developed attempts to identify and classify watersheds by ecosystem characteristics so that results from one watershed analysis can be extrapolated to similar watersheds. The process attempts to maintain the scientific rigor of individual watershed analysis while lowering the costs by allowing extrapolation to other watersheds (Watson et al. 1998).

When performed repeatedly across similar landscapes, watershed analyses begin to produce some common themes that likely can be applied beyond the specific analysis areas with a high level of confidence. A cost effective strategy will apply resources to additional implementation on-the-ground, rather than additional analyses, once investigations have produced sufficient confidence. The Plum Creek approach attempts to minimize risks through analytical procedures of watershed analysis, while at the same time, minimizing the financial commitment necessary to confidently protect fish habitat over a large area exhibiting a diversity of channel types, landforms, and vegetative communities (Watson et al. 1998).

We should reiterate that Plum Creek's approach is new and has been tested only in the Swan River Basin of western Montana. Our summary here is based on the report from that test (see Watson et al. 1998).

The procedures are based on the premise that geomorphic processes are the primary determinants of stream channel structure and function. Geomorphic processes and elements are predicted by patterns of larger-scale physiographic variables, such as parent geology, erosional processes, drainage area, and climate patterns. These same elements are the basis for ecological classification systems (ecoregions). The distribution of aquatic organisms is associated with those patterns of geomorphic elements (Watson et al. 1998).

Researchers (Watson et al. 1998) tested the hypothesis that a geographic information system (GIS)-based hierarchical ecoclassification can be used to delineate groups of channel segments that exhibit similar characteristics in terms of fish habitat, fish distribution, and sensitivity to land management activities. They also tested the hypothesis that these groups can be used as a template for extrapolation of results of watershed analysis (from a subsample of the analysis area) so as to provide for the effective protection of aquatic resources over a large area (Watson et al. 1998). They conducted two separate but complementary analytical procedures to segregate, and then combine, stream channel segments into functionally similar groups exhibiting similar fish habitat attributes, fish population assemblages, and sensitivities to fluxes of upland inputs (from both natural and human-caused disturbances) (Watson et al. 1998).

Where the two independent approaches produce complementary results, the two approaches were integrated into a tool for the protection and management of aquatic resources (Watson et al. 1998). It is beyond the scope of our report to describe the integration process in detail; however, Watson et al. (1998) summarized the results of their experiment as follows:

> By coupling knowledge gained through intensive watershed analysis with ecological classification of larger areas, we believe we have a powerful approach to make preliminary determinations of locations where moderate to high hazards exist with regard to upland processes. With regard to mass wasting, hazards are typically associated with specific landforms. In many cases, these landforms are directly mapped in the ecological classification. In other cases ... ecological classification provides information that expedites hazard mapping. ...
>
> With regard to road and hillslope erosion, completion of watershed analysis not only determined that low hazards existed, but identified the actual circumstances that resulted in the low hazard. This knowledge can be used to screen other watersheds, grouping them into those that likely don't have road erosion and those that likely do. Any such determinations would have to be validated by additional assessments. This same approach could be used to address issues relating to watershed hydrology. Although peak flow changes due to timber harvesting were not found to be significant...the watershed analysis also revealed the reasons <u>why</u> it was not an issue. Other watersheds can be screened for these characteristics to provide an initial hypothesis of their status that can be validated through further assessments (Watson et al. 1998:37-38).

To summarize, Plum Creek Timber Company is attempting to pursue a dual set of management objectives: to maximize both commodity production and aquatic resource protection. Intensive watershed analysis across an entire landscape is likely to provide optimal resource protection through the acquisition of site-specific knowledge, thus minimizing risk of impacts. Watershed analysis, however, can be an expensive and time-consuming process. Hence, the cost of acquisition of comprehensive knowledge is likely to be cost prohibitive. Conversely, relatively little knowledge is required to apply state-mandated protection programs. Since by-the-book regulatory scenarios do not account for all of the inherent variation across a landscape, risk of impact to aquatic resources may be relatively high in some areas, while in others the regulatory standards impose management restrictions in excess of what is needed to protect habitat. The approach that Plum Creek is developing, ecoclassification and extrapolation, is intended to optimize the balance between objectives (Watson et al. 1998).

6.6. Conclusions

Watershed analysis is a relatively new tool that expands the range of factors that managers examine before undertaking land management activities. The hope is that negative consequences of those activities and the risks of unintended consequences can be reduced to acceptable levels. Watershed analysis may help ensure that timber harvesting contributes positively towards sustainable management of a forest.

Methods for conducting watershed analysis are still being developed by various government entities and private companies. It is not possible to declare one method better than others because each is designed with somewhat different objectives in mind. However, while the specific objectives are somewhat different, most of them are complementary, and the overall goal—to reduce the negative effects of land management activities in a watershed—is similar for all watershed analysis processes.

As watershed analysis develops, any effort to design new methods will require decisions about the intended uses of results, the range of topics to be considered, the spatial scale of analysis, and the level of oversight and review to be sought (Reid 1998). Desired characteristics of every watershed analysis method are presented in Table 6-3.

Table 6-3. Desired characteristics of a generally applicable watershed analysis method.

1.	Fits the particular needs of the agency or organization instituting it.
2.	Evaluates any potentially important impacts.
3.	Evaluates impacts at any point downstream.
4.	Evaluates impacts accumulating through both time and space.
5.	Evaluates the influence of any expected kind of land-use activity.
6.	Evaluates any lands within the analysis area.
7.	Uses the best available analysis methods for each aspect of the analysis.
8.	Incorporates new information as understanding grows.
9.	Can be done for a reasonable cost over a reasonable length of time.
10.	Produces a readable and useable product.
11.	Is credible and widely accepted.

Source: Reid (1998).

Chapter 7. Conclusions

Sustainability has become a watchword for many human endeavors. Sustainability as it relates to forests is expressed through the concept of sustainable forest management, which is forest management that is ecologically sound, economically viable, and socially desirable (Aplet et al. 1993). People want to be sure that they continue to receive the benefits that they value from forests and that those benefits will be available to future generations.

One of the benefits that people receive from forests is timber, i.e., trees used to make products such as lumber, plywood, and paper. People have harvested timber and used timber products for thousands of years. People's attentiveness to other forest values has increased recently, and some people are questioning our ability to continue to produce timber while simultaneously producing and protecting other forest values.

Timber harvesting is one management activity within the broad realm of forest management and is not necessarily a part of management for every forest. Timber harvesting's place in the management scheme of any particular forest depends on the management goals of the owner of that forest. Not all forest owners have timber harvesting as a goal.

To assess role of timber harvesting in the sustainable management of Idaho's forests, we looked at the three perspectives from our definition of sustainable forest management—ecological soundness, economic viability, and social desirability.

Is timber harvesting in Idaho's forests ecologically sound? In some forests it may be; in others it may not be. There is no widely accepted, technical definition of soundness, and whatever definition is used reflects people's values.

To some people, the traditional forester's measure of sustainable management—sustained yield—serves as a proxy for ecological soundness. If we are harvesting no more timber each year than is being added by growth, then it seems we are managing within the realm of ecological soundness. In 1990, about 38% of net annual growth in Idaho's forests was removed, well within this sustained yield definition. Timber harvests statewide across all ownerships have not increased since then.

Sustained yield, however, is limited in its usefulness as a proxy for ecological soundness. Among sustained yield's deficiencies are that it only looks at trees and does not examine other forest components and the processes that contribute to tree growth. Sustained yield may be partial measure of ecological soundness, but it is incomplete.

Current concepts of ecological soundness are based on the idea of resiliency—the ability to recover from disturbance. Each component of an ecological system contributes to the system as a whole. Management activities, such as timber harvesting, can affect many of these components. Sound management keeps vital components intact or within ranges where their contributions to the system can be maintained. Ecological processes are complex, and while our knowledge is incomplete now, we are learning more about individual ecosystem components and entire ecosystems every day. Given our incomplete understanding, caution in all forest management activities, including timber harvesting, seems prudent.

Ecological soundness also involves some measure of baseline or "natural" conditions. Any measure of such involves human judgment. Should the baseline be conditions or processes that existed one hundred, one thousand, or ten thousand years ago? The answer is a value judgment. Even if a range of historic variability is used as a baseline, that range is bounded by a time period set by people.

The tree species composition in the forests of Idaho has changed over the last half century. White pine and ponderosa pine make up less of the forest than they did fifty years ago; Douglas-fir and true firs are more prevalent. Diseases, such as white pine blister rust, timber harvesting practices that favored pines and large trees, and exclusion of fire have all contributed to the changes in composition. The changes in species composition have also led to changes in the prevalence of insects, diseases, and fire in existing forests. If the goal of managing a particular forest is to return it to a species composition that existed historically, then timber management practices, such as harvesting and thinning, may contribute to ecological soundness. In other forests, where continued change without active management is an objective, timber harvesting may not contribute to ecological soundness. Changes in forest conditions, whether they are managed by humans or not, are inevitable.

In this report, we attempted to look at ecological soundness in several ways. Timber inventory information (**Chapter 3**) provides some information about tree growing stock, growth, and removal. A look at other resources (**Chapter 5**) provides a glimpse of how a few other components of the forest ecosystem are affected by timber harvesting. Watershed analysis (**Chapter 6**) is a tool that attempts to ensure ecological soundness by integrating knowledge about many ecosystem components so that negative effects of land management activities, including timber harvesting, can be minimized and mitigated. The evidence indicates that timber harvesting in some Idaho forests can be ecologically sound, but prudence is warranted.

Is timber harvesting in Idaho economically viable? Measuring economic viability involves measuring and comparing benefits and costs. Viability usually means that benefits at least equal costs. Some benefits and costs are measured monetarily through markets, but others are not easily measured. Which benefits and which costs are included in an analysis determines its outcome. There is not always agreement as to what the benefits and costs of timber harvesting are, nor in the ways they should be handled in analyses. For example, some people suggest that some traditional economic techniques such as discounting should be adjusted because of the long time horizons for forests and the concern of sustainability about future generations.

Among the monetary benefits that timber harvesting from Idaho's forests provide is income to landowners, woods workers, and forest product manufacturers. One can assume that if income from harvesting and selling timber did not exceed the costs of doing so, then most private owners, operators, and manufacturers would not be in business in Idaho. It would appear that most timber harvesting on private lands is economically viable; otherwise, it would not be done. Some people may argue, however, that private owners do not bear the full costs of their actions, particularly the environmental costs that may occur away from the harvested site.

On publicly owned forests, including Idaho's national forests, determining economic viability is difficult. Because management objectives are broader, there is more disagreement about which costs and benefits should be attributed to timber harvesting. Some people argue that the costs of timber harvesting on national forests outweigh the benefits; others argue that the opposite is true. Again, the answer depends on which costs and benefits are included and how they are treated in an analysis.

We did not provide an in-depth analysis of the economic viability of timber harvesting in Idaho in this report. Such a task would be extremely difficult, and much necessary information is unavailable. However, in **Chapter 2** we provided discussion of the economic value of timber harvesting in Idaho. Timber harvesting provides income and jobs, but economic viability will vary depending on changes in benefits and costs, particularly as markets change. Economic viability for some forests and for some people may depend on not harvesting trees in particular areas.

Is timber harvesting in Idaho socially desirable? There are no widely used measures of social desirability, but one definition is that activities must conform with social norms or not stretch them beyond society's tolerance for change. Public opinion and lawfulness may provide some indication of social norms. In **Chapter 2** we examined public opinions toward timber harvesting in the context of forest values. Most Idahoans find timber harvesting an appropriate activity in many of Idaho's forests. Timber harvesting has been a part of the culture of Idaho and has provided economic and personal benefits to some people. However, like ecosystems, societies change, and it is unclear what social roles timber harvesting will play in the future.

Chapter 4 examined laws and other policies that affect timber harvesting. Timber harvesting is lawful and embodied in the management goals for many of Idaho's forests. Environmental laws attempt to reduce and mitigate negative consequences of timber harvesting.

One reason that timber harvesting is a contentious issue in Idaho is that not all segments of society agree about the desirability of timber harvesting in Idaho's forests. Because three-fourths of Idaho's forests are national forests, national opinions, norms, politics, and policies determine many of the management actions in national forests. Much of the current debate about national forest management reflects differences in opinion about the influence of different interests—local or national—in management decisions. It is a political question whose values and whose tolerance for change are considered in determining the social desirability of timber harvesting.

Is timber harvesting in Idaho's forests sustainable? Remember, sustainable forest management must consider three dimensions—ecological soundness, economic viability, and social desirability. The reply is "yes" for some of Idaho's forests, "no" for others, and "we don't know"for others. The reply depends on many factors including:

- the ecological conditions existing in the forest;
- the way in which timber harvesting is done; the plans for and actions on the site after harvesting;

- market conditions for timber at the time of harvesting;
- the values of the site other than timber;
- the management goals of the forest owner;
- the laws and policies that apply to the owner, the land, and the actions taken.

These factors will change over time. Sustainable management is not immutable and absolute. Although we can never answer definitively for all forests or for all time, we can say that timber harvesting is "more" or "less" sustainable in a particular forest than it would be somewhere else at a particular time. Progress toward sustainable forest management is measurable in this relative sense.

7.1. Future Directions

Sustainable forest management is an evolving concept that reflects the changing nature of and perceptions about our world. It is about the values and aspirations people have for their natural resource endowments and the way these resources are managed. Indicators of sustainable forest management are in their developing stages. Until such indicators and procedures for using them to evaluate management methods have been agreed upon, applied, and evaluated, we cannot say much about the sustainability of resource management approaches. Sustainability is also about our place as citizens of Idaho in a bigger world, and it is about our consumption patterns. It is about our values.

7.1.1. Evolving Indicators of Sustainable Forest Management. Since this project was first suggested to the Policy Analysis Group in 1993, the concept of sustainable forest management and ways to measure it have evolved. One model for measurement, commonly called "criteria and indicators" or "C&I," has become a popular way to assess sustainable forest management. Sets of C&I have been developed at several scales—from international to local— by governments as well as private entities. These efforts are examined in detail in Part I of this analysis, published separately (see PAG Report #18, Cook and O'Laughlin 1999).

No set of C&I has been developed specifically for the state level, the geographic scale we were asked to examine. However, some states, including Oregon, have attempted to use the C&I developed for the national scale in the Montreal Process. The Montreal Process C&I are widely accepted and consist of seven criteria and 67 indicators. The Oregon Department of Forestry (2000) has produced a report providing a "first approximation" of the availability of data for each of the indicators and outlining data needs for the future. Their report provides a baseline for monitoring progress towards sustainable forest management at the state level. If Idaho were to follow suit and conduct its own analyses on different ownerships using the Montreal Process C&I, it would be the first state to do so.

7.1.2. A World Perspective on Idaho's Timber Resources. As stated earlier, the scale at which we look at timber harvesting is crucial to assessing it's sustainability. In this report we have looked at the state or smaller levels; however, Idaho is part of the larger world as a whole. Idaho does not exist independently ecologically, economically, or socially. The amount of timber harvesting in Idaho is determined, in part, by outside forces, including world markets for its resources. How does Idaho's timber resource fit into the region's, nation's, and world's supply? We take a brief look at some statistics here.

The forests and people of the world produce billions of cubic feet of wood products each year (Table 7-1), and the United States and Idaho are significant contributors to that supply. The amount of forest land worldwide is somewhere around 10 billion acres, or about 30% of the land area (Brooks 1993). In the United States, there are about 737 million acres of forest land, or about 33% of the land area (Powell et al. 1993). In Idaho, there are about 21 million acres of timberland, or about 40% of the land area. Idaho has about 0.2% of the world's forests and almost 3% of U.S. forests.

Idaho has over 3 million acres of high productivity timberlands (i.e., lands that could produce >120 cu.ft./ac./yr.), or about 18% of its timberlands (see **Chapter 3**). In the United States, only the coastal Pacific Northwest (Oregon and Washington) and the south-central states (Arkansas, Alabama, Louisiana, and Mississippi) have more high productivity timberlands (Powell et al. 1993, FIA 1997).

Idaho's 39 billion cubic feet of softwood growing stock represents about 7% of the softwood growing stock in the U.S. (Powell et al. 1993, Brown and Chojnacky 1996). Only Oregon, Washington, and California have more softwood growing stock than Idaho (Powell et al. 1993).

Idaho's 1.8 billion board feet of lumber production in 1996 was about 5% of the softwood lumber produced in the U.S. (WWPA 1997). Idaho ranked ninth among states for lumber production. Again, the leaders are the Pacific northwest, south-central, and southeastern states. Nineteen percent of the

Table 7-1. World and U.S. production of timber and timber products, 1990.

	World	United States	
Timber or product group	*million cubic feet*		*% of world's production*
Fuelwood	63,432	3,034	4.8
Industrial roundwood	58,417	14,659	25.1
Sawn wood	17,159	3,669	21.4
Wood-based panels	4,411	1,134	25.7
	million tons		
Paper and paper board	263	79	30.2

Source: Brooks (1993).

forest products produced from Idaho's forests remain in Idaho, one percent are exported to other countries, and the rest are used throughout the U.S., primarily in the surrounding (Keegan et al. 1997).

What would happen if Idaho either stopped producing timber or dramatically increased its production? The answers are beyond the scope of this report, but have implications for the sustainability of forest management worldwide. Additional analyses looking at a broader geographic scale would provide insights for managing Idaho forests to meet peoples' needs today and tomorrow without causing irreversible ecological damage.

7.1.3. Consumption and "Sustainability"

> Espousing environmental values is easy, crafting both personal lifestyles and national policies consistent with those values is not (Carroll and Daniels 1995:20).

> U.S. accomplishments in managing and producing forest products are exceeded only by its consumption of forest products (Brooks 1993).

> The long and short of the matter is that forest conservation depends in part on intelligent consumption, as well as intelligent production of lumber (Leopold 1928).

Sustainable forest management is not just about production of forest products and other benefits, but also about consumption of them. The sustainability of forest management does not start with the forest; it starts with consumers. Consumers create the demands for resources, which are then met by the producing industries. As consumers we must evaluate our options and make choices. Which resources we choose, where we get them, how we use them, and how we dispose of them are all critical issues for sustainable forest management (Temperate Forest Foundation 1998).

We do not have consumption figures specific to Idaho, but on a per capita basis, the U.S. consumes timber at more than four times the world average. The U.S. consumes nearly 30% of the world's production of industrial timber and is both a net importer and the world's leading importer of forest products (Figure 7-1). At the same time, however, the U.S. is also one of the leading exporters of forest products (Brooks 1993).

Recent reductions in timber harvest levels from national forests in Idaho and other regions of the U.S. have caused many people to ask, if we do not produce timber to meet our needs, are we exporting environmental problems to other countries? Schallau and Goetzl (1992) argued that incremental decisions about restricting harvests from particular regions of the U.S. eventually will have global consequences. Bowyer (1992) argued that examination of the issues related to this question suggests that restrictive protection of local resources without considering global consequences can translate to irresponsible and unethical regional environmentalism. Brooks (1993) said to argue that international environmental impacts should influence domestic timber supply policies, one must conclude [1] that international

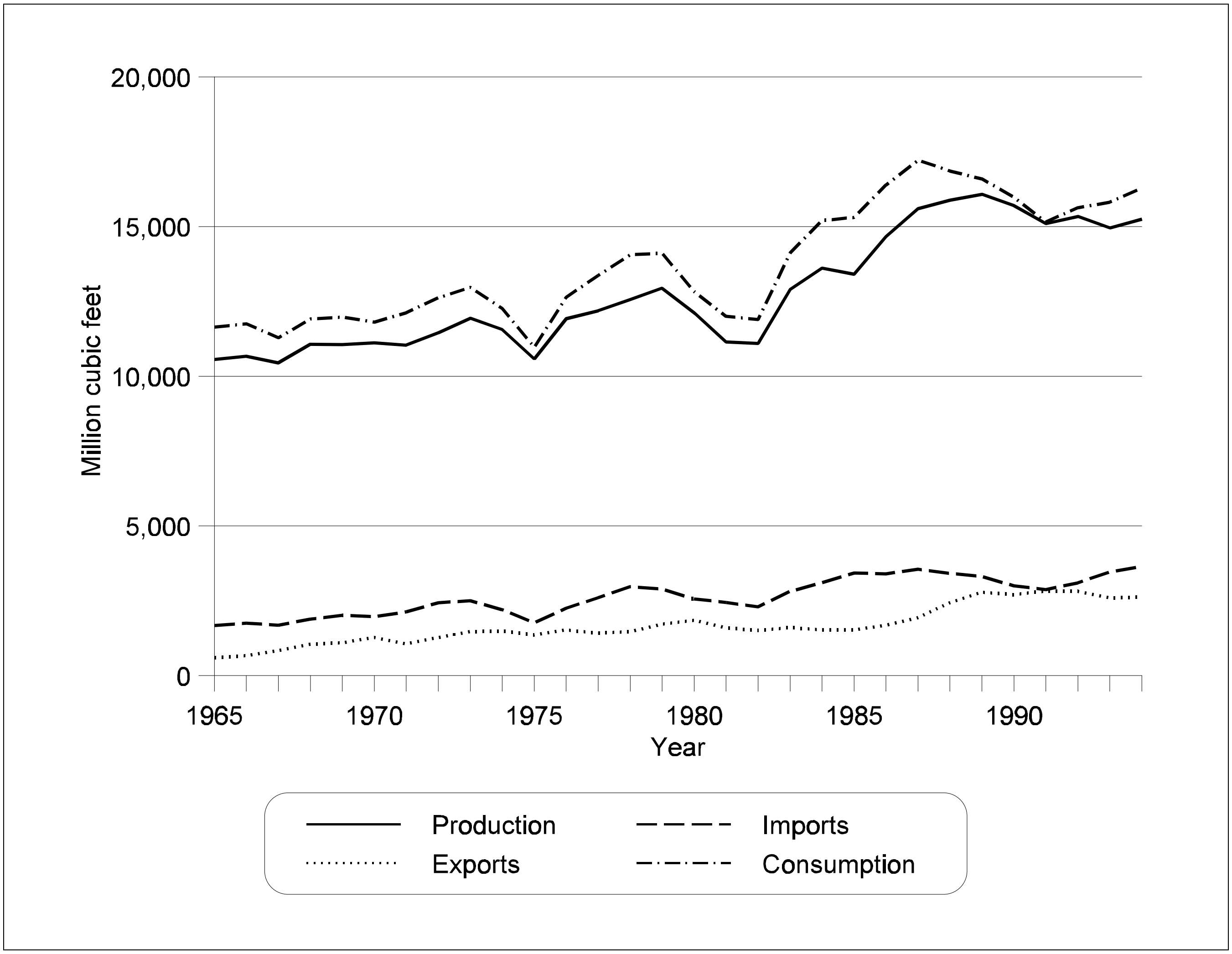

Figure 7-1. Production, imports, exports, and consumption of timber products in the U.S., 1965-1994.

Source: Howard (1997).

environmental impacts of timber harvesting are significant; [2] that these impacts are greater than domestic environmental impacts and are attributable to U.S. policies; and [3] that other countries will not make environmentally acceptable choices in the management and use of their resources. The truth of these conclusions depends upon the value set by which they are judged (Brooks 1993). Replies to the question of our responsibility to meet our own timber needs depends on viewpoints towards fairness, ethics, and morality (Bowyer 1992, Schallau and Goetzl 1992, Brooks 1993). As the human population continues to increase, analysis of consumption patterns and the responsibility of nations to produce what they consume will become more important.

7.1.4. "Sustainability" and Human Values. In this report, we have only begun to scratch the surface of sustainable forest management issues because ultimately everything is related to sustainability. This includes not just decisions about forests but every decision we make in our daily lives. Sustainability is about resource allocation and social values. Professor William Burch of Yale University's School of Forestry and Environmental Studies summarizes his experience with three central "laws" of resource management (quoted in Grumbine 1997:46):

- All resource allocation decisions are matters of political struggle rather than technical fact.

- Resource management decisions are about use; therefore they are decisions about manipulating human behavior rather than physical things.
- Resource managers, when confronted with social value decisions, will seek to convert them into technical decisions.

The question of whether or not timber harvesting in Idaho is sustainable does not have a technical answer. However, we hope that the technical information provided in this report contributes positively to discussions among all Idahoans and encourages them to make informed decisions about the management of Idaho's forests.

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GLOSSARY

Basic industry: An industry that produces goods and services that are exported from the local economy.

Board foot: Nominally a board foot is a piece of lumber 1 inch thick, 12 inches wide, and 1 foot long, or its equivalent in dried and surfaced lumber (Wenger 1984).

Capital: Assets available for use in the production of further assets.

Codominant trees: Trees with crowns forming the general level of the crown cover.

Dominant trees: Trees with crowns extending above the general level of the crown cover.

Dozer piling: Piling of woody debris using a bulldozer to push the debris into a pile or windrow.

Forest land: Land at least 10% stocked by forest trees of any size, including land that formerly had such tree cover and that will be regenerated naturally or artificially (Brown and Chojnacky 1996).

Forest type: A classification of forest land based on and named for the tree species presently forming a plurality of living tree stocking (Brown and Chojnacky 1996).

Grapple piling: Piling of woody debris using a backhoe equipped with a grapple, or equipped with a bucket that is capable of opening and holding pieces of debris (Reynolds et al. 1992).

Growing stock trees: Live timber species trees meeting specified standards of quality and vigor; excludes cull trees (Brown and Chojnacky 1996).

Growing stock volume: Net cubic-foot volume in live poletimber size and sawtimber size growing stock trees from a 1-foot stump to a minimum 4-inch top (Brown and Chojnacky 1996).

Habitat type: An aggregation of all land areas potentially capable of producing similar plant communities at climax (Steele et al. 1981).

Hand piling: Piling of woody debris using human muscle power.

Home range: The area that an animal habitually uses during, nesting, resting, bathing, foraging, and roosting. A nesting home range contains nest areas (active and historical), the post-fledging family area, and the foraging area (Reynolds et al. 1992).

Hiding cover: Vegetation capable of hiding 90 percent of a standing adult elk from the view of a human at a distance equal to or less than 200 feet (Servheen 1997).

Logging: The felling, skidding, on-site processing, and loading of trees or logs onto trucks (Helms 1998).

Lopping and scattering: A method to disperse logging debris, and to reduce it to a specific height (usually 2-3 feet) above the ground (Reynolds et al. 1992).

Net annual growth: Gross annual growth minus average annual mortality (Brown and Chojnacky 1996).

Net volume (in cubic feet): Gross cubic-foot volume in the merchantable portion of trees, less deductions for cull volume (Brown and Chojnacky 1996).

Nonforest land: Land that does not currently qualify as forest land (Brown and Chojnacky 1996).

Nonreserved land: Land that is not classified as **reserved**.

Nonstocked areas: Forest land less than 10% stocked with live trees (Brown and Chojnacky 1996).

Poletimber stands: Stands at least 10% stocked with growing-stock trees, in which half or more of the stocking is sawtimber or poletimber trees or both, with poletimber stocking exceeding that of sawtimber (Brown and Chojnacky 1996).

Prescribed burning: Controlled application of fire to wildland fuels in either their natural or modified state, under such conditions of weather, fuel moisture, soil moisture, etc. as allow the fire to be confined to a predetermined area and at the same time to produce the intensity of heat and rate of spread required to further certain planned objectives of silviculture, wildlife management, fire hazard reduction, etc. (Ford-Robertson 1971).

Recreation activity day: All or part of a calendar day spent participating in a given recreation activity.

Recreation visitor day: 12 hours of visitation by one or more persons.

Removals: The net volume of growing-stock trees removed from the inventory by harvesting, cultural operations, land clearing, and changes in land use (Brown and Chojnacky 1996).

Replacement nest area: Forest areas with physiographic characteristics and size similar to suitable goshawk nest areas. Replacement areas can have young to mature forests that can be developed into suitable nest areas (Reynolds et al. 1992).

Reserved forest land: Forest land withdrawn from tree utilization through statute or administrative designation (e.g., Wilderness areas) (Brown and Chojnacky 1996).

Saplings: Live trees 1 to 4.9 inches d.b.h. (Brown and Chojnacky 1996).

Sawtimber: A classification of timber inventory that is composed of sawtimber trees of commercial species (Powell et al. 1993).

Sawtimber trees: Live timber species meeting regional size and defect specifications. Softwood trees must beat least 9 inches d.b.h. and hardwood trees 11 inches d.b.h. (Brown and Chojnacky 1996).

Sawtimber stands: Stands at least 10% stocked with growing-stock trees, with half or more of total stocking in sawtimber or poletimber trees, and with sawtimber stocking at least equal to poletimber stocking (Brown and Chojnacky 1996).

Seedlings: Established live timber species trees less than 1 inch d.b.h. (Brown and Chojnacky 1996).

Seral stage: A temporal and intermediate stage in the process of succession (Helms 1998).

Sight distance: The distance at which 90 percent or more of an adult elk is hidden from human view (Servheen 1997).

Site-potential tree height: The average maximum height for mature trees on a site, given the local growing conditions

Stand size class: A classification of forest land based on the predominant size of trees present (see **Sawtimber stands**, **Poletimber stands**, **Saplings**, and **Seedlings**) (Brown and Chojnacky 1996).

Stocking: An expression of the extent to which growing space is effectively utilized by present or potential growing-stock trees (Brown and Chojnacky 1996).

Suitable nest area: An area that includes all of the attributes of a nest area and is, therefore usable for nesting by goshawks (Reynolds et al. 1992).

Thermal cover: For elk, vegetation used by elk to help maintain comfortable body temperature with minimal energy expenditure. A stand of coniferous trees 40 ft., or more tall with average crown cover exceeding 70 percent (Servheen 1997).

Thinning from below: The removal of the slower growing trees in the lower portion of the canopy. This intermediate treatment leaves the taller, faster-growing trees at a selected density and spacing (Reynolds et al. 1992).

Timberland: Forest land where timber species make up at least 10% stocking (Brown and Chojnacky 1996).

Woodland: Forest land where timber species make up less than 10% stocking (Brown and Chojnacky 1996).