The Ecosystem-Economy Relationship: Insights from Six Forested LTER Sites

A Report to the National Science Foundation

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I. INTRODUCTION

The debate over forest-management policy in the U.S. often is cast as a choice between jobs and [pick the environmental attribute of your choice].[1] The purpose of this paper is neither to rehash nor to characterize these conflicts, but to discuss insights into them that have emerged from an examination of the forest-economy relationship in different regions of the U.S. Specifically, we examine the forest-economy relationship associated with six of the Long Term Ecosystem Research (LTER) sites: Bonanza Creek, Alaska; H.J. Andrews, Oregon; Sevilleta, New Mexico; Coweeta, North Carolina; Northern Temperate Lakes, Wisconsin, and Hubbard Brook, New Hampshire.

Decades ago, the jobs-vs.-environment tradeoff made more sense. It was not a huge error to conclude that economic demand for forest resources came only from the extractive consumption of forest resources and development of forest lands. Usually, the allocation of forest resources to one of these uses significantly did not deprive the economy of other benefits and other jobs. Today, however, economic tradeoffs are more complex. The competition for forest resources is more diverse and any forest-management decision is likely to promote some economic benefits, jobs, and environmental attributes at the expense of others. The conventional demands of logging, urban development, irrigation, grazing, mining, and road building compete more with one another and have been joined by widespread demand for both goods, such as clean water, and services, such as recreational opportunities. Additional demands have materialized with the concerns of scientists and the public about the environmental impacts of forest use.

In short, it seems safe to say that competing demands exist, more or less, for the resources of every forested ecosystem, watershed, or other environmental unit in the U.S. Virtually any decision allocating resources to one component of the economy inevitably deprives another, so that some demands for goods or services are met while others are not, some groups see an increase in employment opportunities or otherwise experience an increase in their standard of living while others experience a decrease, and some perceive that the decision is fair while others see it as unfair. Thus, the characterization of forest-management issues as a contest between jobs and the environment is too simple. Competing allocations of forest resources represent alternative bundles of jobs, environmental quality, winners, and losers.

This report represents a component of the National Science Foundation's initial efforts to (a) integrate economics and other social sciences into the LTER program, and (b) compare and contrast the characteristics across multiple LTER sites. As such, it is largely a scoping study to summarize the relevant literature, clarify important relationships, and identify important research needs. The research proposal (DEB94-16809) underlying this report had three objectives:

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[1] See, for example, Forest Ecosystem Management Assessment Team (1993), Gorte (1992), and Lippke and Conway (1994).

Descriptive objective: to develop a technically sound though intuitively accessible framework and language for describing and eventually assessing the multiple relationships between a forested ecosystem and a regional economy that can be applied to different ecosystems and regional economies.

Explanatory objective: to improve understanding of the factors that influence the multiple relationships between forested ecosystems and regional economies.

Institutional-communicative objective: to lay the institutional foundation for (1) providing resource managers, policymakers, and the public with effective tools for describing and assessing the economic effects of changes in resource-management policy, (2) undertaking further cross-site research regarding the relationships between ecosystems and regional economies, and (3) integrating economics research

Most of this report focuses on our descriptive and explanatory findings. Relying on readily available data, we describe the forest-economy relationship as it exists in six widely dispersed sections of the U.S. One of our major findings is that there are important similarities in the fundamental, structural components of this relationship as one moves among the six regions. In Chapter II we conceptualize these components into a framework that explains four major types of competing demands for forest resources. In the remainder of the report we apply the conceptual framework to the six case-study regions. We first provide some background on each case study (Chapter III) and then (Chapter IV) describe the economic importance of a major, historically important, extractive activity at each site. In most cases, this is the industrial production of timber. In Chapter V we assess the timber industry's demand for forest resources, and in Chapter VI we describe the important competing demands for forest resources. In Chapter VII we offer some concluding remarks regarding the implications of our findings for forest management and future research.

II. A CONCEPTUAL FRAMEWORK OF THE FOREST-ECONOMY RELATIONSHIP

Understanding the economic effects of policies and practices that affect forest use—a change in ecosystem management broadly defined—requires an analytical framework for tracing the change through both the demand and supply sides of various markets and industries in both the long run and the short run.[2] We elsewhere report on our efforts to develop such a framework, the centerpiece of which is a typology of the competing demands for forest resources (Courant et al. 1997b). Here, to conserve space, we summarize the framework briefly and then discuss how it helps clarify several forest-management issues.

A. Ecosystem-Economy Interactions

A forested ecosystem and the surrounding economy continuously interact with one another in multiple, complicated ways.[3] Human activities associated with the production, distribution, and consumption of wealth derive goods and services from the ecosystem and, in doing so, they alter the ecosystem's physical and biological characteristics. These changes, in turn, affect the stock of goods and services available for enhancing human standards of living, thereby altering future human activities, and so the cycle of interactions between the ecological system and economic system continues. Hence, the evaluation of what the economy would look like with a given forest-management policy or activity is, at least in principle, a complicated, dynamic exercise.

Forested ecosystems play important roles in the economy by producing things that benefit humans, things that impose costs on humans, or both.[4] That is, forests affect our well-being, either along paths commonly associated with the economy and our standard of

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[2] This definition of ecosystem management may cause some confusion for forest ecologists, who see ecosystem management as an intentional effort to sustain a full set of ecological functions and processes while producing goods, services, and social benefits (Personal communication with Fred Swanson 1997). We deliberately take the broader perspective, recognizing that many decisions affecting forest ecosystems, driven by the economic forces and incentives we describe in this report, are not consistent with the ecologists' objectives.

[3] For a wide-ranging discussion of the ecosystem's economic importance, see Daily (1997).

[4] This formulation of the interaction between ecosystems and the economy inherently places humans at the center and views forests as important only insofar as they affect the quality of life of human society, or parts thereof. We recognize that many find this anthropocentric view, at best, incomplete, for it ignores the biocentric view that a forested ecosystem enhanced by a forest-management policy has value in and of itself. It also artificially views humans as exogenous to the ecosystem. We narrow our scope not just to keep our task from becoming intractable but also because the focus on an ecosystem's contribution to human quality of life mirrors a central consideration underlying human actions affecting the ecosystem. We take a broad view, however, of the ways in which the ecosystem affects human standards of living and quality of life, including humans' aesthetic, cultural, and spiritual values and motivations.

living—subsistence, commercial production, and property development—or along paths no less important economically, but associated with the quality of life in our communities—attractive neighborhoods, recreation, and the presence of wildlife. In addition, there are important interactions with spirituality/religion, aesthetics, community comity, and sense of obligation to future generations. In short, forests are important to the economy because they can affect—and be affected by—all types of human activity. Although our focus is on forested ecosystems, this same observation seems to apply equally to others.

Describing the economically important products derived from a forest is not always a straightforward task. One approach combines ecological with economic concepts and distinguishes among ecosystem goods, functions, and states (Quigley et al. 1996). Under this approach, *ecosystem goods* are specific components of ecosystems that might be extracted (e.g., timber or forage) or remain *in situ*, as when sections of a forest are used for recreational hiking, and a waterfall is a notable landmark. *Ecosystem functions* are economically important processes, such as the stabilization of soils on upland slopes or a riparian zone's filtration of sediment in runoff from uplands. Box 2.1 illustrates, for example, the ecosystem functions associated with forested wetlands and rivers. *Ecosystem states* are economically important systemic or integrated characteristics, such as those associated with healthy ecosystems, scenic landscapes, and watersheds with low flood risk. Although this approach appears initially to embody a seamless and comprehensive transition from ecologic to economic issues, it deceives us. It emphasizes only the good—those things from an ecosystem that contribute positively to the economy—and obscures or ignores the bad—those things such as floods, fires, and pests that contribute negatively.

Box 2.1: Identifying Economically Important Products via Ecological Functions of, e.g., Forested Wetlands and Rivers

- Help sustain the local and global web of life.
- Store and convey flood water and diminish peak flows.
- Provide habitat for fish, shellfish, waterfowl, and other wildlife.
- Reduce erosion during flooding.
- Improve water quality by removing sediment, nutrients, and chemical contaminants.
- Produce fiber, e.g., timber, and food e.g., wild rice, for human consumption.
- Supply water for municipal and industrial use.
- Provide recreational opportunities, e.g., fishing, hunting, and viewing wildlife.
- Provide aesthetic value, e.g., open space and natural scenery.

Source: Baskin (1997) and National Research Council (1992).

Two other approaches have similar problems. One categorizes all ecosystem products as goods and services, and the other treats them as amenities. (Box 2.2 illustrates, for example, the goods and services derived from forested wetlands and rivers.) Neither approach distinguishes clearly between negatives and positives. And neither distinguishes the state of the ecosystem itself from the separate flows of goods, services, and amenities from the ecosystem.

In our approach, we opt for the conventional economics shorthand and use either *goods and services* or *amenities* to describe those attributes of forested ecosystems that are economically important.[5] With these terms we mean to represent the full set of positives and negatives derived from an ecosystem and associated with the state of the ecosystem itself. Thus, *goods and services* includes *bads and disservices* and *amenities* includes *disamenities.*

A large number of social, cultural, physical, and biological factors influence the evolution of a particular ecosystem-economy relationship. Figure 2.1, however, highlights the three factors that offer especially useful insights into the economic aspects of this relationship: knowledge, institutions, and incentives. The relevant *knowledge* includes both the understanding of ecological and economic systems coming from scientific research and the experience gained from applying that understanding to the development and implementation of policy.

> **Box 2.2: Identifying Economically Important Products via Goods and Services Derived from, e.g., Forested Wetlands and Rivers**
>
> Water Supply for
> - **Household use** (drinking, cooking, washing, waste disposal)
> - **Industrial use** (production input, process medium, heating and cooling)
> - **Irrigation** (commercial agriculture, subsistence gardens, lawns and flowers, parks and golf courses)
> - **Aquaculture**
> - **Aesthetics** (fountains, swimming pools)
>
> Goods Other than Water
> - **Animal products** (fish, shellfish, fur-bearers)
> - **Plant products** (cereals, landscaping)
> - **Mineral products** (nutrients, gravel)
>
> Nonextractive Goods and Services
> - **Flood control**
> - **Soil fertilization**
> - **Aesthetics** (scenery)
> - **Waterborne transportation**
> - **Hydroelectric generation**
> - **Recreation** (boating, swimming, fishing, wildlife viewing, hunting)
> - **Pollution control** (dilution of effluent, removal of pollutants)
>
> Source: Based on Postel (1997).

The relevant *economic-development and ecosystem-management institutions* include fundamental social and economic building blocks, such as the laws governing the rights, privileges, and responsibilities of property owners and the operation of markets. There also is an institutional superstructure built upon this foundation, including the network of public and private bureaucracies and the regulations attending to the interests of specific groups.

The *economic incentives* that influence the resource-use decisions of individuals, firms, public officials, and other entities are shaped by the patterns of costs and benefits that accompany alternative resource-uses. All else equal, a person will try to avoid costs and capture benefits. Often, however, one person's actions have consequences that impose costs or benefits on others. In a market setting with well-defined property rights, no subsidies, and no market distortions from governmental regulations and policies, these other affected parties will force the economic actor to take account of these impacts. When markets are not operating in the ideal manner and/or property rights are not well defined, the initial actor will tend to ignore these external-to-the-market impacts on others. Economists call these external impacts "externalities." Externalities often manifest themselves through changes in the physical-biological environment. Note, however, that these environmental externalities are not the changes

[5] For additional discussion on alternative methods of modeling forested ecosystem-economy interactions, see Hansen et al. (1995) and Iverson and Alston (1993).

in the physical-biological environment, *per* se, but the costs and benefits associated with those changes. As we discuss throughout the remainder of this report, externalities can have an especially strong influence on the overall level and mix of goods and services derived from forested ecosystems, as well as on the distribution of costs and benefits among different groups.

Ultimately, the incentives are shaped by human tastes and preferences, and by the distribution of wealth and political power. The patterns of costs, benefits, and externalities shaping these incentives can shift over time as tastes, preferences, wealth, and power shift. Analytically, it usually is more productive to focus on costs, benefits, and externalities than on the underlying factors. In this part of the discussion we apply a broad interpretation of *costs, benefits, and externalities* to refer not just to issues of economic efficiency but also to those of economic structure and distribution (equity). Thus, a *cost* might be the opportunity cost of a resource used for one purpose and not others, as well as the negative impacts on jobs, incomes, and other elements of an area's economic structure, plus undesirable changes in the distribution of wealth and jobs among different groups. In Chapter IV we examine these issues separately.

Institutions and incentives are often interlocked. O'Toole (1988), for example, describes how bureaucratic and financial incentives within the Forest Service have pushed forest-management decisions toward greater timber production. King and Bohlen (1994) examine the performance of wetland-creation and -restoration projects to mitigate adverse impacts of development and resource-extraction projects on forested and other wetlands. They conclude that the nearly 20 year-old record of this program shows

> a persistent pattern of low cost and poor success rates. This record, however, reflects more about institutional inadequacies and the failure of restoration policies than the cost or difficulty of designing and implementing high quality restoration projects. It is the result of perverse incentives in the market for restored and created wetlands ... where mitigation suppliers earn high profits by providing low quality restoration and low profits by providing high quality restoration.

In effect, the three factors in the middle of Figure 2.1 serve as a lens that focuses the interactions between the ecosystem and economy. Just as the ecosystem and economy are not static, neither are these three factors. Indeed, changes in knowledge, institutions, and incentives often control much of the evolution in the ecosystem-economy relationship. Furthermore, each of the three factors in the lens exerts an influence on the other. New knowledge of the ecosystem, for example, can lead to institutional changes that, in turn, alter the incentives associated with alternative resource uses and economic activities.

Forest-management projects have economic consequences when they alter (1) the overall value of goods and services derived from the forest; (2) the mix of goods and services (holding the overall value constant); or (3) the distribution of goods and services—or amenities—among current human groups or between this generation and future ones. To describe the economic consequences of a forest-management policy or activity, therefore, is to describe these alterations. And to evaluate alternative means of forest management is to evaluate the economic consequences—both negative and positive—the alternative policies and activities bring about. The conceptual framework we describe addresses each aspect of this analytical challenge.

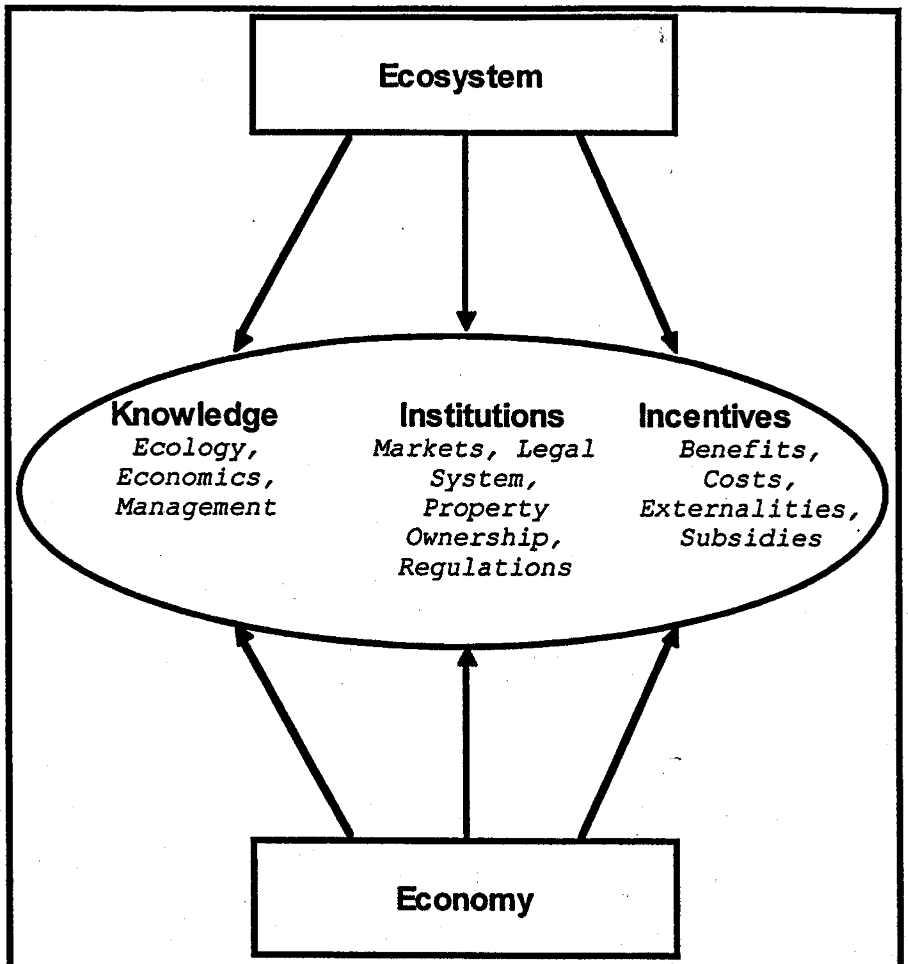

Figure 2.1: Ecosystem-Economy Interactions Are Influenced by Knowledge, Institutions, and Incentives

The dynamic character of each of the components of Figure 2.1 has important implications for assessing the economic consequences of forest management. The greater the uncertainty about the potential change in any component, the less one can rely on the past as a reliable predictor of the future. This is especially true if more than one component is changing, which is typically the case in the United States today, where rapid growth in knowledge about ecosystems indicates that many of them are far less resilient than in the past (Mooney and Ehrlich 1997), the extraction of resource commodities is playing a smaller economic role relative to services (more of this later in the report), and the nation, through the debate over the Endangered Species Act and other resource-and-environmental-management acts, is engaged in a wide-ranging examination of the institutions governing the rights, privileges, and responsibilities of property owners. See, for example, Knight and Bates (1995), and Perry and Amaranthus (1997).

Only where all the components of Figure 2.1 are highly stable or predictable—a rare event—can an analyst justifiably rely on techniques that take a static view of the economy. In most cases, the economic consequences of forest-management decisions will evolve over time, shaped by (a) external economic and ecological forces independent of the decision; (b) economic and ecological changes independent of the decision; and (c) economic and ecological response to the decision. Using Figure 2.1 as a guide, one should account for external and local sources of dynamism for each of the five components in Figure 2.1, the ecological and economic systems plus the three factors in the middle of the lens.

In the next chapter, we extend the conceptual framework of Figure 2.1 by adding an analytical framework for addressing and understanding the right-hand element of the *lens* in Figure 2.1. Specifically, we explain an approach for comprehensively describing the costs, benefits, and externalities associated with alternative uses of forest resources.

B. The Competing Demands for Forest Resources

At any point in time, a forest ecosystem contains a stock of attributes, such as soils, trees, snowpack, streams, flora and fauna, climate, minerals, and scenic views. Subsequently, depending in part on its management and in part on its natural processes,[6] its natural resource amenities, in combination with other inputs (labor, capital, equipment, etc.) will produce a flow of products. By "natural resource amenities" we mean flows of goods and services, generally positively valued, that derive from the ecosystem. We distinguish between amenities that become inputs to a production process and those that directly enhance the well-being of consumers. Our definition of "products" includes anything that is produced by the ecosystem and valued by anyone, whether marketed or not. The human valuation of a given product implies a demand for forest resources and, unless all demands can be met, it also implies competition.

One could categorize the competition in any of a number of ways, but we propose a taxonomy that distinguishes among four types of products (see Figure 2.2).[7] The left side of Figure 2.2 shows two types of demand for production amenities; the right side shows two types of demand for consumption amenities. Each type of demand exists independently, but the competition among them is best understood by assuming that one type (Type 1) prevails and then looking at the consequences for the others.

Competition for Production Amenities

On the left side of Figure 2.2 we place the competing demands for a forest's productive amenities. In general, these demands will exhibit some characteristics of commercial markets. The most easily identifiable demands for productive amenities entail the extraction or development of forest resources. We use the term, extraction, to embrace activities, resource uses, and industries associated with crop production, grazing, timber production, mining, and other activities that chemically, electrically, or physically remove one or more elements (flora, fauna, mineral, or energy) of the ecosystem from its source.

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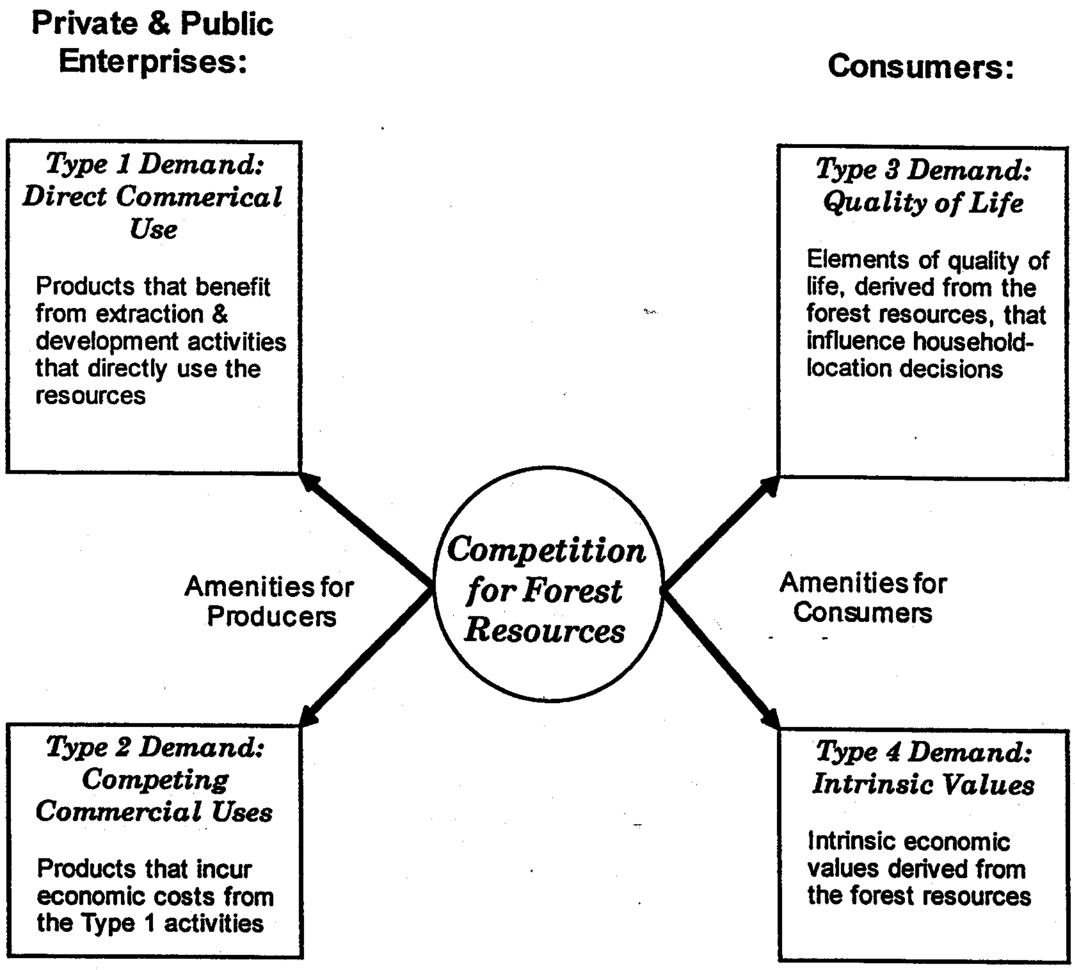
[6] The distinction between management and natural processes is somewhat artificial, insofar as a management strategy can include letting natural processes alone.

[7] For a more thorough treatment of competitive products and the interactions among them, see Courant et al. (1997b).

Figure 2.2: The Competing Demands for Forest Resources



We generally use the term, development, to refer to the occupation of a site by human structures, such as occurs during urbanization. Development also includes intense human activity—draining a wetland, changing the composition of an area's floral community, concentrating traffic by off-road vehicles, and so forth—that substantially alters the site's ecosystem processes. Farming, ranching, logging, mining, and development are the most important of the demands for production amenities, although there are many others, including commercial fishing, and, to a certain extent, tourism. Demand for the productive amenities of a forested ecosystem comes from "private and public enterprises," which we define broadly, to include chartered institutions, such as private corporations, incorporated cities, and public agencies, as well as to households that farm land, build a house, and recreate, and to other groups that sponsor extractive or development activities.

Type 1 Products - Extractive and Development Activities. We separate the demands for productive amenities into two groups. We first identify a specific extractive or development product derived from a forest and call it Type 1. Type 1 products have two important characteristics: they directly use natural resources and they deplete the stocks of resources. The identification of a particular product as Type 1 is arbitrary, but purposeful. This type of demand usually is associated with a familiar extractive industry, such as farming, ranching, logging, or mining, or with common development activities: developed recreation, urbanization, bridge construction, and the like. In general, only one Type 1 product benefits from a particular use of forest resources, but sometimes there may be more than one. The construction and operation of a dam may benefit irrigators, barge companies, and consumers of hydroelectricity, for example, or logging may benefit the timber industry and some sectors of the recreation industry (Quigley et al. 1996).

Type 2 Products - Products Upon Which Type 1 Production Imposes Costs. After identifying the products that benefit from a specific resource use, we then identify those that incur costs from that use, and call these Type 2 products. We purposefully distinguish between Type 1 and Type 2 products to drive home the message that there may be competition, within the extractive and development sectors, for forest resources. This message is important because, too often, the competition for forest resources is characterized as simply a jobs-vs.-environment contest between an industry seeking to use a resource as a productive input and those who want to protect the environment. By highlighting products that incur economic costs from extractive and development activities, we emphasize the point that the positive consequences arising from one set of extractive or development activities frequently has negative effects on one or more others.

There are three mechanisms by which production of outputs associated with extractive and development activities (Type 1 products) can impose costs on Type 2 products: direct displacement of resource-related production; displacement through the existence of negative externalities; and subsidies. The reader should recognize that, given the arbitrary selection of the Type 1 product, these mechanisms apply equally to the Type 2 products. It also is important to note that, although we discuss these mechanisms here in the context of the competition between different demands for a forest's production amenities, *the same mechanisms apply to all types of demand for these resources*. It is only to conserve space that we do not repeat the discussion as we subsequently address the remaining elements of Figure 2.2.

Direct displacement occurs when two or more enterprises compete directly for the natural resource amenities of a forest. In this setting, an increase in the output of a given Type 1 product, other things equal, will reduce the output of a Type 2 product by reducing the supply of some ecosystem amenities for Type 2 production. Direct displacement generally occurs through a formal or informal competitive-bidding process. Through this process, a Type 1 use of a resource decreases the resource's availability for use in the production of some Type 2 product. As a result, the Type 2 product becomes either more scarce or more costly than would otherwise be the case. There currently is considerable concern in the Pacific Northwest, for example, about the impacts of logging and related activities on the quality of surface water available downstream for municipal-industrial water use (Bernton 1996). With reductions in water quality, the affected water utility would have to curtail production or incur additional costs to obtain water from other sources.

Displacement also occurs when the production of a Type 1 product is accompanied by negative externalities.[8] Negative externalities are ubiquitous when Type 1 activities affect

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[8] In some cases externalities are positive. We would include such cases under the rubric of economic impacts of Type 1 production.

the quality of air, water, habitat and landscapes.[9] Increased sedimentation from timber production, for example, can create additional costs for downstream fisheries, landowners, municipal-industrial water users, and public agencies (Meehan 1991; Reid 1993). These costs arise not because of competitive bidding for the use of the relevant resource but because the downstream effects are external to the incentives facing those who determine the upstream economic activities. Externalities are an important source of market failure. Generally, solving market failures requires public policies that attempt to make individual incentives compatible with collective objectives (Field 1997; Goodstein 1995; Tietenberg 1996).

The third mechanism by which a Type 1 use of forest resources can impose costs on other producers comes into play when government subsidies distort the prices or production levels of a Type 1 product. Similar distortions can arise from regulatory and other actions, such as trade policy, but, to conserve space, we lump them all under the rubric of subsidies. Subsidies draw money from, and thereby restrict the output and profits of, other producers, including some who have no other relationship to the Type 1 product or its use of forest resources. Hence, subsidies are akin to externalities. Subsidies can arise in three ways. One entails subsidies to the Type 1 product itself, for example, price-support payments for certain agricultural products (Environmental Working Group 1995; Offutt and Shoemaker 1990). Another occurs through subsidies to the Type 1 use of a resource as a productive input, for example, below-cost pricing for timber, forage, hydropower, and navigation derived from federal lands and facilities (Council of Economic Advisers 1994; U.S. House of Representatives 1994). Subsidies also can be directed at labor, capital, or some other nonresource input to the Type 1 production process (Black and Smillie 1988; Meyer and Rosenbaum 1996; Nauth 1992).

Subsidies may be conspicuous, as when states give tax concessions to Type 1 industries or protect them from competition (Black and Smillie 1988; Nauth 1992), but they may be more hidden, as when firms in other sectors of the economy subsidize (relative to actuarial cost) unemployment insurance in some highly cyclical resource-extraction industries (Meyer and Rosenbaum 1996). Regardless of their visibility, subsidies suppress the level of Type 2 production and lower the well-being of those who otherwise would benefit from the forgone production and enjoyment of Type 2 products. These effects may materialize in the vicinity of the forest resources used in the production of the Type 1 product, but not necessarily.

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[9] As one might expect, there is an extensive literature regarding when a particular cost or benefit is or is not an externality, or whether a particular price or production phenomenon stems from displacement, an externality, or a subsidy. Any assessment of displacement, externalities, and subsidies should be accompanied by a discussion of the vague boundaries among them. Baumol and Oates (1988 pp. 14-15), in an important text on environmental externalities, provide a useful background for such discussion:

"The externality is in some ways a straightforward concept; yet, in others, it is extraordinarily elusive. We know how to take it into account in our analysis, and we are aware of many of its implications, but, despite a number of illuminating attempts to define the notion, [footnote omitted] one is left with the feeling that we still have not captured all its ramifications. Perhaps this does not matter greatly. ... Ultimately, definitions are a matter of taste and convenience."

Competition Directly from Consumers

On the left side of Figure 2.2, forest resources are economically important because they are inputs in the production of other things, such as housing, transportation systems (e.g., pallets), and hydroelectricity that consumers want to have. On the right side, the connection between these resources and consumers is more direct. That is, consumers consider these resources economically important for what they are and for how they directly contribute to consumers' well-being. Figure 2.2 shows there are two types of demand for forest resources coming directly from consumers: one affects consumers' residential location decisions; the other does not.

Type 3 Products - Consumption Amenities and Residential Location. Sometimes a forest produces amenities, such as recreational opportunities, scenic vistas, and healthy environments, that contribute directly to the well-being of people who have access to them. In economic parlance, these are known as consumption amenities. Their contribution to consumers' well-being makes consumption amenities economically important in their own right, but they also influence the location decisions of households and firms (Knapp and Graves 1989; Mathur 1993; Mueser and Graves 1995), thus, adding to their economic interest. We use the term, Type 3 products, to represent consumption amenities that influence location decisions and, as Figure 2.2 shows, they represent a significant source of competition for forest resources.

Economists' explanation of why some consumption amenities can influence location revolves around the concept of consumer surplus. Whenever a consumer derives benefits (increases in well-being) from a good or service that exceed the costs the consumer pays to obtain it, the net benefit represents a net increase in well-being. This increment is called consumer surplus. It is important because, whenever the costs and benefits of a good or service are equal, the consumer's consumer surplus is zero and acquisition of the good or service does not represent an increase in his or her well-being. Increases in consumers' well-being can occur only when they are able to obtain goods and services that have a positive consumer surplus.

In general, consumption amenities offer the prospect of positive consumer surplus. The nearer that people live to such amenities, the better their access, and the lower their cost of taking advantage of them. Thus, consumers can increase their consumer surplus—their economic well-being—by living near forests that offer recreational opportunities, wildlife viewing, and other amenities.

Whitelaw and Niemi (1989) have likened this consumer surplus to a *second paycheck* residents receive from living in a place where they have easy access to amenities, so that the total welfare of residents within commuting distance of the amenities is the sum of this second paycheck plus the purchasing power of their money income. The size of the second paycheck affects behavior in the local and regional economies by influencing household demand for residential location. In equilibrium, changes in the value of amenities must also affect money wages and housing costs, and thereby the real wage. All else equal, if amenities in a region improve, people will tend to move to that region, bidding housing prices up and wages down, until there is no net advantage from further migration.

That location-specific consumption amenities are an important influence in residential location decisions is well documented.[10] Much of this literature attempts to compute the size of the second paycheck associated with particular amenities, or derived from living in specific cities or states, inferred from wage and housing cost differences associated with those locations. The range is quite large. For example, Blomquist et al. (1988) find a range of over $5,000 per year per household for 253 urban counties in 1980. For technical reasons, this probably overestimates the true range. Given that median personal income per household then was $17,710 (U.S. Department of Commerce and Bureau of the Census 1995), however, it is clear that the second paycheck can be a significant fraction of the first one.

Essentially all of the existing literature on the value of amenities implicitly assumes that the amenity value is reflected in wages and prices in the same county or city as the amenity itself. This view probably is too restrictive. Natural-resource amenities a few hours drive from an urban area also will plausibly contribute to the quality of life in that area, showing up as lower wages and higher housing costs at locations that are some distance from the amenity itself. Furthermore, forest resources in one place can materially influence the quality and quantity of recreational opportunities and other amenities some distance away.

As pointed out by Roback (1988) and others, lower real wages that arise from consumption amenities act as a special type of production amenity for firms that are able to reduce their costs by locating where wages are lower. This mechanism allows natural-resource consumption amenities to affect where goods and services are produced. Thus, the quantity and quality of natural resource amenities can affect the levels and types of jobs (and economic activities in general) throughout the local and regional economies, including sectors with no direct link to the use of ecosystem resources.

It is important to recognize that, where amenity-driven growth is sufficiently strong, the predictable outcome is that the amenities become congested. Congestion can occur quickly, especially where the residential, and then commercial and industrial, development initially attracted by an area's amenities occurs without bearing the full cost it imposes on providing roads, schools, and other public services. In such cases, not only do the amenities that triggered this process become congested, but they often also become degraded.

Some elements of an ecosystem can act as both a production and a consumption amenity. Thus, a forested mountainside can produce lumber (Type 1), support a watershed that has commercial value downstream (Type 2) and provide an environment for backpacking (Type 3). In some cases, the boundary between Type 2 and Type 3 products and other Type 1 activities is ambiguous. To distinguish among them, we employ a general principle: When a given amenity diminished by a Type 1 activity is used directly as an input into the production of a marketed good, the marketed good is a Type 2 product. To the extent that people choose to live in or near the ecosystem to take advantage of recreational and

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[10] The early contributions are Rosen (1979) and Roback (1982). For more recent work on this topic see Beeson (1991); Berger and Blomquist (1992); Blomquist et al. (1988); Brady (1995); Brown (1994); Browne (1984); Cooper (1994); Cushing (1987); Figlio (1996); Gabriel et al. (1996); Gottlieb (1994); Greenwood et al. (no date); and Sherwood-Call (1994).

tourism opportunities, whether marketed or not, we count the location of such people (and its indirect economic effects) as arising from a Type 3 use of the natural resource.

Type 4 Products - Intrinsic Economic Value. The Type 4 products shown in Figure 2.2 are ecosystem products people value for their intrinsic properties. Intrinsic values, often termed "existence values," do not entail an explicit current use of the resource. [11] [12]They arise whenever individuals place a value on maintaining the existence of a species, scenic waterfall, or other resource for its own sake, or on the prospect that the resource will be useful, for example, to future generations. Actions that increase the robustness of the resources, for example, by preventing degradation of critical habitat for an endangered species or by ensuring the flow of the waterfall, increase the welfare of those concerned about these issues, and actions that degrade the resources decrease this welfare.

Unlike the other three uses of ecosystem amenities that we have discussed, Type 4 products, by themselves, are unlikely to have any manifest economic effect on jobs, income, or other indicators of economic activity. The forests of New England may be of intrinsic value to some residents of Miami, Los Angeles, and other distant places, but the effect of this on economic activity in the region of the forests will be small unless it is articulated through the political system. Still, the resource affects the real well-being of real people, and this well-being belongs in any comprehensive analysis of the value of the resource.[13] For some environmental issues, such as maintaining the biodiversity and integrity of ecosystems passed to future generations, Type 4 values may be very large.

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[11] We use the phrase, intrinsic value, because it is more accessible to a layperson than equivalent phrases, such as passive nonuse value, that economists commonly employ. It refers to value separate from the current or expected use of a resource, including both consumptive and nonconsumptive use. Economists have devised several approaches for dividing the intrinsic value of a resource into component parts. A common approach is to distinguish between option value and existence value (Cicchetti and Wilde 1992). Option value is the value one derives from knowing that the resource will be available for one's use in the future. Existence value can be either the inherent value one places on the existence of the resource, itself, or the vicarious value of knowing that the resource is or will be available for others. The vicarious value of knowing that the resource will be available for future generations is commonly called bequest value. For the purposes of this discussion it is not necessary to examine these components separately.

[12] Some ecologists argue that none of the intrinsic value categories fully recognize the value of the life-support services ecosystems provide that make the earth habitable (Baskin 1997). Although conventional economists have attempted to include biological diversity in their calculations of the value of life support services, they have not been able to directly get at what it is worth to have species work together within ecosystems to provide these services. It could be argued that they constitute a fifth type of demand in our typology. On the other hand, a case could also be made that without life-support services, Types 1–4 would be faced with large problems. We do not debate the point here but, instead, expand the category of Type 4 products to include this life-support value.

[13] While there is general agreement on the statement in the text as a matter of principle, the literature is sharply divided on the question of whether such value can be accurately measured. See Arrow et al. (1993); Castle et al. (1994); Coursey et al. (1987); Eberle and Hayden (1991); Gregory et al.(1995); and Stevens et al. (1991).

III. ANALYTICAL ISSUES

The conceptual framework described in the preceding chapter brings into focus several critical issues that inevitably arise whenever one is analyzing the ecosystem-economy relationship for forest resources. These include:

- Defining the spatial characteristics of the relevant economy.
- Selecting appropriate variables and time periods for measuring the economic consequences of ecosystem-management policies and activities.
- Placing ecosystem-management decisions in the context of autonomous factors influencing adjacent economies.
- Clarifying the rights and responsibilities of property owners.
- Understanding concerns about sustainability.

A. Defining the Relevant Economy

The competing demands for a forest's resources, represented by the four types of demand shown in Figure 2.2 (Chapter II), generally do not originate from a common set of workers, households, firms, communities, and regions. Each interest group exerts an influence on forest management through its own set of competitive mechanisms, operating through markets, administrative proceedings, political contests, and other forums. Accordingly, one should not expect that the different types of competition will exhibit common geographic boundaries.

A general, but typical, illustration reinforces this conclusion. In a given situation, the competition for forest resources coming from those who benefit from timber production (Type 1) might be concentrated on one side of the forest, in nearby communities having both milling capacity and transportation facilities appropriate for hauling heavy loads. If the timber production results in increased turbidity and flooding in streams, the competition coming from those who incur these environmental externalities (Type 2) might encompass residents of the mill communities as well as others living hundreds of miles downstream in the watershed. The competition coming from those who see timber production as having an adverse impact on the quality of life (Type 3) might include residents of the watershed, as well as residents who live nearby but are outside the watershed. Those competing for forest resources because they place an intrinsic value on forest resources affected by timber production (Type 4) may live in the vicinity of the forest or far afield.

Only by chance will all the competing demands for a forest's resources share a common boundary. Furthermore, in most situations, the economic landscape relevant to a forest extends far beyond the economy itself. Although some individuals, groups, and communities with competitive interests in a forest's resources live nearby, or perhaps even within the forest itself, the bulk of the competition can come from hundreds, perhaps thousands of miles away.

Even this casual view of the relevant economic region(s) has important implications for forest researchers and managers. The common approach for evaluating the economic consequences of forest-management alternatives circumscribes the relevant economy with the boundaries of the forest. In others words, the spatial dimensions of the ecosystem and the economy are assumed to be the same. Recent examples of this include the studies underlying the Northwest Forest Plan (Forest Ecosystem Management Assessment Team 1993), the assessment of biophysical and socioeconomic characteristics of the Southern Appalachian Highlands (Southern Appalachian Man and the Biosphere 1996), and the integrated scientific assessment of the interior Columbia River Basin (U.S. Department of Agriculture 1996).

To implement an alternative approach, based on the discussion thus far, one must define both economic region(s) and the geographic (or regional) compass of ecosystems. We recommend starting with the ecosystems, then looking at the relevant economic regions, taking into account the special importance of metropolitan areas.

Ecosystems

Implicitly, we have defined ecosystems as sources of natural resource amenities that are of economic interest. The science of ecology, of course, defines ecosystems in other terms: "a unit comprising interacting organisms considered together with their environment" (Forest Ecosystem Management Assessment Team 1993 p. IX II). For our purposes, it is essential that the ecosystems under consideration have sufficient biological coherence so that they make sense as potential loci of management from a scientific perspective. We say this recognizing full well that the boundaries of ecosystems (at least ones that are smaller than continents) are subject to debate and controversy, and will vary depending on the purposes for which they are being drawn.

One essential objective of the research program that we outline in this discussion is to improve, at least marginally, the understanding of how human activity affects ecosystems and the flows of products derived from them. Although the equations of motion of a given ecosystem are not fully known there can be little doubt that such activities as building roads, houses, and sewage systems, clearcutting, damming rivers, or, in some cases, walking on the landscape, change the state of the system in ways that change both the current and future flows of products that interest people. Nonetheless, there is both enormous political controversy and scientific uncertainty regarding the details of this subject. Notwithstanding this controversy, we find that ecologists are generally willing and able to divide the world up into ecosystems, recognizing that there is overlap at the boundaries, that a given place may be part of more than an ecosystem, and that changes in behavior may have ecological effects that are removed from the ecosystem in which the initial behavior takes place.[14] This last possibility arises quite naturally when waterborne material transport is important. Forest management practices in a wooded upland may have important biological effects well downstream, in agricultural and urbanized valleys and in distant estuarine ecosystems.

Given our interest in ecosystem management, we tend to be interested in ecosystems of fairly large size, so that the flow of products and stock of future potential products deriving from a given ecosystem are significant enough to be of interest to policymakers and citizens. In this context, ecosystem management can be broadly defined as any human activity that alters the flow of ecosystem products (and generally the stock, which is implicit in the current state of the ecosystem, described biophysically). Note that in this broad definition, the management of the ecosystem need not be consciously intended as such. The actions of Forest Service officials are surely ecosystem management, but so too are tax, regulatory, and subsidy policies that affect the use of ecosystem resources, and so are actions of private landowners, ranchers, and backpackers. From social and political perspectives, it is useful to distinguish between conscious management activities and other behaviors and policies that affect ecosystems. But for our purposes they are all "ecosystem management."

Economic Regions

Delimiting economic regions suffers from problems that are similar to those involved in delimiting ecosystems. Here the mechanism of transporting material and energy (and services) is some set of markets and other systems of economic exchange, rather than rivers or airsheds.

Generally, a place can be economically near to another place while being geographically very distant. Consider the case of a printer in Los Angeles who uses paper processed in New England. Environmental regulation in New England will then affect the economy of southern California. The effect in this case is not likely to be large, partly because alternative sources of supply can probably be found (although at higher cost) and in part because the enterprise under consideration in Los Angeles is small relative to the regional economy.

In light of these difficulties, we propose to start at the level of the ecosystem that is directly being managed, and to define the relevant economic region as the set of geographic areas for which management changes will have discernible economic impacts. Different management tools will generally have different economic regions associated with them. A regulation limiting ranching activities in riparian zones will likely have economic impact via changes in local ranching behavior and changes in local and downstream water quality. A change that affects logging practices in the same general area might also affect the economy of the local mill town. Each could affect recreational activity, but not necessarily the same group of recreationists in the same places. In both cases, we would also include in

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[14] In personal communication with scientific staff at six of NSF's Long Term Ecological Research (LTER) sites, we have found that ecologists can and do identify the ecosystems within which their sites sit, and also larger ecosystems of which their sites are typical.

the relevant economic region the location of significant secondary economic impacts, e.g., suppliers to the affected meat processors, logging contractors, and recreation-equipment retailers.

What is true for paper manufacture is also true for logging—the economic effect of ecosystem management may take place in locations that are geographically neither near nor contiguous to the relevant ecosystem. Loggers in the Pacific Northwest and Alaska, for example, often travel long distances to find work and mills compete intensely for logs over distances of several hundred miles (ECONorthwest 1996a). Within this environment of area-wide competition, employment reductions arising from a reduction in timber harvest in one locality are likely to occur at the least efficient sawmill in the entire area, rather than at the mill closest to the site of the reduced harvest. Similarly, the timber-harvest reduction might affect the paycheck, not of the logger who lives nearby, but of the one who lives several hundred miles away. In short, the distribution of economic impacts that follow from a specific environmental-decision will generally be complicated and dispersed.

Of course, at some point the effects become too small to be worth considering or the regions are so far away that they are of little or no policy interest to relevant policy makers. For accounting and conceptual purposes it still makes sense to keep track once these bounds are reached, but as a practical matter such effects will generally be assigned to "the rest of the world."

As an operational guide for defining the economic region(s) relevant to the management of an ecosystem, Haynes and Horne (1997) recommend adapting a principle of ecological research: to set and understand context one level higher than the primary scale of interest and to examine and understand processes one level lower than the primary level. If the primary area of interest is a river basin, then set and examine the context at the regional and national levels. To understand processes, look at subbasin economies, such as the functional economic areas defined largely by data on labor commuting patterns (Johnson 1995).

We generally endorse this approach, recognizing, however, that it leaves unanswered the question, How large is the relevant region? There is no good, widely accepted answer. As a practical matter, therefore, we recommend that one begin large and gradually work smaller. For a forest ecosystem of fairly large size, one should begin with the encompassing regional economy that functions as a distinct, subnational economic unit and consists of one (sometimes more) large metropolitan center, which serves as the economic node for the region, plus the peripheral smaller metropolitan areas and nonmetropolitan areas that have close economic ties to the metropolitan center. These nodal centers include the nation's major cities: Boston, Chicago, Atlanta, etc.

After looking at the impact of forest-management decisions on the major subnational regional economy, one should step down to a set of one or more nested, smaller economic regions. The steppingstones should be the one or more smaller, peripheral metropolitan areas that lie between the central nodal core and the ecosystem. We illustrate this process as we discuss the case studies in Chapter IV. In the following section, though, we describe in more detail the economic importance of metropolitan areas.

The Importance of Metropolitan Areas

Forest-policy analysts often assume that the economic effects of forest-management decisions will impinge primarily on rural communities. They conclude that, because these communities are isolated, they are necessarily dependent on the production of extractive products, primarily timber, from the adjacent forest and, hence, they are especially fragile with respect to changes in the flow of these products. Using this logic, the community-impact section of the environmental impact statement accompanying the Northwest Forest Plan, for example, focuses exclusively on the region's rural counties and communities and assesses the extent to which reductions in timber production would place these communities "at risk" (U.S. Department of Agriculture and U.S. Department of the Interior 1994).

This view sees the forest-economy relationship in far simpler terms than we represent in Figures 2.1 and 2.2. Specifically, it sees the forest's importance to the economy primarily, if not solely, through its production of extractive and development products (Type 1 in Figure 2.2), overlooking the offsetting consequences for competing demands and products (Types 2–4). Further, it exaggerates the economic isolation of rural communities and the economy's sensitivity to changes in timber and other commodities. A common denominator in these shortcomings is the failure to acknowledge the importance of metropolitan areas to the relationship between forested ecosystems and the economy. One generally cannot obtain a full understanding of potential impacts on rural communities from forest-management decisions by looking at these communities in isolation, separate from their economic integration with metropolitan areas.

The historical economic isolation of nonmetropolitan communities is diminishing and, in many respects, it has expired. Clearly, some communities are more isolated than others, and within a given community, some residents are more integrated than others. But virtually all nonmetropolitan residents are getting closer economically to metropolitan centers. To see the full extent of the competition for forest resources and to understand the full economic consequences of forest-management decisions, except in rare instances, one must take into account the economic integration of nonmetropolitan areas with metropolitan centers, near and far.

The 1920 census was the first to show more than half the U.S. population living in towns and cities. Currently, more than three-fourths of the population live in metropolitan areas, and more than half live in metropolitan areas with more than 1 million people. The growing concentration of the U.S. population in large metropolitan centers, however, does not mean that these centers are divorced from the surrounding nonmetropolitan areas. To the contrary, the economic and cultural ties between metropolitan and nonmetropolitan areas always have been and continue to be strong and complex.

Nonmetropolitan counties, which contain more than 80 percent of the land area in the United States, house about 21 percent of the people, provide about 18 percent of the jobs, and generate about 14 percent of the earnings (USDA Economic Research Service 1995). In general, rural residents are less likely than in the past to be tied to resource-intensive industries. Since World War II, farming employment, for example, has dropped from about 8 million to about 3 million, and only 5 million people—less than 2 percent of the total population and less than 10 percent of the rural population—live on farms. In counties with the highest concentration of farm jobs, these jobs, on average, pay considerably more than nonfarm jobs ($28,000 versus $19,000 in 1989). Nonetheless, of all the households operating farms, nearly 60 percent rely partly on nonfarm income, with one or more household members working in an off-farm job and earning, on average, nearly $30,000 from nonfarm employment (USDA Economic Research Service 1995). Rural residents also are less likely than in the past to work in timber, mining, and other industries related to resource extraction. These industries historically located processing plants adjacent to the raw material to reduce the costs of transporting the raw material to the factory. Because of technological changes that both allow and require additional processing per unit of final output, raw materials are a smaller component of costs for most final products, and many manufacturers seek to locate, not near the raw material, but near large markets and large pools of qualified workers. Most of these industries are no longer dispersed throughout rural areas. They have consolidated near urban centers for better access to both buyers and workers (Duffy 1994).

In conjunction with technological changes in manufacturing processes, the development of transportation systems also has reduced economic barriers between nonmetropolitan and metropolitan areas (Mills 1987). Transportation systems, especially the trucking industry and the interstate highway system, have reinforced the technological changes and allowed many manufacturing firms to locate outside metropolitan areas, but still have ready access to urban customers and a large labor pool. In many sections of the country, the location of manufacturing on the fringes of metropolitan centers has considerably blurred the distinction between urban and rural, so that communities once considered rural are rural no more.

Many residents of nonmetropolitan areas have prospered from the increasing economic connections to metropolitan areas. Nonmetropolitan areas, as a whole, now have a smaller portion of persons living in poverty than metropolitan areas (Danziger and others 1994). In fact, by most measures, nonmetropolitan poverty seems to be declining. In 1990, for example, 765 nonmetropolitan counties in the United States had more than 20 percent of their population living in poverty, down from 2,083 counties in 1960 (USDA Economic Research Service 1995).

The migration patterns of workers and households and the locational decisions of firms have important consequences for nonmetropolitan-metropolitan links. The locational patterns of the elderly illustrate these consequences. Nonmetropolitan areas, which historically have had a higher concentration of elderly persons, seem to be attracting even more. Nationally, the number of persons 65 years and over has increased 60 percent since 1970, and this group now represents about 13 percent of the total U.S. population (U.S. Department of Commerce, Bureau of the Census 1992). During each of the three previous decades, elderly persons exhibited general movement from metropolitan areas to nonmetropolitan areas (Heberlein 1994).

An increasing elderly population in nonmetropolitan areas tends to reduce the isolation of nonmetropolitan communities in several ways, primarily by supporting nonmetropolitan-metropolitan trading networks. Because of national entitlement programs, pensions, accumulated savings, and other factors, the elderly, as a group, now have greater wealth and income than in the past. Their expenditure of the transfer payments provides an important source of financial support for nonmetropolitan retailers, health clinics, and other businesses. The economies of nonmetropolitan counties that experienced 15 percent or greater in-migration of persons age 60 or older during the 1980s performed far more strongly than the economies of other nonmetropolitan counties. On average, the elderly population of these counties grew by about 50 percent during the decade and total population by 23 percent (versus 0.6 percent for nonmetropolitan counties as a whole), while total earnings grew more than 25 percent and employment by nearly 35 percent. These counties tend to be in the Sunbelt and to be close to natural-resource amenities. Many military retirees also locate near military bases to have access to medical and shopping facilities on the bases (U.S. Department of Agriculture 1995). As the contribution of retirees to the local economy grows, so does the connection between metropolitan and nonmetropolitan areas.

Most discussions of the economic relationship between resource-rich rural areas and the broader economy examine bilateral trade in which the rural periphery sells raw materials (perhaps with some processing) to the urban core. The core purchases these materials with manufactured goods and specialized services. These may be produced in the core city, or that city may act as an intermediary in trade with the rest of the world.

The typology of demands on natural resources that we present as Type 1–3 products is generally consistent with this conventional view of intra-regional trade flows, but it suggests that we should look at a greatly enriched variety of ways in which the trade may take place. Most important, the consumption amenities that we discuss as Type 3 products may induce migration to cities that are near (but not directly part of) places that possess such amenities.[15] People who like to sail may choose to live in Baltimore rather than Philadelphia; people who like to fish may choose to live in Detroit rather than St. Louis; software engineers who like to kayak may choose Portland over San Jose. Thus, ecosystem management at the periphery may have profound effects on population and economic behavior in the core, not only via the direct effects of resource-using industries of Type 1 and Type 2 but also via the indirect effects on the quality of life (and willingness to pay for quality of life) of urban residents, via the consumption amenities that generate products of Type 3.[16]

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[15] Most studies of economic development potential associated with recreational sites at the periphery focus on the local effects. See, for example, English and Bergstrom (1994). This model, however, misses the possibility (which will generally be invisible in standard industrial and employment data) that the economy of the core is enhanced by recreational and other amenity values of the periphery. If people choose their urban areas based on nearby, but rural, natural resource amenities, the value of those amenities may largely be reflected in urban, not rural, labor and housing markets.

[16] For people who value both urban and natural-resource amenities (e.g., kayakers who like opera) the connection between the core and periphery is even closer. All things being equal, such people would most prefer to live in or near cities that are also near mountain rivers. They will be willing to accept, in some combination, lower wages and higher housing costs to live in such places. In this case, the relevant vector of consumption amenities includes both types of amenities and their locations.

B. Relevant Variables: Economic Value, Impact, and Equity

A variety of economic consequences will follow any forest-management decision. The economist can best help resource managers, decisionmakers and the public assess the economic consequences of any forest-management decision by providing an evaluative approach, based on economic analysis, that reflects the needs and concerns of those involved in the policy arena (Shabman and Stephenson 1996).

One way to measure the economic consequences and, hence, the relative strengths of the competing demands for forest resources is to compare the *values* society ascribes to the different bundles of goods and services derived from the forest under alternative forest-management decisions[17] This comparison can help members of the public and those who allocate forest resources assess the extent to which the alternatives are economically efficient and have the potential to increase the economic well-being of society as a whole. In general, the value an individual places on a specific use is the amount the person is willing to pay for it if the person does not already possess the right to use the resource in this manner, or if the right is possessed, the amount the person is willing to accept to relinquish the right and forgo this use. For a more detailed discussion of the issues and analytical methods related to estimating the value society ascribes to different uses of forest resources, we refer the reader to standard texts on natural-resource economics such as Freeman (1993), Goodstein (1995), and Tietenberg (1996).

Much of the public's concern over forest management lies not with value but with how forest-management decisions will affect economic opportunities available to workers, families, and investors and the structures of the local, regional, and national economies. These effects are commonly called the economic *impacts* of a decision and are different from the effects on economic value, which are based on costs and willingness to pay for different outcomes.

Where there is competition for forest resources, any resource-allocation decision necessarily creates both winners and losers. The characteristics of these two groups influence perceptions about the fairness of the decision. These perceptions, in turn, can play an important role as resource managers, decisionmakers, and the public evaluate forest-management decisions. Hence, an assessment of the competition for forest resources and the consequences of forest-management decision should examine issues associated with economic *equity* and keep track of winners and losers and examine the impacts on perceptions of fairness. In particular, the assessment should examine issues associated with property ownership, subsidies and externalities, and groups of special concern. For additional discussion of these issues, see Courant et al. (1997b) and Niemi and Whitelaw (1997).

[17] Economists tend to identify the relevant bundle of goods and services by looking through the eyes of consumers rather than those of producers.

C. Relevant Time Periods[18]

Changes in forest management can effect strong responses in the local, regional, and national economy, in both the short and the long run. The economic changes initiated by the management decision will occur in four general stages, shown in Figure 3.1. In Stage 1, the decision is adopted and, in Stage 2, this action sends economic signals to the local, statewide, regional, and national economies, indicating a change in the economic role of natural resources. The signals have four major destinations, represented by the four types of competing demands for the forest resources, as indicated in Figure 2.2 in Chapter II. Although Figure 3.1 shows Stages 1 and 2 occurring as a single, abrupt event, they generally transpire over a longer period, especially for public lands or whenever the forest-management decision is subject to public regulation.

Stages 3 and 4 of Figure 3.1 illustrate the dynamic character of the economy's response to the adoption of the forest-management decision. In Stage 3, the economy responds to the economic signals sent in the second stage through changes in prices or incomes or both. If the prices of goods and services rise or fall to levels that otherwise would not occur, buyers and sellers adjust their behavior accordingly. A change in the output of a good or service, even in the absence of a price change, similarly causes a change in the level and distribution of incomes and a change in the behavior of buyers and sellers. The prices of some goods and services in some locations may rise in response to a reduction in supply or an increase in demand, and for the opposite reasons, the prices of some goods and services in some locations may decline. Separate price-effects and income-effects manifest themselves for the different types of demand.

In Stage 4, prices and incomes reach their new levels, and the economy exhibits the long-run effects of the adoption of the forest-management decision. (The long-run adjustment may entail feedback loops, through which changes in prices and incomes may influence future forest-management decisions.) Alterations in the structure of the economy occur at the local, regional, and national levels; that is, the distributions of forest-related activity, quality of life, jobs, incomes, and wealth are different at each level than they would have been without it. The precise path through Stages 3 and 4—the transitional adjustment to the forest-management decision—will depend, not just on the characteristics of the decision, itself, but also on the multiple economic forces and trends that are continuously altering and shaping the economy at all levels. Individual concern often is raised about the impacts of the transition on capital, property, and labor markets. Most markets should adjust quickly to the forest-management decision, and they may adjust fully in anticipation of the decision. The larger and more diverse the affected economy, the smoother the transition.

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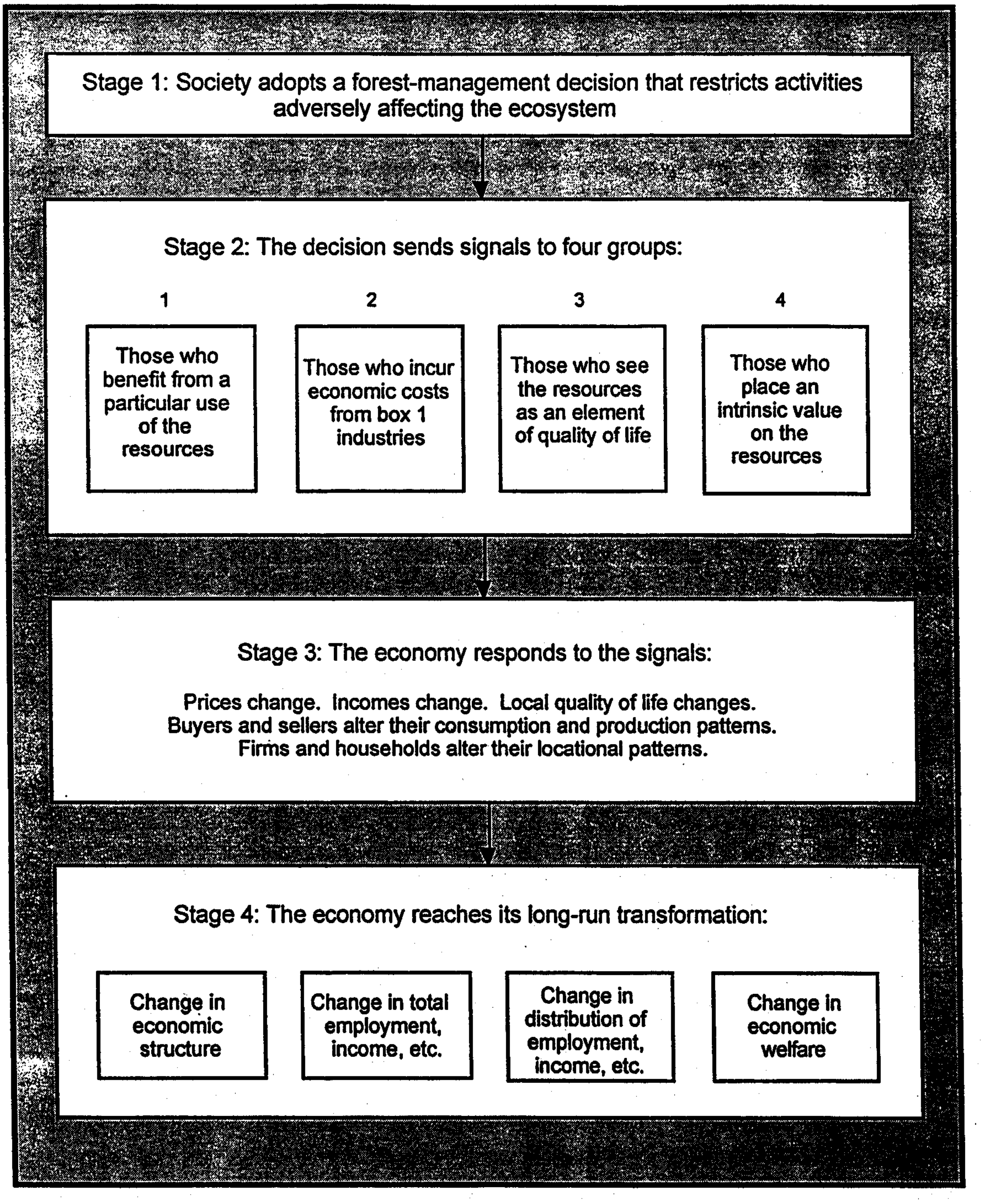
[18] For further discussion of this topic, see Niemi and Whitelaw (1997).

Figure 3.1: The General Process by Which the Adoption of a Forest-Management Decision Will Lead to Changes in the Economy



Source: ECONorthwest.

As Figure 3.1 indicates, the economic consequences of a forest-management decision do not occur instantaneously, but evolve over time. How long does it take? There is no single, simple answer to this question: both the nature and the duration of the economy's response depend on many variables. There are good reasons, however, to believe that many aspects of the economy are adjusting more quickly than in the past to changes in forest-management policy. For example, by the middle of 1997, lumber prices throughout the U.S. had stabilized in adjusting to the major decrease in federal timber sales in the Pacific Northwest that accompanied the April 1994, adoption of the Northwest Forest Plan. This was far quicker than many industry analysts had expected (Bernton 1997). Labor markets also are dynamic. Power (1996) reports that, of the workers nationwide who lost their jobs because of plant closures or other mass layoffs in the 1980s, about half were unemployed 10 weeks later and the percent remaining unemployed after twelve months was roughly the same as the rate of unemployment in the overall labor force.

This is not to say that everyone adjusts this quickly, or that the costs of adjusting to a change in forest-management policy are trivial. Instead, we are only pointing out that adjusting to change is one of the widely-trumpeted virtues of market economies. One necessarily will overestimate the economic consequences of a policy change if one focuses solely on the initial impacts—the initial price effect, increase in unemployment, and so forth—and fails to trace through the adjustment and transition.

D. Economic Base Models

In contrast with the dynamic reality of the ecosystem-economy relation, many analytical tools for assessing the economic impacts of a forest-management decision take a static view of the relationship between natural resources and the surrounding economies. This is especially true of perhaps the most commonly used tool, the economic base model. Because it is so frequently applied, and yields results so misleading, we single it out.

An economic base model divides the economy of an area into two sectors: the export sector, which produces goods and services sold to buyers outside the area, and the local sector, which sells its products within the area. Proponents of the economic-base model conclude that, because the export sector brings in money from the outside that is spent and respent on local goods, it is the "economic base" that "supports" the local sector. With such models, the fate of a region's economy is in the hands of outsiders: the only way the welfare of local residents improves is if outsiders buy more of the goods being exported from the area. Because resource-intensive industries typically export their products to other regions or countries, proponents of the economic-base approach often conclude that these industries play a key role in sustaining the welfare of local residents (Beuter 1995; Schallau 1994).

Economic base models also contain a simplifying assumption that arrests the economy in its current configuration so that an increase or decrease in the supply of a particular product can be traced through the now-assumed-to-be-static economy. In general, the results from this approach tend to overestimate the negative impacts and underestimate, even ignore, the positive impacts of any change from the status quo. This bias can be called the dumb-person bias, because the technique explicitly assumes that investors, managers of firms, workers, and consumers will not adapt to the forest-management decision but instead will continue to behave as if the management decision had not occurred (Mendelsohn et al. 1994). In reality, investors, managers, workers, and consumers are neither static nor dumb. The regional and subregional economies of the U.S. are tremendously dynamic, and they adapt remarkably to changing conditions. If the supply of a productive input is restricted, or if the demand for a final product falls, investors will try to reduce their risks and the managers of firms will adapt their production processes accordingly.

Using an economic base model to crank through the effect on employment or income of eliminating a given amount of employment in the basic industry, an analyst is answering the following question: What would happen if the given amount of employment were eliminated, and

- those who lost their jobs as a result never worked again, but also did not move
- the local and regional establishments that sold goods and services to those who lost their jobs permanently lost that business and obtained no replacement business (and also did not move)
- those enterprises in the region that used the output of the original job-losers obtained no replacement inputs from elsewhere (and also did not move)
- everyone throughout this chain who lost her or his job acted exactly the same way as the original job losers, in that they never worked again and stayed put?

There may be good reasons for answering this question: it puts an upper bound on the extent of adjustment an economic region will have to undergo in response to a change in policy (or technology, or demand). However, as Power (1996a) so nicely puts it, using the economic-base model for forecasting is like driving by looking in the rear-view mirror. The economic-base model generates a measure of the maximum extent to which changes will take place, but this is very different from a forecast of what will actually happen. Economic-base models tell us how many jobs (or, more generally, how much economic activity) *currently* depend on a given industry or line of work. They also tell us who stands to gain or lose in the short run, which can aid in the design of policies and programs designed to help people who may suffer dislocation.[19] However, they tell us very little about what the local economy will look like after it adjusts to growth, decline, or other change in a basic industry.

Adjusting to change is one of the widely-trumpeted virtues of market economies. When a specific industry in a specific location goes into decline, for whatever reasons, two sets of things must happen in some combination: (1) other activities will replace the industry in decline and (2) capital and people whose incomes fall will leave the area. To forecast how a given local economy will adjust requires not only a detailed knowledge of what that economy currently does, but also knowledge of other things that it might do. Where the local economy has few economic assets, activity can be expected to decline and population to fall. Even then, the overwhelming majority of the people affected will find other work, at an average of about 75 to 90 percent of their old pay (Jacobson et al. 1993; Ruhm 1991). Where assets are more plentiful, the local economy will do better. When natural resources are important assets, it is quite likely that current activities coded as "basic" are competitive with each other (e.g., logging vs. fishing) or that current basic activities are competitive

[19] These are the workers who lose most, and the losses average much less than 100 percent. See, for example, Farber (1996), Heberlein (1994), Herzog and Schlottmann (1995), Jacobson et al. (1993), and Ruhm (1991).

with unseen alternatives (e.g., logging vs. retirement homes.) In these cases, coding of the economy's current activities as "base" and "other" will not be at all helpful in forecasting the economy's adjustment to change.

E. Autonomous Forces

Any forest-management decision occurs within the context of powerful, international and national economic trends that shape the competition for forest resources, which in turn shape the economic consequences of the decision. Such trends include changes in the age structure of the population, changes in family structure, interregional migration, shifts in the ethnic mix of regional populations, and a growing network of international agreements on managing environmental resources. Four trends are especially important:

1. The decline in employment in resource-intensive industries and the increase in employment in service and high-tech manufacturing sectors of the economy.

2. The growing importance of education as a determinant of wages and household income.

3. The increasing role of amenities and other nonwage factors as determinants of the locational decisions of households and firms.

4. The evolving economic integration of nonmetropolitan and metropolitan areas.

These trends result from fundamental changes in tastes, technologies, and demographics within the U.S., as well as changes in the economic relation between the U.S. and other countries. The economic forces underlying these changes will persist for many years, perhaps decades. The four trends have brought and will continue to bring about profound shifts in the contributions natural resources make to the economic well-being of workers, families, and communities in the U.S. They do not, however, uniformly influence each regional or subregional economy, or by extension, each community, or household. Depending on the characteristics of the individual economies, some will respond more strongly to the trends, and others less so. Earlier in this report we discuss the last two trends—the importance of amenities and the nonmetro-metro integration. In the following sections we provide a brief overview of the other two. For more detail on the four trends, see Niemi and Whitelaw (1997).

Employment and Incomes Stagnant or Declining in Resource-Intensive Industries

As we state earlier, groups use different mechanisms to compete for forest resources. To the extent that workers, communities, and political leaders place a premium on increasing the employment opportunities available to them or their constituents, they promote forest-management decisions that will yield this result. Typically, this means promoting decisions that allocate more forest resources to resource-intensive industries, such as agriculture and the resource-extractive industries, typically logging and mining[20]Long ago these industries, along with their derivative industries, such as food processing, sawmills and smelters, were the primary sources of income and wealth in the United States. Today they play a much smaller role in the nation's economy. Employment in the resource-related industries has declined, both relatively and absolutely, and we can expect this decline to continue. Now, and for the foreseeable future, most increases in jobs and incomes will occur in industries other than the resource-intensive industries. This trend represents a fundamental reduction of the role of resource-intensive industries in the jobs-related competition for uses of forest resources.

Between 1969 and 1994, direct employment in agriculture (farm employment and agricultural services), mining, and timber (lumber and wood products, pulp and paper, and forestry services) declined from about 7 percent of total U.S. employment to about 5 percent. During this same time period, while the percentage of total U.S. employment attributed to manufacturing declined, employment in the service sector, as a percentage of total U.S. employment, grew dramatically (U.S. Department of Agriculture 1995).

Several economic and social factors underlie the decline in the resource-related industries as a source of jobs and income in the U.S. economy. The adoption of labor-saving technological advances by U.S. firms in the resource-extraction and heavy manufacturing industries is a major factor (Kasa 1994; Lawrence and Slaughter 1993). Technological innovation has been an important characteristic of some portions of the U.S. timber industry (Greber 1993) and is expected to play a major role in the increasing globalization of the wood furniture industry. Failure to apply new technologies to production has been cited as a contributing factor to the recent decline in the competitiveness of U.S. wood furniture manufacturers in both the domestic and international markets (Smith and West 1994; West and Sinclair 1991). Other factors affecting timber and other resource-related industries during the past decade have been a marked decline in the influence of labor unions (Mishel and Voos 1992) and an accompanying decline in real incomes (Power 1996a).

In the foreseeable future, these trends will not reverse. Economic forecasters do not expect jobs or wages in the resource-extraction and manufacturing sectors to increase significantly (Franklin 1993). These industries are and will remain important elements of the nation's economy, but they will not be as important as they were in the past. In fact, the resource-extractive sector most likely will eliminate jobs and shrink its payroll.

These trends have important implications for the competition for forest resources. Allocating a unit of forest resources—whether measured in acres, million board feet, or other units—to a resource-intensive industry in the future probably will generate fewer jobs and smaller incomes than in the past. Communities seeking to develop new jobs generally will have to look to industries other than resource-related industries. Communities that have depended heavily on resource-related industries generally should expect economic stagnation or contraction in the future if they continue to look mainly to these industries for maintenance of economic vitality.

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[20] In some situations, elements of the developed-recreation, such as destination ski resorts, also can be resource intensive.

Education Increasingly Important to Wages

For many reasons, resource-intensive industries exhibit a declining ability to generate jobs and incomes. One of the most important of these is a shift in the factors determining workers' wages. In the past, a general expectation existed that allocations of forest resources to the resource-extraction industries would result in jobs with high wages, allocations to recreation would yield jobs with low wages, and allocations to environmental protection would not yield any jobs at all. Over the past two decades, however, this relationship between resource allocation and wage level has disintegrated. Forest-related wages, like wages throughout the economy, are increasingly determined by structural changes in the economy that have diminished the scarcity of workers with the set of skills traditionally employed in resource-extraction industries..

A review of historical data on education and earnings indicates that workers with more education earn higher wages, but during the past two decades, education has become an increasingly important determinant of workers' earnings (Bound and Johnson 1995; Juhn and Murphy 1995). In 1980, for example, male workers aged 25 to 34 with a college degree earned about 20 percent more than their counterparts with only a high school diploma, but by 1990, this differential had increased to about 50 percent. The comparable figures for female workers are about 30 percent more in 1980 and 60 percent more in 1990 (Ehrenberg and Smith 1994) .

Multiple economic and demographic factors contribute to the growth in the earnings gap between workers who have a college education and those who do not. One of the more important is a shift in occupational patterns, with an increase in the number of employment opportunities in managerial, professional, and other high-wage occupations and a decrease in the number of workers in middle-wage occupations, including the blue collar jobs that until recently have typified many of the older manufacturing industries (Brauer and Hickok 1995; Kutscher 1993). The shift in occupations has been accompanied by explosive growth in the use of computers and other high-tech equipment that require high-skilled workers to operate. In many instances, as industries install high-tech equipment which lowers the overall demand for labor, and especially the demand for workers with low-to-medium skills, the demand for high-skilled workers increases (Bound and Johnson 1992; Eck 1993). This process underlies much of the displacement of blue-collar workers in the resource-related industries, described above.

These trends are expected to continue as more and more high-tech equipment is developed in the future (Bound and Johnson 1992; Brauer and Hickok 1995). There is little, if anything, that will compensate for the lack of education. In particular, increasing the supply of raw material to resource-related industries, such as increasing the flow of logs to the timber industry, will not arrest the fundamental economic forces causing the industry to invest in labor-saving technology, eliminate jobs, and reduce the wages of workers lacking a high level of education. Indeed, the resource-intensive industries are subject to the same forces at play in the economy as a whole. Within these industries, jobs are growing fastest in the occupations—executive, administrative, managerial, professional, and precision-crafts—that require the highest training and pay the highest earnings (Ilg 1996).

Within the context of these changes in the structure of wages and earnings, it is clear that the conventional resource-intensive industries have declining ability to satisfy the economic hopes of workers, families, and communities. Instead, these industries promise economic decline for all but those relatively few who have the requisite skills to command wage increases. The bulk of the workers in the resource-related industries cannot expect substantial wage increases without an increase in their skills.

F. Sustainability and Congestibility

We do not pretend to provide a thorough discussion of the literature and issues associated with the sustainability of alternative forest-management schemes. Instead, we return to Figures 2.1 and 2.2 (Chapter II) to make three points. The first is that for forests throughout the U.S. the four types of demands shown in Figure 2.2 are competing for a forest's resources and the balance among the four is shifting in response to changes in demographics, tastes, technologies, and the resources, themselves. Consequently, strong economic pressures will seek to modify any effort to manage a forest to satisfy only one of the demands. In particular, a management scheme aimed solely to meet the demand for timber (Type 1) inevitably will confront resistance, rooted in economics, if the scheme displaces other commercial demands for forest amenities, derives subsidies from or imposes externalities on others (Type 2), degrades the quality of life for nearby residents (Type 3), or threatens the forest's intrinsic values (Type 4). Stated differently, there will be pressures to manage every forest, whether privately or publicly owned, to respond to a mix of competing demands. Insofar as there are no organized, open markets to channel many, if not most, of the competing demands, those who do not see their demands being met inevitably will turn to political and public-relations arenas to pursue their desires. These pressures can be largely explained and analyzed in economic terms.

The second point is that, whenever the consumption amenities of a forest are sufficiently attractive to spur local growth in the human population, and there is no extra-market regulatory mechanism, the process inevitably will converge to an outcome that is overcongested (Myers 1987). That is, the population will grow to a level where the benefit gained by new households arriving to take advantage of the amenities is less than the loss due to crowding incurred by those already there.

Consideration of the first two points in the context of Figure 2.1 leads to the third point. In our discussion of Figure 2.1 we describe how our knowledge, institutions, and incentives act as a *lens* that focuses the interactions between a forest ecosystem and human economic activity. It has typically been the case in the past that this *lens* has encouraged the allocation of forest resources to extractive and development uses. These are sustainable only insofar as society is willing to forgo alternative uses, sustain subsidies, and endure externalities. That is to say, they are not sustainable forever. But merely ceasing the bias favoring resource extraction and development will not set the stage for a sustainable forest-economy relationship. Without active intervention to ensure that all demands for forest resources—including those amenity-related demands that often are considered benign—are sensitive to scarcity, and resources are allocated systematically to the strongest demands first, the ecosystem-economy relationship will inevitably deteriorate and unravel.

These three points highlight the greatest gaps in our knowledge of the ecosystem-economy relationship. As we demonstrate in the next chapter, little is known of the extent of the displacements, subsidies, and externalities associated with particular forest uses, or about how to manage the attenuation of them. Even less is known about households' responsiveness to the consumer amenities of forests and about how to avoid overcongestion. In short, there are important gaps in our knowledge of the demands for forest resources we label Types 2 and 3 in Figure 2.2. Filling these gaps is mandatory if ecologists and economists are to contribute meaningfully to the changes in institutions and incentives needed to move toward sustainable management of the nation's forests.

IV. SIX CASE-STUDY FORESTS, REGIONS, AND COMPETING DEMANDS

Our case studies begin in the Pacific Northwest. Economic growth in the Pacific Northwest during the 1980s and 1990s was robust at the same time that timber industry income and employment declined.[21] This rapid growth in Oregon and Washington is difficult, even impossible, to understand in light of standard input-output models (Richardson 1985), predictions made by many economic analyses during the period (Beuter 1995; Oliver et al. 1997; Schamberger et al. 1992) and standard governmental practice (Schamberger et al. 1992; U.S. Department of Agriculture and U.S. Department of the Interior 1994) used to estimate the economic effects of reduced logging on so-called timber-dependent communities. All of these predicted that a marked decline in timber production would lead to widespread economic havoc. Instead, the area exhibits widespread increases in economic prosperity.

In Oregon, for example, employment and income generated by the lumber-and-wood products industry—Standard Industrial Classification (SIC) 24—fell by 17 and 35 percent respectively between the successive cyclical peak years, 1979 and 1989, while Oregon's total employment increased by 257,000 or 23 percent (Oregon Employment Department Various Years). The Northwest Forest Plan (U.S. Department of Agriculture 1994), which formalized actions initiated by the owl's listing in 1990, reducing planned timber harvests by about three-quarters on federal lands and by three-eighths overall in western Washington, Oregon, and northern California. Throughout this period, the regional economy has consistently outperformed the rest of the nation (Pearson 1997). The inconsistency between these expectations and the Pacific Northwest's actual response to reductions in logging indicates that, even if the export-base logic once offered a useful model of the forest-economy relationship, something has changed to render it useless.

This experience supports the hypothesis that the ecosystem-economy linkages other than timber—i.e., the demands we've labeled Types 2–3—are more powerful than the timber linkage (Type 1). More fundamentally, it substantiates the analytical framework we present in the previous chapters. But, if this framework works well to explain the forest-economy relationship in the spotted-owl forests of the Pacific Northwest, how well does it work elsewhere? To answer this question, we use the framework to examine the data and literature describing the forests and economies in six disparate regions. There are few data that are both uniformly available for all sites and relevant to the analysis. It is possible, however, to cobble together enough to draw some initial conclusions.

In the remainder of this chapter, we describe the six case-study forests, discuss the economic regions associated with each of them, and summarize the competing demands for forest resources at each site. In Chapter V we present and discuss data regarding the different types of demand.

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[21] See, for example, Power et al. (1996b) and Whitelaw (1992).

Pacific Northwest (Westside)

The temperate coniferous forest represented by the H.J. Andrews Experimental Forest in Oregon covers most of Oregon and Washington west of the Cascades, with extensions into Northern California and British Columbia. The lower-elevation forests are dominated by Douglas-fir, western hemlock, and western red cedar. The upper-elevation forests contain noble fir, Pacific silver fir, Douglas-fir, and western hemlock. The lower- and middle-elevation forests in this area are among the tallest and most productive in the world.

The primary regional economic centers for the Pacific Northwest are the Seattle-Tacoma and Portland-Vancouver metropolitan complexes; the primary centers for Northern California are the Bay Area metropolitan complex, and the Sacramento area. Vancouver, British Columbia, serves as the primary regional economic center for the Canadian portion of the forest. Although the boundaries of each region are blurred by a high level of interregional and international economic intercourse, it is reasonable to conclude the Pacific Northwest region consists primarily of the states of Washington, Oregon, Idaho, and western Montana, and that the Northern California region consists primarily of the northern half of California and Nevada.

If one wants to determine if a management decision for this forest will alter discernibly the outlook for economic activity and welfare in the region, one first must consider it in the context of at least one of these large subnational regions. Only if the decision is sufficiently momentous to affect one or both of these regional economies, can one conclude that the decision will alter the overall competitiveness of the region's residents relative to the remainder of the national and global economies. If the decision is too insignificant to have such an effect, then its economic consequences will manifest themselves primarily within the region, i.e., they will be subregional or local in nature. To examine the decision's subregional effects, one should examine subregions centered on smaller metropolitan areas. Those most relevant to this forest are from north to south, Bellingham, Washington; Salem, Eugene-Springfield, and Medford, Oregon; and Redding and Santa Rosa, California.

Note that this is the only one of the six case studies where the forest surrounds the major metropolitan center (Seattle-Tacoma and Portland-Vancouver complexes) that is the core of the subnational regional economy.

Table 4.1 illustrates the competing demands for the resources of this forest. The primary commercial demand (Type 1) is the industrial production of timber. Competing commercial demands (Type 2) exist insofar as timber displaces other commercial uses of forest resources, receives subsidies, and imposes negative externalities on others. Notable displacement occurs when logging (and other factors) has an adverse effect on the supply of salmon and related species available for commercial fishing (Meehan 1991). Important subsidies occur when logging on federal lands fails to cover the full costs and receipts from logging are diverted to underwrite the industry's direct and indirect costs (Alkire 1994; Gorte 1994; Wilderness Society 1997). Important negative externalities arise when timber production increases stream sedimentation (Jones and Grant 1996) and degrades municipal-industrial water supplies.

Table 4.1: The Six Case Studies—Overview of the Competing Demands

Case-Study Forest (LTER Site)	Primary Commercial Demand (Type 1)	Examples of Competing Commercial Demands (Type 2)			Example of Quality-of-Life Demand (Type 3)	Example of Intrinsic-Value Demand (Type 4)
		Displaced Products	Subsidies	Externalities		
Pacific Northwest Westside (H.J. Andrews)	Timber	Commercial Fishing	Local Expenditure of Federal Timber Receipts	Stream Sediment	Recreational Fishing	At-Risk Species (Northern Spotted Owl)
Southern Appalachian Highlands (Coweeta)	Timber	Residential Development	Below-Cost Federal Timber Sales	Stream Sediment	Recreational Fishing	At-Risk Species (Red Wolf)
New England Northern Hardwoods (Hubbard Brook)	Timber	Residential Development Air-Pollution Treatment	Unemployment Insurance	Stream Sediment	Rural Lifestyle Near Cities	At-Risk Species (Lynx, Wolverine, Panther, Pine Marten)
Southwest (Sevilleta)						
Highland	Timber	Outdoor recreation	Below-Cost Federal Timber Sales	Stream Sediment	Associations with Pueblo Cultural History	At-Risk Species (Mexican Spotted Owl)
Riparian Bosque	Irrigated Agriculture	Municipal-Industrial Water	Federal Water Projects	Stream Dewatering	Aesthetics of Streams in a Desert Environment	At-Risk Species (Rio Grande Silvery Minnow)
Upper Midwest (North Temperate Lakes)	Timber	Residential Development	Below-Cost Federal Timber Sales	Degradation of Visual Aesthetics	Rural Lifestyle Near Cities	At-Risk Species (Gray Wolf)
Interior Alaska (Bonanza Creek)	—	—	—	—	Subsistence Hunting & Fishing	Subsistence Hunting & Fishing

The demands (Type 3) stemming from this forest's contributions to the quality of life of the region's residents are widely recognized. Although much of the evidence regarding the economic importance of these contributions is anecdotal, some survey research confirms that a sizable segment of migrants to the region are attracted by its natural-resource amenities and they are willing to accept a reduction in income to be closer to them (Oregon Business Council 1993; Oregon Employment Division 1993). The controversy over the northern spotted owl, other at-risk species, and old-growth forests amply illustrates the demands (Type 4) associated with the intrinsic value of some forest resources.

Southern Appalachian Highlands

The Southern Appalachian Highlands include parts of the Appalachian Mountains and Shenandoah Valley extending southward from the Potomac River to northern Georgia and the northeastern corner of Alabama. The Coweeta Hydrologic Laboratory is located near the southern end of the Southern Appalachias. The area's 24.9 million acres of eastern deciduous forest are known for their high species diversity: more species of trees are native to Southern Appalachia than to any of the other northern temperate regions in the world. In the northernmost part of the region, chestnut oak and select oak species dominate, but Virginia pine, chestnut oak, non-select red oaks, yellow-poplar, and shortleaf pine become more prevalent as one moves south. In eastern Tennessee the forests are predominately non-select white and red oaks, Virginia pine, and yellow-poplar. This species diversity complicates the timber markets of the region greatly because a stand may contain an array of forest products with widely varying market values (Southern Appalachian Man and the Biosphere 1996).

Atlanta is the primary metropolitan center for the economic region associated with the Southern Appalachians, especially the southern portion. Even though it is located outside the forest area, Atlanta dominates most economic activity occurring in the forest. Moving north through the forest, the forest-economy relationship feels the influence of other metropolitan centers, including Charlotte and the Research Triangle cities of North Carolina; Knoxville, Tennessee; Louisville, Kentucky; Richmond, Virginia; and Baltimore, Maryland-Washington, D.C. Indeed, centers farther afield are not irrelevant to some management issues in the forest, given the many transportation corridors through the forest and high level of visitation from throughout the eastern states (Smoky Mountain Host of North Carolina 1995; Southern Appalachian Man and the Biosphere 1996).

For our purposes, we identify industrial timber production as the primary commercial demand (Type 1) of forest resources (see Table 4.1). Competing commercial demands (Type 2) exist insofar as the timber industry displaces residential development and other commercial uses of forest resources, receives subsidies, such as below-cost federal timber sales, and imposes negative externalities, such as increased stream sedimentation, on others. The forest's cool climate relative to other areas further south, scenic views, and recreational opportunities make it a recreational oasis for many residents of the eastern seaboard. These amenities are the target of residential demand (Type 2) attracting immigrants, particularly retirees, and encouraging the development of second homes. Expansion of Atlanta's urban fringe has reached the southern edge of the forest. Surveys of residents of Southern Appalachia confirm that forest resources and the accompanying scenic vistas, wildlife habitat, and recreational opportunities add to area's quality of life

(Type 3) for many residents (Southern Appalachian Man and the Biosphere 1996). The forest's biodiversity is the focus of considerable demand for protection of intrinsic values (Type 4).

New England Northern Hardwoods

The eastern deciduous forest of New England, represented by the Hubbard Brook Experimental Forest, covers more than 10 million acres, including small portions of Maine, Massachusetts, and Connecticut, and much of the forested areas of New Hampshire and Vermont. American beech, yellow birch, and sugar maple predominate, occurring either singly or in combination. Red maple, white ash, eastern hemlock, paper birch, quaking and big tooth aspen, eastern white pine, red spruce, and northern red oak make up most of the remaining species (Hornbeck and Leak 1992).

Boston is the primary economic center related to this forest. Other, smaller metropolitan centers relevant to management decisions in this forest include the smaller metropolitan areas in Massachusetts; Manchester and Nashua, New Hampshire; Portland, Maine; and Burlington, Vermont.

Industrial timber production is the primary extractive or development demand (Type 1) for forest resources (see Table 4.1). A major competing commercial demand (Type 2) for the forest's resources is residential development. The forests of New England currently are experiencing a period of land use change associated with increased residential use of the resources as evidenced by a decrease in the average size of forest land ownership unit and an increase in the number of owners of small acreage (Brooks et al. 1992). Another competing commercial demand (Type 2) for the forest's resources comes primarily from outside the vicinity. The forest receives a large amount of airborne pollution generated by factories, electricity generators, and automobiles associated with cities generally to the east. Industrial timber production can deplete the forest's ability to assimilate this pollution. Whole-tree clearcutting and acidic precipitation, for example, has been found to deplete calcium from New England's northern forests and have been cited as a potential contributing factor to red spruce mortality at higher elevations (Pierce et al. 1993). Other Type 2 demands competing with timber are subsidies to unemployment-insurance costs for timber workers (Meyer and Rosenbaum 1996), and negative externalities associated with increased sediment levels in streams. The forest long has attracted families to live in or near it and, whenever timber production reduces the demand (Type 3) for these amenities, there is competition for the forest's resources. The demand to protect the intrinsic value (Type 4) of numerous at-risk species, including the lynx, wolverine, and panther dependent on forest habitat also competes with timber for forest resources.

Southwest

The forests of the Southwest that are represented by the Sevilleta National wildlife Refuge occur in New Mexico, southern Nevada, and Arizona. At high elevations, spruce-fir subalpine forests dominate, transitioning into valleys of pinon pine-juniper woodlands and mixed conifer forests. In riparian zones, most notably along the Rio Grande, cottonwood-willow *bosque* forests dominate.

At the most fundamental level, the economic region relevant to this forest is huge, and embraces three major metropolitan centers: Los Angeles, Denver, and Dallas. Smaller economic regions relevant to forest-management decisions are centered on Phoenix and Tucson, Arizona; Las Vegas, Nevada; Albuquerque, Las Cruces, and Santa Fe, New Mexico; and El Paso, Texas.

Table 4.1 illustrates the competing demands for the two different southwestern forests. For the high-elevation forest, the dominant commercial demand (Type 1) is the timber industry's demand for wood fiber, but, for the riparian forest, the dominant demand is agriculture's demand for irrigation water. Both types of activities can displace competing demands (Type 2) for municipal-industrial water, by diminishing the quality, quantity, or both. Both of the Type 1 demands receive federal subsidies: timber through below-cost timber sales and agriculture through subsidized dams and other federal water projects. The externalities associated with timber are similar to those described for the other sites. Those associated with irrigated agriculture include removal of water from streams and increased salinization of runoff returned to streams. The area's forests and streams are associated with some of the region's most attractive residential areas (Type 3 demand), given that much of the remainder of the region is desert. As elsewhere, extractive and development demands for forest resources must compete with the demands to protect the intrinsic value of at-risk species, such as the Mexican spotted owl and the Rio Grande silvery minnow, dependent on forest habitat.

Upper Midwest

Temperate lakes and mixed coniferous-deciduous forests characterize the forests of Northern Michigan, Wisconsin and Minnesota that are represented by the North Temperate Lakes LTER station in Wisconsin. Sugar maple, yellow birch and hemlock dominate, interspersed with extensive stands of white and red pine. Numerous peat bogs support black spruce, tamarach, and white cedar.

The regional economy associated with these forests is linked to the great cities of the Upper Midwest. Chicago has long exerted a strong economic influence over these forests, serving as the primary market and transshipment point for lumber from Michigan and Wisconsin throughout the last few decades of the 19th Century (Cronon 1991). It's influence continues, although it is filtered through or siphoned off by other large metropolitan centers: Milwaukee, Detroit, and Minneapolis.

The competing demands for the resources of these forests, shown in Table 4.1, are similar to those in New England and the southern Appalachians. Timber is the dominant commercial use of the forest (Type 1) and, as elsewhere, it displace other commercial uses, receives subsidies, and imposes environmental externalities on others (Type 2). displacement often involves residential development, including second homes. Subsidies include below-cost timber sales from the national forests. Given the absence of major river systems, the major water-related externality from logging is not streamborne sediment, but changes in the visual character of landscapes important for recreation. The forests have important consumer amenities (Type 3) and intrinsic values (Type 4).

Interior Alaska

The taiga forests of Interior Alaska, bounded on the south by the Alaska Range and on the north by the Brooks Range, are part of a circumpolar band of boreal forests. These forests are the subject of the Bonanza Creek Experimental Forest. Black spruce, larch, quaking aspen, white spruce, paper birch and balsam poplar predominate. These forests are unique for their association with an environment characterized by drastic seasonal fluctuations in length of day, and temperature, as well as by a short growing season, consistently low soil temperatures, low precipitation, and the occurrence of permafrost.

The economy of Alaska is not sufficiently well developed to constitute a major subnational regional economy. Instead, it is part of the hinterland for the Seattle-Tacoma metropolitan area. Any examination of the regional effect of a change in forest-management policy should be viewed in terms of its effects on this metropolitan center. Subregional effects should be viewed in terms of effects on Anchorage and Fairbanks.

There is little commercial use of this forest currently. It is clear, however, that any future major commercial use would encounter competing demands similar to those seen elsewhere. The forest was extensively logged in the past. Future logging is not foreseeable in the absence of major subsidization. Here, more than elsewhere, competition would come from subsistence hunting and fishing. The opportunity for subsistence hunting and fishing seems also to have considerable intrinsic value apart from its consumptive value.

V. ASSESSING THE DEMANDS FOR FOREST RESOURCES: THE TIMBER INDUSTRY

In this chapter and the next, we summarize readily available data describing the major characteristics of the competing demands for forest resources. Here, we focus on demand for timber, the most widespread of the extractive or development demands we have labeled Type 1 demand in Chapter II (see Figure 2.2). We first briefly examine data on forest land and timberland in the six states relevant to the LTER sites. We next examine data on timber production and then turn to indicators of prices, jobs, and incomes associated with timber-related products. In the next chapter we report data on the demands, which we have labeled Types 2-4, competing with the timber industry for forest resources.

The story of the competing demands for forest resources in the six case study areas is a difficult one to tell with readily available data. Although there are mountains of data on the timber industry, almost all of it is aggregated nationwide or according to the political boundaries of individual states or agglomerations of states—aggregations that fail to reflect the spatial dimensions of either the six forest ecosystems or the related regional economies. Nonetheless, the data reveal some messages important for those making or analyzing forest-management policy. These include:

- The timber industry's demand for forest resources is substantial nationwide and in all but the Interior Alaska case study. Rising prices indicate the increasing strength of this demand.

- In some important ways, however, this demand is noticeably less powerful in producing jobs and incomes than in the past. Converting a given unit of forest resources to timber is likely to generate less of an economic impact—measured primarily in jobs and incomes—than in the past. Fewer rural communities and households will be heavily dependent on timber for their prosperity.

A. Forest Land and Timberland Resources

At the national level, about 66 percent, or 490 million acres, of all forest land is classed as timberland—forest land capable of producing more than 20 cubic feet per acre per year and not withdrawn from timber production. The majority of timberland in the U.S., about 70 percent, is located in the East (Powell et al. 1993). Over 90 percent of the forest land in the eastern states of New Hampshire and North Carolina is classified as timberland (Table 5.1). Wisconsin also has an extremely high percentage of its forest land, about 96 percent, classified as timberland. In contrast, Alaska, with more acres of forest land than the other five states combined, has only 12 percent of its forest land classified as timberland. Oregon, second only to Alaska of the six states depicted in Table 5.1 in the amount of forest land, classifies three-quarters of its forest land as timberland. About one-third of New Mexico's forest land is deemed capable of producing more than 20 cubic feet per acre year and is not withdrawn from timber production.

Table 5.1: Forest and Timberland Area (Thousands of Acres) by State, 1992

State	Forest Land	Timberland	Timberland as a Percentage of Forest Land
Alaska	129,131	15,068	11.7
New Hampshire	4,981	4,760	95.6
New Mexico	15,296	5,420	35.4
North Carolina	19,278	18,710	97.1
Oregon	27,997	21,614	77.2
Wisconsin	15,513	14,921	96.2

Source: ECONorthwest with data from Powell et al. (1993).

Most of the timberland in New Hampshire, North Carolina, and Wisconsin is privately owned, with non-industrial landowners playing a primary role (Table 5.2). Alaska is unique among the six states, in that 30 percent of its timberland is owned by the State of Alaska, whereas state ownership in the remaining five states is less than 4 percent. Wisconsin has the largest percentage, 15 percent, of public timberlands controlled by counties and municipalities. Over half of the timberland in Oregon and New Mexico is under the direction of the federal government.

Table 5.2: Percent of Timberland by Ownership and State, 1992

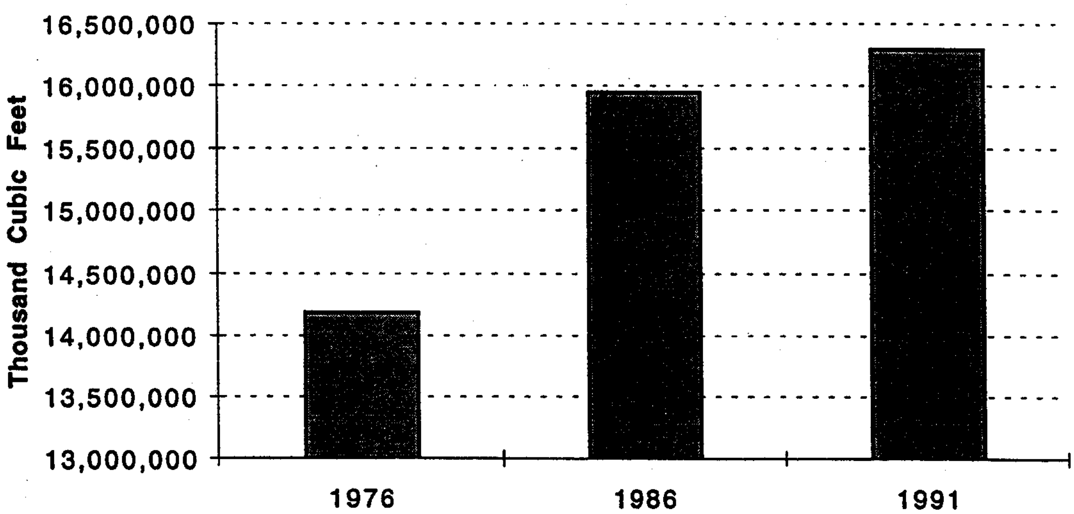
		PUBLIC (percent of total)			PRIVATE (percent of total)	
State	Total (Thousands of Acres)	Federal	State	County & Municipal	Forest Industry	Non Industrial
Alaska	15,068	28.1	30.7	0.10	0.0	41.1
New Hampshire	4,760	11.2	1.7	2.1	13.8	71.2
New Mexico	5,420	62.1	1.6	0.2	0.0	36.1
North Carolina	18,710	8.1	1.9	0.5	12.0	77.5
Oregon	21,614	56.1	3.6	0.4	22.8	17.1
Wisconsin	14,921	9.6	3.9	14.8	7.9	63.8

Source: ECONorthwest with data from Powell et al. (1993).

B. Timber Production and Prices

At the national level, annual removals have been increasing for both hardwoods and softwoods, although hardwoods continue to make up only about one-third of all removals (Powell et al. 1993). The volume of timber harvested from public lands was relatively steady in the 1970s and early 1980s but decreased in the late 1980s and early 1990s. Some believe this demonstrates a shift in Forest Service management practices from maximum timber harvest to a more balanced multiple-use framework (Farnham 1995). Removals on private lands, in contrast, have shown marked increases over this period (Haynes et al. 1995). Thus, total harvest at the national level have been increasing, as shown in Figure 5.1.

Figure 5.1: Annual Removals (Thousand Cubic Feet) of Growing Stock on Timberland in the United States 1976, 1986, and 1991.



Source: ECONorthwest with data from Powell et al. (1993).

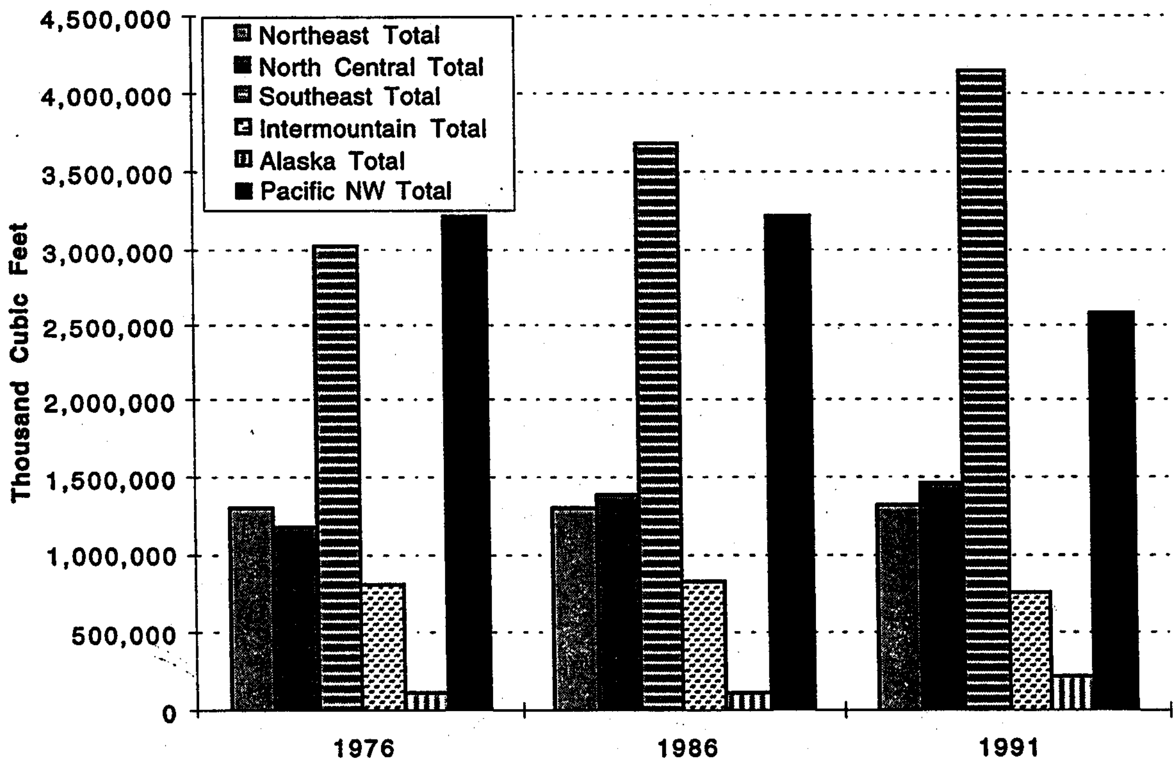
Timber productivity, the volume of timber harvested per acre, varies regionally, reflecting climate, growth rates, and harvest rates. From 1952 to 1992, the average volume of timber harvested per acre of timberland increased 95 percent in the North (includes both the Upper Midwest and the Northeast), 104 percent in the South (including the Southeast), and 27 percent in the Rocky Mountain Region (including the Southwest).[22] In the Pacific Northwest, however, the average volume per acre dropped by 4 percent during this period. Consistent with this finding is the trend in diameter class. Since 1952 the volume of

[22] For purposes of obtaining forest statistics and analyzing forest resources as required by the Forest and Rangeland Renewable Resource Planning Act of 1974 (RPA), the Forest Service divides the forest land of the U.S. into four main regions: Pacific Coast, Rocky Mountains, South, and North. Within each main region, there are subregions. The Pacific Coast region includes the subregions of the Pacific Northwest, Pacific Southwest (California), Alaska, and Hawaii. The Rocky Mountains region includes the Intermountain and Great Plains subregions. The South region is comprised of the South Central and Southeast subregions and the North region includes the North Central (Great Lakes) and Northeast subregions (Powell et al. 1993).

softwood growing stock in trees of 19 inches or greater in diameter has increased in the East and decreased in the West. The volume of large-diameter trees in the East also continues to increase (Powell et al. 1993).

At the regional level, a dramatic shift in timber production is currently occurring, away from the Pacific Northwest and towards the Southeast. The U.S. Forest Service projects an increase in the South's share of national softwood production from 54 percent in 1991 to 64 percent by 2040. Likewise, it is expected that U.S. hardwood harvests will increase by 52 percent between 1991 and 2040, with the South consistently contributing 58 percent of the total. Forest economists predict new market opportunities for eastern hardwoods in the East and Midwest as well (Wiedenbeck and Araman 1993). As Figure 5.2 illustrates, the Southeast region overtook the Pacific Northwest in total volume of timber removed in the early 1980's, while timber removals in the other four regions remained relatively constant (Haynes et al. 1995).[23]

Figure 5.2: Annual Removals of Growing Stock by Region, 1976, 1986 and 1991.



Source: ECONorthwest with data from Powell et al. (1993).

While most of nation's forests produce mainly hardwoods or softwoods, the Southeast is unique among the six regions for producing a high volume of both hardwoods and softwoods. In fact, the Southeast leads the nation in softwood production. However, with

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[23] The majority of timber removals in Alaska occurs in the Tongass National Forest. Thus, Alaskan data are not a good indicator of what is occurring in Interior Alaska. However, given severe data limitations, it is the only indicator available.

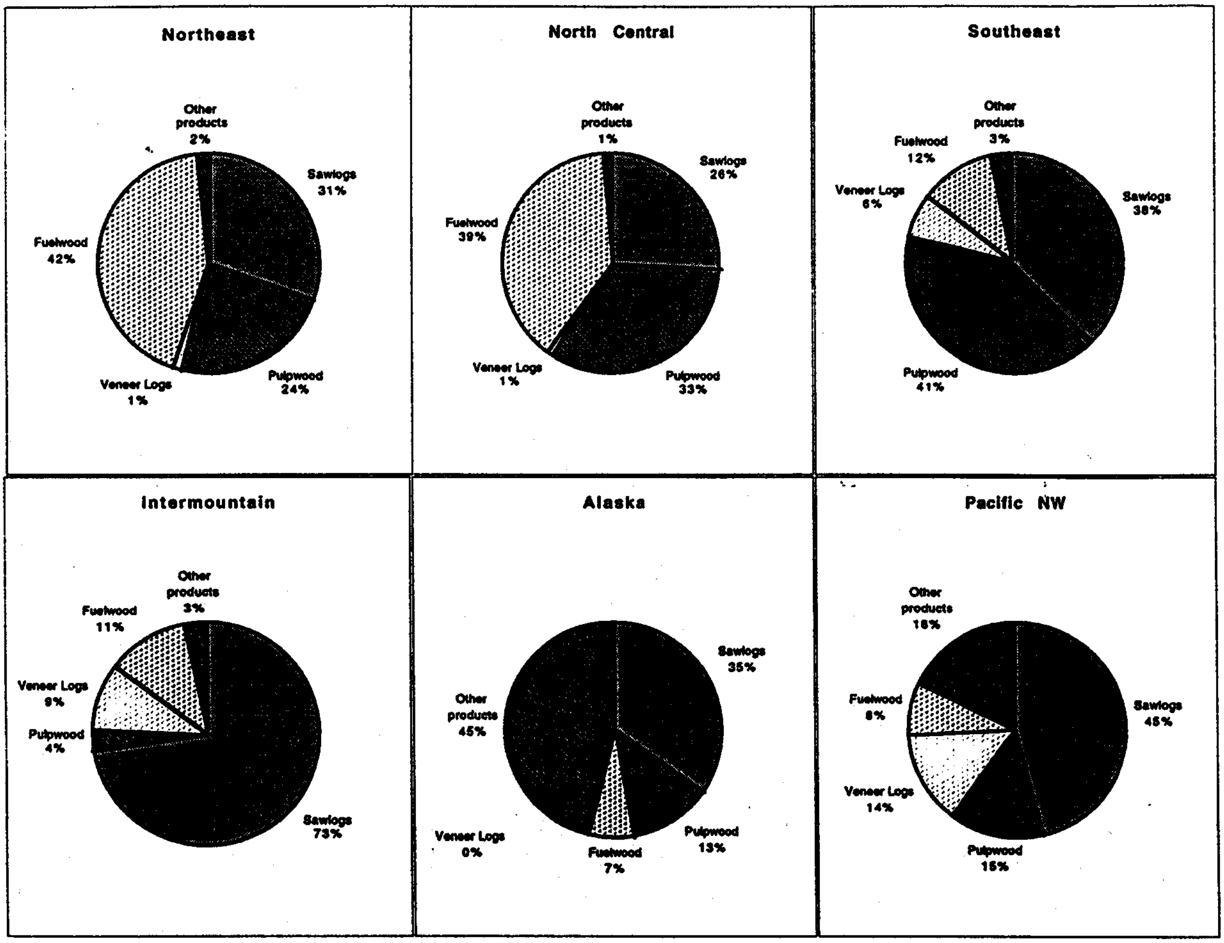
timber removals above net annual growth over large areas, and inventories decreasing since the late 1980's, it's not clear how long the region will be able to continue to log at this rate (Kaiser 1993; U.S. Department of Agriculture 1988). The Pacific Northwest region, the historical leader in softwood production, lost this distinction in the late 1980's, after ignoring warnings appearing in the early 1970's about unsustainable harvest rates (Beuter et al. 1976). Removals in the North Central region have increased over time but not as rapidly as in the Southeast. Notably, the Northeast region has produced a steady stream of hardwoods for the last 15 years. In New Hampshire, timber growth is nearly double removals (Ganser et al. 1990).

Since the type of wood harvested, softwood or hardwood, determines to a large extent the wood product produced, the six regions differ substantially in terms of their product distribution, as illustrated in Figure 5.3. About 40 percent of all timber harvested in the Northeast and the Upper Midwest is used for fuelwood with another 30 percent in sawlogs and pulpwood each, and only a marginal amount being used for veneer or other products. In contrast, almost three out of every 4 logs are used for sawlog production in the Intermountain region which contains the Southwest. The Southeast is almost evenly split between sawlog and pulpwood production, mirroring its harvest of softwood and hardwoods. In the Pacific Northwest and Alaska, 45 and 35 percent, respectively, of timber production is used for sawlogs with approximately 15 percent going to pulpwood production. The category "other", which accounts for nearly half of Alaska's timber production, accounts mostly for timber exports. (We remind the reader that the data for Alaska reflect primarily the southeastern portion of the state, distant from the Bonanza Creek LTER site.)

The value of timber in the different regions reflects the quality, costs, and supply of timber available. The U.S. Forest Service projects a rise in sawtimber prices over the next 25 years in all regions, but most notably in the Pacific Northwest and South, as adjustments are made to timber supply limitations. By 2015, however, the Forest Service expects prices to be generally stable in most regions. In the South, stumpage prices have traditionally lagged behind the rest of the nation. The price differential is projected to gradually disappear during the 1990s as Southern output replaces that of the Pacific Northwest. In pulpwood, short-term prices are expected to decline as a result of the impact of recycling on the demand for fiber. By 2010, however, prices are expected to begin to rise more rapidly as recycling rates stabilize (Haynes et al. 1995).[24]

[24] Severe data limitations prevent a more thorough discussion of price trends at the state level. For a good explanation see Lutz et al. (1992).

Figure 5.3: Timber Products by Region, 1991.



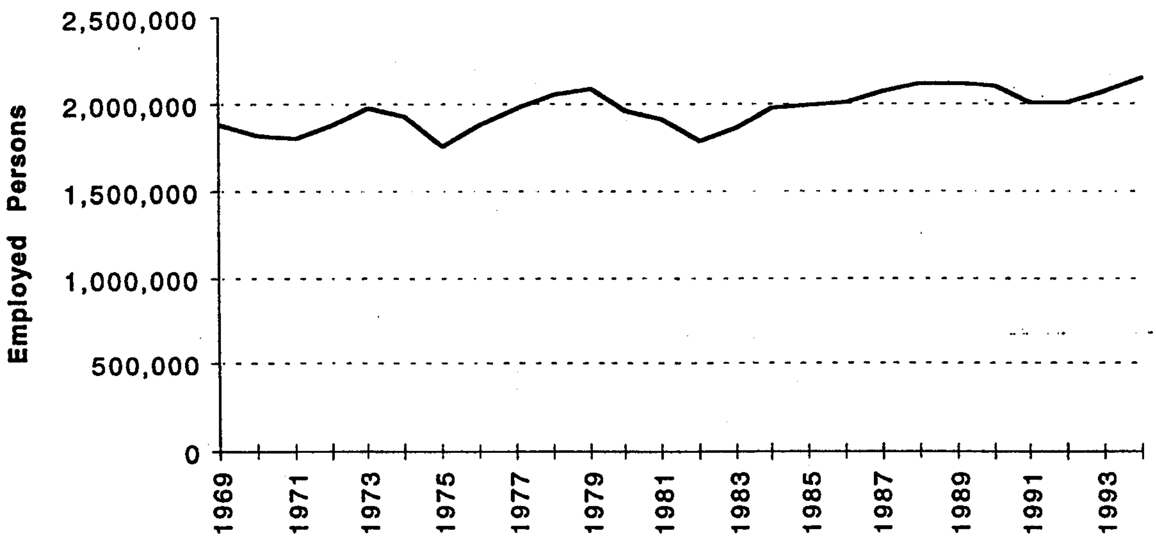
Source: ECONorthwest with data from Powell et al. (1993)

In summary, timber production and prices continue to rise for both hardwoods and softwoods. Over time, however, one can expect production to shift from the public lands in the Pacific Northwest to private lands in the Southeast and Upper Midwest as these regions' volume per acre and trunk diameters continue to increase.

C. Timber-Industry Employment and Incomes

Groups use different mechanisms to compete for forest resources. Much of this competition manifests itself through concerns about jobs and incomes. To the extent that workers, communities, and political leaders place a premium on increasing the employment opportunities available to them or their constituents, they promote forest-management alternatives that will yield this result, especially in the relatively short run. Typically, this means promoting decisions that allocate greater amounts of forest resources to resource-intensive industries. Long ago, these industries, along with their derivative industries, such as food processing, sawmills and smelters, were the primary sources of income and wealth in the U.S. Today they play a much smaller role in the nation's economy. As Figure 5.4 illustrates, employment in the timber industry (lumber and wood products (SIC 24), furniture and fixtures (SIC 25), and paper and allied products (SIC 26)has been relatively stagnant, and we expect this trend to continue.

Figure 5.4: U.S. Employment in the Timber Industry (SIC 24, 25, and 26), 1969–94.

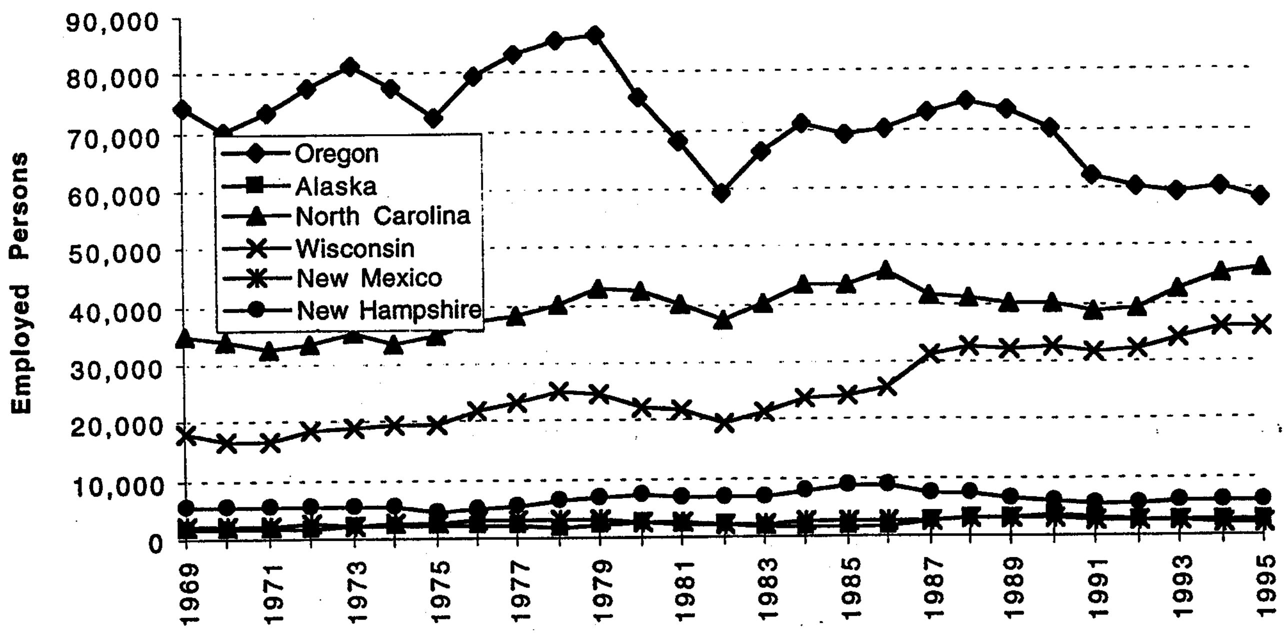


Source: ECONorthwest with data from the U.S. Department of Commerce (1995).

Employment in the lumber-and-wood products industry, as shown in Figure 5.5, illustrates the national shift in timber employment away from the Pacific Northwest and towards the Southern Appalachian Highlands and Upper Midwest.[25] This shift in employment, however, occurred slowly over a 25 year period. In three of the states, New Mexico, New Hampshire and Alaska, the lumber-and-wood products industry has remained relatively static. In Oregon, employment in the lumber-and-wood-products industry in recent years has returned to the levels of the early 1980s, when the collapse of this industry was widely seen as the cause of a major recession. This time, though, the state's economy has continued to expand, largely independent of low timber employment.

[25] We chose to focus on the lumber-and-wood-products industry because it is most closely tied to forest resources. The furniture industry, in contrast, often operates at great distance from its supply of wood. We exclude the pulp-and-paper sector due to its ability to find substitute sources of pulp in both the global market and through utilization of alternative species (Forest Ecosystem Management Assessment Team 1993).

Figure 5.5: Employment in the Lumber-and-Wood Products Industry (SIC 24), 1969–95.



Source: ECONorthwest with data from the U.S. Department of Commerce (1995).

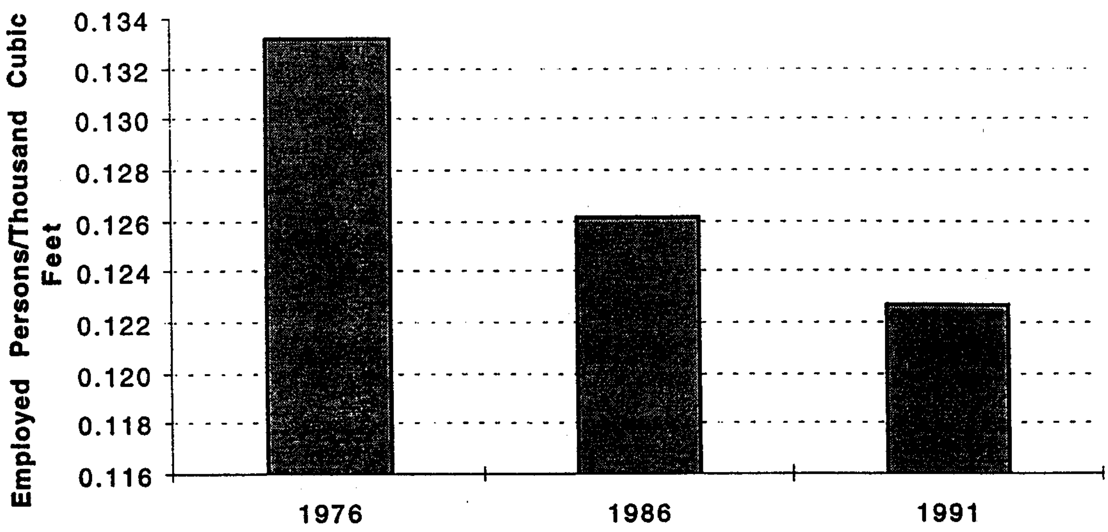
In Chapter III, we discuss the economic and social factors, including the adoption of labor-saving technological advances, a decline in the influence of labor unions, and a decline in real wages, underlying the decline in resource-related industries as a source of jobs and incomes in the U.S. economy. Figure 5.6 illustrates the declining ability of the timber industry to generate jobs and incomes for communities throughout the nation. The number of jobs per thousand cubic feet of timber harvest has been declining for the last 20 years.

In the foreseeable future, these trends will not reverse and, thus, the resource-related industries will not become major sources of new jobs and higher incomes. Economic forecasters do not expect jobs or wages in the resource-extraction and manufacturing sectors to increases significantly (Franklin 1993; Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife 1995). Labor economists in Oregon note these realities:

> Where in 1979 it took 4.5 workers to process 1 million board feet of product in Northwest mills, by 1987 it took only 2.7 workers. More recent figures for 'high tech' mills show the number down to only 1.5 workers needed for the same production. Even if production levels could be held constant, fewer workers would be needed to produce the same output (Oregon Employment Division: Research et al. 1993 p. 13).

There is some evidence that the displacement of labor through the integration of computers and other high-technology into the timber industry also is occurring in other regions, including the Southeast (West and Sinclair 1991).

Figure 5.6: Timber Employment-Harvest Ratios (SIC 24, 25, and 26) for the U.S., 1976, 1986, 1991.



Source: ECONorthwest with data from Powell et al. (1993) and the U.S. Department of Commerce (1995).

The same forces and phenomena apply to the industry's contributions to household income. The amount of money workers take home per unit of forest extracted by the industry has been declining or stagnant for at least the past two decades. The most striking decline has occurred in the Pacific Northwest. Table 5.3 compares 1979 and 1989, the peak years of the two economic expansions prior to the listing of the northern spotted owl as a threatened species. The data show that although the amount of wood harvested in Oregon was up almost 10 percent in 1989, jobs and payrolls in the lumber-and-wood-products industry were down (Niemi and Whitelaw 1994). The number of jobs per million board feet was down 24 percent, while the payroll, adjusted for inflation, was down 38 percent. In other words, during the decade, this aspect of the demand for timber extraction, expressed in political arenas through policies to encourage short-run jobs and incomes for workers in the timber industry, declined by about one-quarter to one-third.

Table 5.3: Changes in Employment and Payrolls in Oregon's Lumber-and-Wood-Products Industry

Variable	Change Between 1979 and 1989	
	Percent	Amount
Harvest	+ 9	– –
Jobs in Lumber and Wood Products Manufacturing	-17	-13,892
Jobs per Million Board Feet	-24	-2.6
Payroll/Employee[a]	-18	-$6,235
Payroll per Million Board Feet	-38	-$138,852

[a]Payroll in 1992 dollars

Source: Niemi and Whitelaw (1994).

The industry in other areas has not demonstrated similar reductions in wages, at least in part because wages already are low. The average wage in 1994 for workers in the lumber-and-wood-products industry in the Southern Appalachian Highlands, for example, was 3 percent below the income considered the threshold of poverty for a family of four, and the average wage in the furniture industry was 2 percent above the threshold (Southern Appalachian Man and the Biosphere 1996).[26] Only the paper industry, which provides less than one-quarter of the region's timber-related jobs, paid wages significantly more than (nearly double) the poverty threshold.

Table 5.4 shows total wage and salary employment, total wage and salary disbursements, and annual wage and salary disbursements per worker in the lumber-and-wood-products industry for the six states representative of the six case-study forests, and compares this with the state and national wage and salary information for all manufacturing. The data show that, in all states but Alaska, the annual wage and salary earnings per worker in the lumber-and-wood-products industry in 1995 was significantly less than the annual wage and salary earnings for workers in the manufacturing industry as a whole. Individuals employed in Alaska and Oregon's lumber-and-wood products industries, on average, earned more in 1995 than their counterparts in the four remaining states, although the higher wages in Alaska largely reflect the state's higher cost of living.

Table 5.4: Total Wage and Salary Employment and Disbursement, and Annual Wage and Salary Disbursements Per Worker in the Lumber-and Wood-Products (SIC 24) and Manufacturing Industries (SIC 20–39), 1995

	Total Employment (SIC 24)	Total Wage and Salary (SIC 24) ($000)	Annual Wage and Salary Per Worker (SIC 24)	Total Employment (SIC 20-39)	Total Wage and Salary (SIC 20-39) ($000)	Annual Wage and Salary Per Worker (SIC 20-39)
Alaska	2,299	$98,495	$42,843	17,190	$512,100	$29,791
New Hampshire	4,616	107,909	23,377	102,658	3,547,848	34,560
New Mexico	2,124	43,535	20,497	45,804	1,279,032	27,924
North Carolina	42,808	953,987	22,285	865,822	24,292,693	28,057
Oregon	54,735	1,637,868	29,924	230,095	7,634,532	33,180
Wisconsin	30,947	705,755	22,805	604,640	19,489,230	32,233
U.S.	789,000	19,370,000	24,550	18,585,000	648,469,000	34,892

Source: ECONorthwest with data from the U.S. Department of Commerce, Bureau of Economic Analysis (1996).

[26] Although the furniture industry (SIC 25), is often considered part of the timber industry, especially in the Southeast, its connection to a particular forested ecosystem and regional economy is tenuous. The economic justification for locating adjacent to the forest that is the source of raw material is not as compelling as it is for the other two timber sectors, lumber-and-wood products and paper-and-allied products. One of the largest concentrations of SIC 25 employment, for example, is in Los Angeles, a long distance from raw materials.

The low wages in those sectors of the timber industry other than the manufacture of paper and allied products have important implications for households and communities. For the past century, forest-management agencies—the Forest Service and Bureau of Land Management, along with numerous state and local counterparts—have held that the allocation of forest resources to the timber industry could be manipulated to produce prosperous and stable communities (Robbins 1989). Research from different regions, however, casts serious doubts on this premise. Looking at Western Washington during the 1980s, Cook (1995) found that areas where the timber industry was a larger percentage of total employment tended to exhibit rising poverty, slower growth in employment and incomes, and increasing family instability. Kusel and Fortmann (1991) found that socioeconomic well-being in forest-dependent communities is most closely related to the diversity of the human capital in the community, the diversity of uses of the adjacent forest, and the diversity of control (ownership) over nearby resources. Those communities with the narrowest ties to the forest had the lowest well-being. These findings are generally confirmed by others. Overdevest and Green (1995), for example, find that although counties with well-capitalized pulp and paper plants generally exhibit better economic indicators, the same cannot be said about those linked more closely to forest-management itself and to the primary processing of timber.

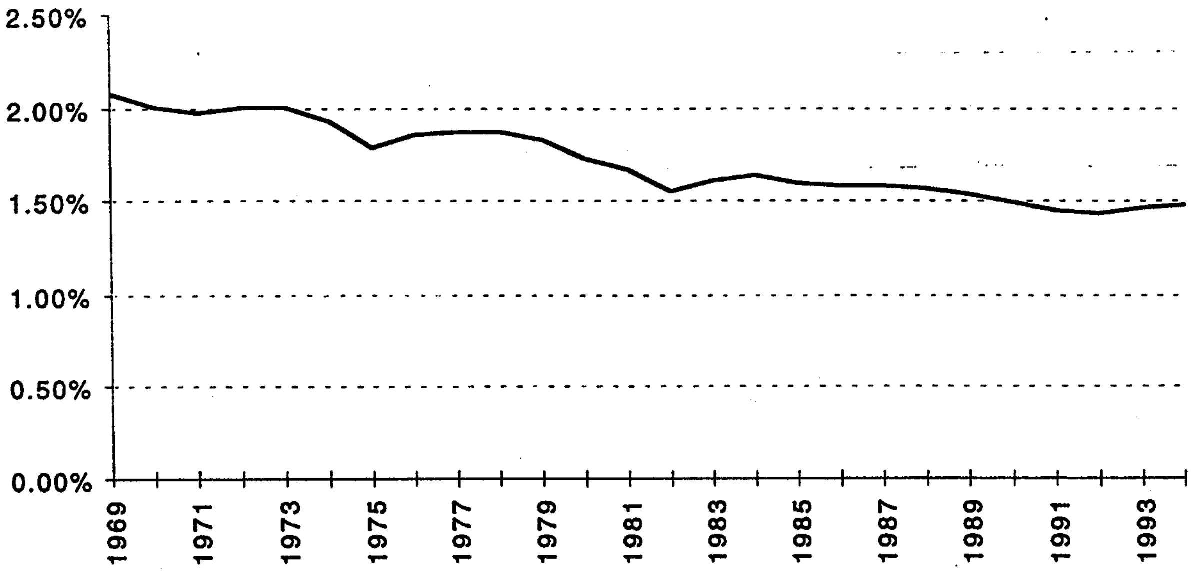
The central message here is that the timber industry has made, and will continue to make, important contributions to the economic well-being of many American workers, families, and communities, but it will not be as important as it was in the past. In terms of the economic variables—jobs and incomes—immediately important to most households, the timber industry will yield fewer benefits per unit of forest it consumes. Arguments that allocating forest resources to timber production is needed to sustain prosperous and stable communities increasingly will be seen as having less substance than in the past.

D. Timber's Role in the Overall Economy

Several additional indicators confirm that timber's importance within the greater economy is diminishing over time. This is true at both the national and regional levels, even where timber harvest and employment are increasing. Evidence below suggests that a giant decoupling of the economy from its natural resource base has occurred in the last 25 years. No longer are harvest rates driving regional economies in any of the states we examine. This is true of the traditional timber state of Oregon, as well as those, such as North Carolina and Wisconsin, where timber production is likely to grow.

Figure 5.7 illustrates the magnitude of the decline in the timber industry relative to other industries. Between 1969 and 1994, direct employment in the timber industry (lumber and wood products, furniture and fixtures, and paper and allied products) declined from a little over 2 percent of total U.S. employment to about 1.5 percent. Recall from above, that the share of national employment in the timber industry declined even as national harvest levels continue to climb. Now and in the foreseeable future, most increases in jobs and incomes will occur in industries other than the resource-intensive industries. With this trend, most areas should see a diminishing demand for timber extraction coming from those seeking policy promoting short-run extractive jobs and incomes. This shift represents a fundamental reduction of the jobs-related competition for forest resources.

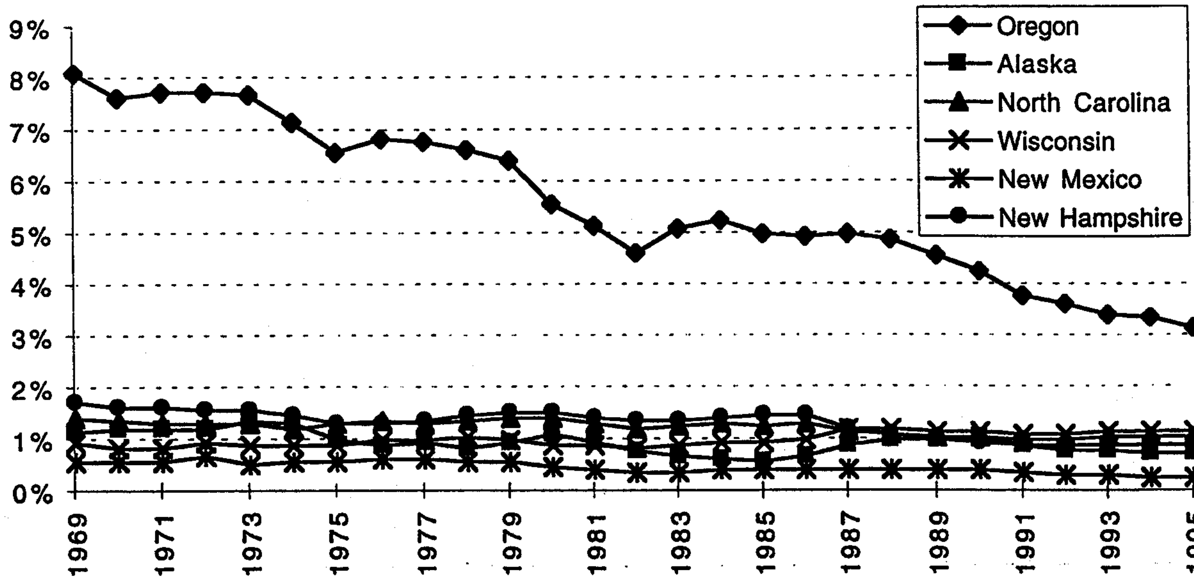
Figure 5.7: U.S. Employment in the Timber Industry (SIC. 24, 25, and 26) as a Percentage of Total U.S. Employment, 1969–94.



Source: ECONorthwest with data from the U.S. Department of Commerce (1995).

Regional trends mirror what's occurring at the national level. Although the six sites are different in terms of amount of harvest and timber manufacturing trends, timber employment as a percentage of state total is declining or static in all regions. This is especially important to note in the Southern Appalachian Highlands and the Upper Midwest, where employment and harvest levels have been increasing. As Figure 5.8 illustrates, employment in the lumber-and-wood products industry makes up about 1 percent of total employment in all the states except Oregon, where it has declined from 8 percent in 1969 to about 3 percent in 1995. One interpretation of this trend is that Oregon, and the Pacific Northwest more generally, represented the last frontier for the timber industry. Now that most of the area has been cut at least once, the industries' importance is falling to levels that mirror that of the other regions. This is not to say, however, that the competition for the remaining, late-successional, old-growth forests is trivial, only that the frontier has a smaller front than in the past.

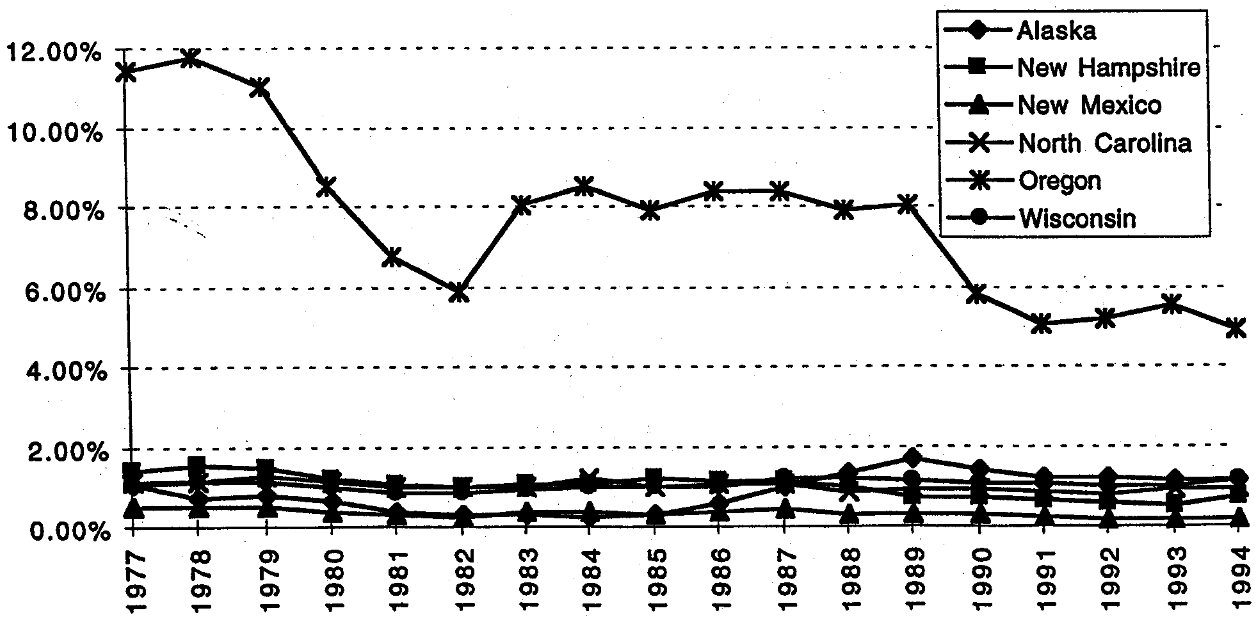
Figure 5.8: Employment in Lumber-and-Wood Products Industry (SIC 24) as a Percentage of Total State Employment, 1969–95.



Source: ECONorthwest with data from the U.S. Department of Commerce (1995).

Another way of examining the importance of the timber industry relative to the rest of the economy, is to look at the portion of the gross state product (GSP) derived from timber industry activity. As Figure 5.9 illustrates, despite the increase in timber harvest occurring in the Southern Appalachian Highlands and Upper Midwest, the percentage of total GSP derived from the lumber-and-wood products industry is static.

Figure 5.9: GSP from the Lumber-and-Wood Products Industry as a Percentage of Total GSP in Respective States, 1977–94.



Source: ECONorthwest with data from the U.S. Department of Commerce (1995).

The only state, Oregon, in which a significant amount of GSP was once derived from the lumber-and-wood products industry, experienced more than a 50 percent reduction in the importance of timber to the state's economy over period 1977–94.

E. Summary

In Chapter III we discuss the different ways people express their demand for forest resources and combine them into three types of variables: value, impact, and equity. In this chapter we summarize value and impact data regarding the timber industry's demand for forest resources. The data indicate that the timber-related demand generally is increasing, i.e., the relative prices of timber products are rising. The regional markets for timber are closely linked nationally, and even globally, however, so that forest-management decisions affecting one regional market are moderated by the response nationally and globally. There are some important regional differences, most notably the essentially zero value of timber in Interior Alaska, which primarily reflects the high cost of extracting timber and exporting it to world markets.

Although economists typically look at value to gauge the strength of a given type of demand and recommend using values to allocate forest resources among competing demands, the American public and political structure often take a different approach. They seek to allocate forest resources to generate jobs and incomes, especially in the short run. The data on jobs and incomes indicate that this aspect of the pressure to convert forest resources to timber products is generally stagnant or declining. In some regions, notably the Pacific Northwest, the jobs and incomes per unit of forest consumed by the timber industry have declined markedly over the past two decades and further declines are anticipated. In other regions, timber-related jobs and incomes have been more stable, in absolute terms, but have remained a small percentage of total jobs and incomes relative to the remainder of the economy.

We now repeat a message from Chapter III. In all regions, allocating a unit of forest resources—measured in acres, million board feet, or other units—to a resource-intensive industry in the future probably will generate fewer jobs and smaller incomes than in the past. Communities seeking to develop new jobs generally will have to look to industries other than resource-related industries. Communities that have depended heavily on resource-related industries generally should expect economic stagnation or contraction in the future if they continue to depend on these industries. Furthermore, communities where the timber industry constitutes a major segment of the local economy often exhibit high levels of poverty and other indicators of social stress. In public opinion, lawsuits, and administrative proceedings, where the competition for forest resources is taking place, these changes undoubtedly weaken the arguments of those supporting allocation of forest resources to timber production. In other words, this component of the timber industry's demand for forest resources weakens.

In the next chapter, we examine the strength of those elements of demand that are competing with the timber industry for forest resources.

VI. ASSESSING THE DEMANDS FOR FOREST RESOURCES: DEMANDS COMPETING WITH THE TIMBER INDUSTRY

In this chapter we examine the major sources of demand for forest resources that are competing with the demand from the timber industry. We look first at competing commercial demand (Type 2). As we discuss in Chapter II, this type of demand has three components: direct displacement of other commercial activity, subsidies, and externalities. Here, we discuss only subsidies and externalities, having given examples of displaced commercial activity in Table 4.1. We then examine indicators of the demand for forest-related consumer amenities that may affect the locational decisions of household (Type 3). We conclude with a discussion of some of the demand for protecting the intrinsic value associated with each of the six case-study forests (Type 4).

A. Subsidies to the Timber Industry

The most obvious subsidy to the forest industry occurs through the public timber sale program. U.S. taxpayers subsidize the timber industry by allowing it to obtain timber from national forests across the US and pay less than the costs the Forest Service incurs to administer the timber-sale program (Council of Economic Advisers 1994; Greenberg 1997; Wilderness Society 1997). There is no single accounting scheme for measuring the extent of the subsidy, but the alternative approaches, combined, demonstrate that the subsidy is substantial.

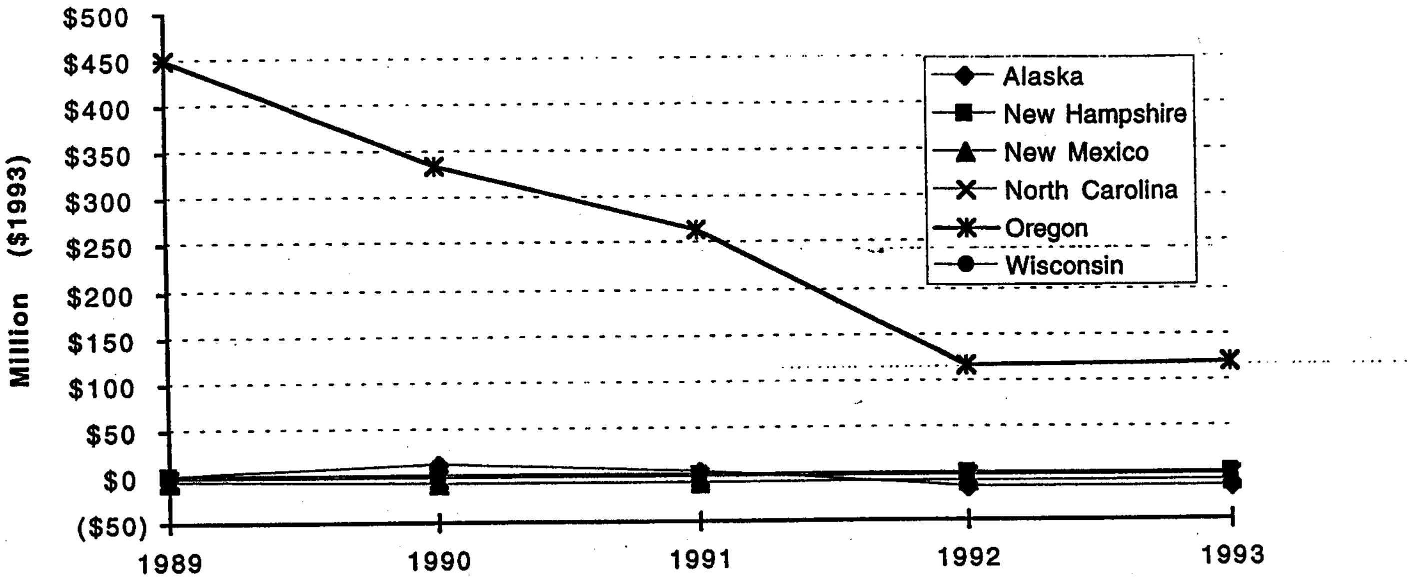
One approach, the so-called cash-flow approach, compares the amount taxpayers spend on the timber-sale program with the amount the program returns to the Treasury. This approach measures the direct impacts of the timber-sale program on the Treasury and taxpayers. Since results may vary from year-to-year, it works best when applied over a multiple-year period. It also is limited if, in the course of implementing the timber-sale program, the Forest Service makes long-term investments. In such cases, the cash-flow analysis will show these as costs but not show the corresponding, subsequent return on the investment.

To address at least some of the limitations of the cash-flow approach, the Forest Service developed the Timber Sale Program Information Reporting System (TSPIRS). It attempts to estimate the annual profits or losses for each national forests in a manner consistent with common accounting practices for private landowners. Although many critics argue that it incorrectly excludes many costs of the timber-sale program,[27] an analysis by the Congressional Research Service (Gorte 1994) concluded that " in general, TSPIRS adequately measures the profitability of the annual timber program for each national forest. Figure 6.1 shows the results from the TSPIRS for the period 1989–93. The data show that, by the Forest Service's own accounting, taxpayers subsidized the timber-sale

[27] See, for example, The Wilderness Society (1994).

program for 5 years in New Mexico, New Hampshire, Minnesota and North Carolina. In Alaska, taxpayers subsidized the timber-sale program in 1992 and 1993 at a cost of close to $15 million. In Oregon, at a statewide basis the National Forests ran at a profit for each of years examined, although the size of that profit fell from $450 million in 1989 to just over $100 million in 1992 and 1993.

Figure 6.1: Net Profit (Loss) as Reported in TSPIRS, 1989–93



Source: ECONorthwest with data from Gorte (1994).

When it implements TSPIRS, the Forest Service does not address logging's impacts on all the competing demands for forest resources and, hence, the trends in Figure 6.1 do not reflect numerous types of economic damage associated with logging. In particular, they do not include two types of damage we discuss below: the off-site, sediment-related damages imposed on others downstream from each logging site, and the damages imposed on those who value the quality of life associated with unlogged forests. Further, the numbers in Figure 6.1 are annual statewide averages and do not represent the profit or loss associated with individual timber sales or national forests. It is possible that, even when, on average, a forest yields a net profit, individual timber sales may yield a loss, and vice versa.

The timber industry also receives a subsidy from workers and business owners insofar as it fails to pay the full cost of its labor practices. Virtually all employers must pay an annual premium to provide unemployment insurance for their employees. It is intended that, over time, the firm's premiums will balance the amount of unemployment benefits paid to its unemployed workers. But for the lumber-and-wood products industry, as well as handful of other industries, the amount of benefits paid to the industry's unemployed workers exceeds the premiums paid in prompting one researcher to conclude, "[A] substantial portion of UI resources subsidize certain firms and industries rather than provide true insurance" (Meyer and Rosenbaum 1996). As the timber industry has shrunk its laborforce, more and more timber workers have drawn on unemployment insurance, increasing the size of the subsidy over time.

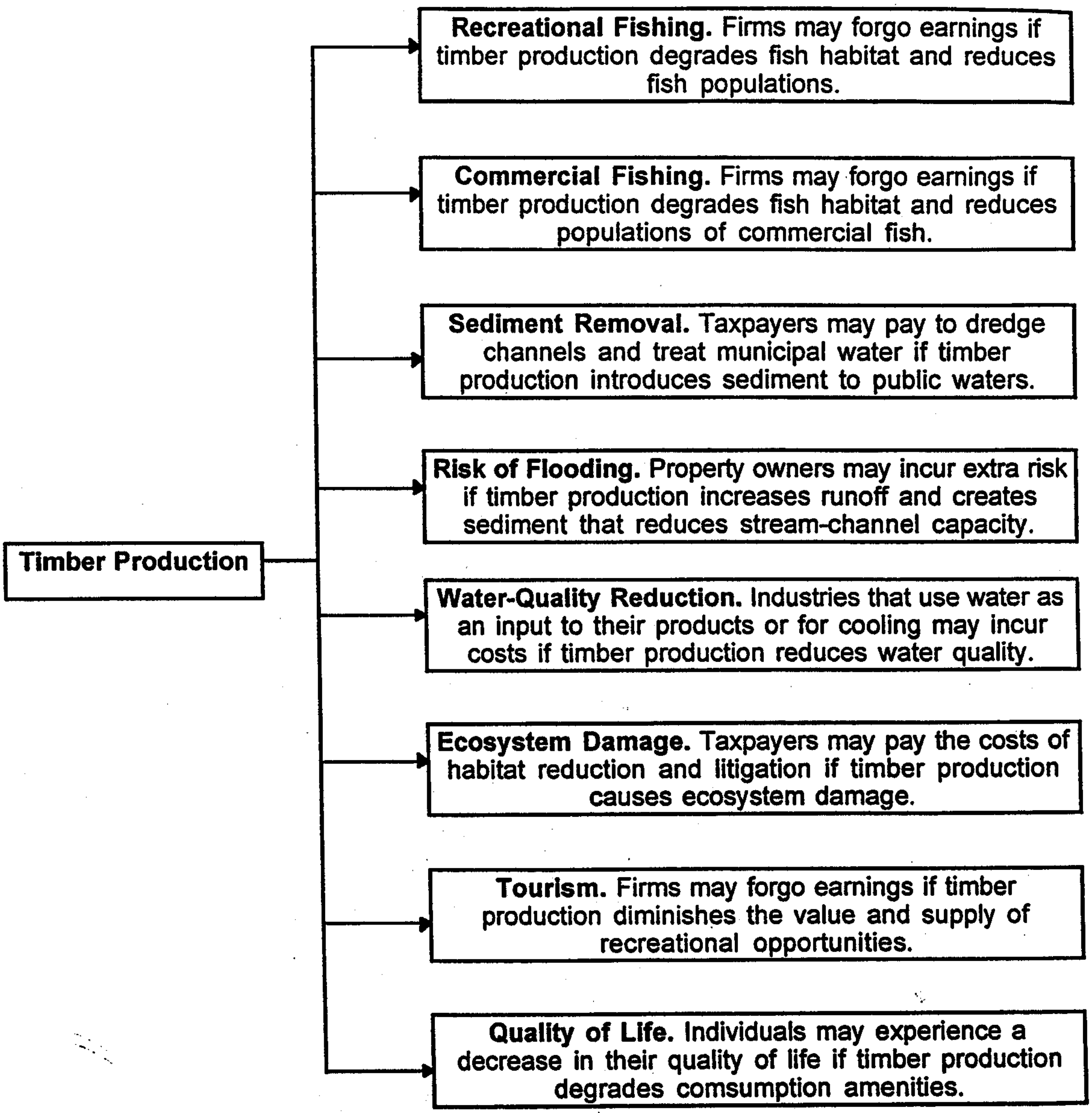
On the surface, subsidies are inherently neither good nor bad, insofar as they reflect decisions by legislatures to employ this public-policy mechanism to achieve particular objectives. From this perspective, subsidies are nothing more than the cost society incurs to obtain the target benefits. It is not uncommon to see the linkages between subsidies and these benefits erode, however, as the social and economic conditions that prompted the subsidy change over time. Even when the linkage is tight, subsidies distort the use of forest resources by giving those who benefit from them an additional incentive to use the resources, while imposing costs on those who provide subsidies. Pressure, political or otherwise, to reduce the subsidies constitutes, in effect, a competing demand for those resources that would not be logged, but for the subsidies. This demand should be taken into account if one is to assess the full competition for forest resources and the full economic consequences of forest-management decisions.

B. Negative Externalities of Timber Production

Environmental externalities occur when industrial timber-production activities alter a forest resource and inadvertently impose increases in costs on taxpayers, households, and firms in other industries. Figure 6.2 identifies seven categories of environmental externalities that might arise from timber production. Most of them stem from alterations in streams that occur when logging and related activities, especially road-building, increase the level of sediment, raise water temperatures, increase streamflows during some periods, and alter riparian vegetation or the hydrologic structure of stream channels. For an introduction to these issues, see Brown and Binkley (1994), Meehan (1991), and Reid (1993).

To facilitate the investigation of externalities associated with timber production, we focus on sediment. Not all effects of sediment production are considered negative, and some positive effects, such as importing soil and soil nutrients to the area where the sediment is deposited, can be especially important. Nonetheless, most of the attention has been given to the negative effects shown in Figure 6.2. There is a long history of investigations into, and often heated debates about, the effects of timber production on sediment, and about the effects of sediment on the ecosystem. Surprisingly, however, there is virtually no literature that answers the question, If timber production increases sedimentation and if the increased sedimentation has specific ecological effects, what are the economic consequences? Indeed, there are only a few efforts to address comprehensively the economic consequences of sediment from other sources. Ribaudo (1989) traces the economic consequences of sediment from agricultural production in the U.S., and Pimentel et al. (1995) look at the worldwide economic costs of sediment from all causes. Our search of the literature found nothing similar focusing on timber production and other forest-management activities.

Figure 6.2: Possible Externalities from Timber Production



Source: ECONorthwest.

Some sedimentation occurs in forest streams in the absence of timber production, with the propensity for sedimentation varying among forests and among sites within a particular forest. In general, the highest sedimentation levels occur in the Southern Rockies, and the lowest occur in New England (see Table 6.1). In the following paragraphs we briefly summarize the backdrop for future efforts to examine the economic importance of sediment-related externalities of timber production in the case-study areas.

Table 6.1: Average Stream Sediment Concentration

Average Stream Sediment Concentration, 1968	Region
Highest	Southern Rocky Mountains
	Plains States
	California
	Central States
	Northern Rocky Mountains
	Southeast
	West Gulf
	Southern Atlantic States
	Pacific Northwest
	Lake States
	Middle Atlantic States
Lowest	New England States

Source: ECONorthwest with Megahan (1972).

Pacific Northwest (Westside). Sedimentation from logging and associated road-building has been extensively researched in this region. See, for example, Adams (1994) and Grant (1991). Studies of small watersheds indicate that episodic mass erosion, influenced heavily by the timing and severity of storms, dominate the Pacific Northwest forest landscape. Despite the highly variable natural erosion processes, harvest activities—road building, yarding, slash burning, and preparing sites for planting—can produce discernible increases in sedimentation. Once sediment becomes available to streams, concentrations are influenced by fluvial processes. The relationships among forest-management activities, sediment delivery, and turbidity vary from watershed to watershed, and from storm to storm, making it difficult to extrapolate from one event or site (Harr 1992).

Much of the attention has focused on the impacts of sediment on fish, especially anadramous salmonids, although the mechanisms of these impacts remain unclear (Reeves 1992). Floods in 1996 focused recent attention on the extent to which logging, roadbuilding, and other practices contributed to high levels of turbidity, especially as it affected municipal-industrial water supplies. The linkages, if any, between timber production and other potential consequences of increased sedimentation, such as siltation of channels and impacts on flood levels, have received less attention (Tuchman et al. 1996; Weaver and Hagans 1996).

Southern Appalachian Highlands. The Southern Appalachians are the headwaters for streams and rivers throughout the southeastern U.S. Sediment is the most significant pollutant in southern streams and about two-thirds of the region's water pollution is attributed to nonpoint sources, including forest-management activities. According to the *Southern Appalachian Assessment*, forest-management activities are considered to be only a minor contributor although Marion and Ursic (1992) observe that most studies on the topic in the South exclude sediment from forest roads. Forest streams generally exhibit the region's lowest concentrations of nonpoint source pollutants and meet sediment-related water quality standards (Neary et al. 1992). These characteristics may change, however, as timber production in the region increases in response to recent and predicted price increases.

Neary et al. (1992) report that studies on federal lands in the South found considerable variability in forest-management practices across physiographic subregions. Human activities raised sediment yields between 5 and 500 percent above natural levels. In mountainous areas of the South, forest-management activities account for 2–10 percent of the human-induced sediment, and the selection of logging and site-preparation techniques can have important influence on sediment levels. Erosion from all sources in the steep portions of the Blue Ridge Mountains is 50–60 times levels in the flat forests of the Atlantic Coastal Plain. The proximity of streams to gravel or low-quality roads makes roads a major contributor of sediment, but the extent to which timber production is responsible for these roads in not certain (Southern Appalachian Man and the Biosphere 1996). There is little research linking sedimentation from forest-management activities to downstream costs.

New England Northern Hardwood Forest. This region's forest soils are not prone to erosion (Martin and Hornbeck 1992). Therefore, substantial increases in turbidity and soil erosion after clearcutting are relatively rare and "with proper precautions can be controlled during and after harvest" (Hornbeck et al. 1987 p. 5). Research instead has focused on the effectiveness of riparian zones to decrease changes in water temperature from the loss of forest canopy and changes in volume of streamflow (Hornbeck and Leak 1992; Pierce et al. 1993).

Southwest. In their summary of the sediment-related literature on the Southwest, DeBano and Baker (1992) observe that the linkages between land management and stream sediment are affected by more than a century of livestock grazing, clearing of trees, industrial logging, wildfires, all of which have affected large landscapes, and smaller activities, such as the development of low-standard roads. Together, these activities have removed riparian and upland vegetation, compacted soils, increased surface runoff, and increased the erosive power of the streams. Especially important are the biological and physical modifications of riparian zones. Wetlands cover less than 1 percent of Arizona and New Mexico, and represent about 65 percent of the wetlands that existed 200 years ago (Fretwell et al. 1996). Most of the wetland losses have occurred in the bosque forests along larger rivers. Higher elevation areas have fared better, although they have been affected by recent logging and grazing.

Increased sedimentation has several important economic consequences in this region. In the Rio Grande Basin, for example, sediment carried from steeper elevations and delivered to the flatter, Middle Rio Grande Valley near Albuquerque, raised the river bed and led to increased flooding. Diking, controlling flows with dams, and related efforts to control the flooding have detached the river from the cottonwood forest that depend on periodic flooding (Crawford et al. 1996). Continued sedimentation fills in reservoirs, diminishing their ability to control future floods and hold water for municipal and agricultural use. The Bureau of Reclamation and other agencies incur extensive costs to remove sediment from channels and from behind dams and other structures. Meanwhile, soil loss from eroded lands can lead to reduced long-term soil productivity and impaired water quality (Finch and Tainter 1995).

Upper Midwest. Research in this region has focused more on human impacts on aquatic, especially lacustrine, ecosystems and less on the sediment-related impacts of forest management. Forestry practices in the areas, however, have been shown to alter aquatic processes through the removal of coarse woody debris and the change in chemical processes in deforested areas. Findings from research on streams in this region generally correspond to those from other regions (Edwards 1992).

Interior Alaska. Because this region is relatively inaccessible, it contains essentially no industrial timber production. However, research done on boreal forests elsewhere demonstrate that logging can generate significant amounts of sedimentation, seriously threatening associated stream ecosystems (Garman and Moring 1991). Looking at sedimentation generated by placer mining, Scannell (1992) reports that the effects on invertebrate populations can persist more than 90 km downstream. If sediment loads were high enough, arctic grayling abandoned a stream entirely. With less extreme loads, population levels dropped as the fish experienced loss of habitat, restricted prey, decreased sight-feeding ability, and mortality. Studies have not revealed how long it will take for streams no longer subjected to sediment inputs to flush embedded sediments or to reestablish side channels in channelized waterways.

C. Consumption Amenities May Affect Locational Decisions of Households

Different attributes of each region's natural amenities can attract workers, retirees, and others seeking proximity to recreational opportunities and other forest amenities. In the process, the amenities act as a second paycheck that increases the overall economic well-being of those who value them and live nearby. As we explain in Chapter II, the associated demand for amenities does not manifest itself directly in the markets for forest resources, themselves, but in housing and labor markets. The amenities that can be affected by industrial timber production include:

- The visual aesthetics of riparian areas. In general, the more natural the appearance of these areas, the greater their aesthetic value. Timber production can reduce the amenity values of these areas by altering their natural appearance.
- The visual aesthetics of some upland areas that otherwise would experience timber harvests. Timber production can reduce the amenity values of these areas by altering their natural appearance.
- The aesthetics and water-related recreational opportunities associated with streams whose water quality is affected by timber-production activities, especially those activities that introduce stream sediment.

- The aesthetics and water-related recreational opportunities associated with the quantity and timing of water runoff. Timber production can alter seasonal stream flow patterns, with more runoff as peak flow in the spring, when recreational demand typically is lower, and less as base flow during the summer, when demand typically is higher.

- The visual aesthetics and recreational opportunities associated with increased populations of wildlife related to riparian areas.

Across the nation, these amenities exert an influence on the location, structure, and rate of economic growth. One of the ways this influence occurs is through the so-called people-first-then-jobs mechanism, in which households move to (or stay in) an area because they want to live there, triggering the development of businesses seeking to take advantage of the household's labor supply and consumptive demand. Insofar as conventional timber production affects the supply of amenities important to households' locational decisions, they will have ripple-effects throughout the area's local and regional economies. In many regions of the U.S. an important element of quality of life is access to the area's natural-resource amenities. By attracting workers, the amenities hold down wages in the local regional economy, creating a comparative advantage for local firms relative to those in regions without wage-suppressing amenities, and spurring faster local economic growth than otherwise would occur.

Numerous studies have confirmed this idea by measuring the effects of amenities, such as average winter and summer temperatures, on incomes and housing (Bloomquist and others 1988, Knapp and Graves 1989, Roback 1982). Research on the value of forest amenities, however, is scarce (Cushing 1987), although recent efforts have examined the proximity to some general amenities, such as federal lands (Gabriel et al. 1996) and wilderness (Rudzitis and Johansen 1991). As Table 6.2 illustrates, both the range of values and variables used to approximate the quality of life factor that pulls individuals, households, and firms to each of the six regions are quite varied. Thus, one is left with a strong theoretical foundation for expecting that society expresses this aspect of the competition for forest amenities through labor and land markets, but the empirical record for quantifying this demand, especially for specific forest-amenity resources is seriously incomplete.

Workers are not the only ones to value natural amenities when making locational decisions. Retirees and recreationists are flocking to areas that provide a unique combination of climate, beauty, and culture. Communities that offer natural amenities are able to attract tourists, seasonal-home owners, and retirees, whose expenditures support the service economy. In particular, researchers are noting that one of the differences between nonmetropolitan communities that are thriving economically and those that are not is a connection to natural amenities (Billings and Tickameyer 1993; Drabenstott and Smith 1996; Sears et al. 1992). The presence of retirees and their non-labor income is especially valuable since they stay longer in the community adjacent to the amenities, purchasing goods and service (Stewart and Stynes 1994).

Table 6.2: Estimates or Indicators for the Economic Value Associated with Quality-of-Life

Variable of Interest	Geographic Scope	Estimate/Result	Source
Importance of federal land as a component of a state's quality-of-life	50 State aggregate	Min. $14 Max. $2,761	Gabriel et al. (1996)
Quality-of-life component of professorial salaries	175 universities throughout the US	Min. -$3,916 Max. $19,722	Clark and Knapp (1994)
Premium that the average household pays implicitly through the labor and housing markets	253 urban counties	Min. -$1,857 Max. $3,289 (1980 dollars)	Blomquist et al. (1988)
Environmental Quality	15 fast growing wilderness counties	Significant in push and pull equations.	von Reichert and Rudzitis (1992)
Distance to recreational amenities	Engineering and management employment in New Jersey	Significant impact on location decisions of firms.	Gottlieb (1995)
Terrain	48 contiguous states	Significant impact on location decisions of individuals.	Cushing (1987)
Impact of maximum level of air pollution in central city on log hourly wages	U.S. cities	.0221	Clark and Cosgrove (1991)
Influence of pull factors on migration decisions by households with telecommuters	Washington State	Quality of Natural Environment: 76 % Outdoor Recreational Opportunities: 70%	Salant et al. (1996)

Source: ECONorthwest.

Finally, recreationists search out areas with specific amenities that they value. However, quantifying quality-of-life values derived from forest resources is a difficult task. These values supplement the benefits residents and others derive from the actual recreational use of these amenities. Economic convention ascribes the term, recreational use, to specific trips made to use specific recreational resources. Using so-called "travel-cost" methods, economists measure the value of such trips by looking at consumers' willingness to incur costs to travel from their homes to recreational sites, e.g., the fishing hole. These techniques, however, generally underestimate the actual amenity-related value of a resource, insofar as they overlook the impact of amenities on the residential-location decisions of households and ignore the value people derive from the amenity when they are not using the amenity recreationally.

Implicitly, travel-cost models assume that people decide where to live and work independent of the recreational resource. If one angler travels from her home in Miami to fish for trout on a river in western North Carolina, these techniques would conclude that she places a greater value on the trout than another angler who travels from his home in Knoxville because she incurs greater travel costs. Furthermore, they would conclude that a third angler, who has purchased a house on the river and fishes off the back porch, places very little value on the trout because he incurs essentially no travel costs to go fishing.

This reasoning overlooks the possibility that the third angler places the greatest value on trout and has based his residential-location decision on a desire to live next to the river. It also overlooks the possibility that the second angler based his residential-location decision on a desire to live near the trout and other considerations and, on balance chose to live in Knoxville rather than on the river, in Miami, or anyplace else.

Recreation-value studies are similarly flawed. These studies often overlook the economic value people place on forest amenities in contexts other than recreational trips. One may be just as willing to pay to see clean, bubbling streams rather than desiccated, dirty ones, or forested vistas rather that clearcuts while on a business or shopping trip or while sitting in the backyard.[28]

While these methodology questions impair the ability to compare the size of the "second paycheck" of the different study sites, a few indicators do exist. Greenwood et al. (1991) examine the patterns of migration across the fifty states and attempt to determine the relative strengths of two primary motives workers and households have for moving: to earn a higher wage (adjusted for differences among the states in the costs of living); and to have access to the particular amenities of the individual states. Based on migration patterns for 1971 to 1987, the authors find that the amenity-related differentials for the six study states varies, as illustrated in Table 6.3. Workers in Oregon, New Mexico and New Hampshire would not relocate elsewhere in the U.S. unless they received an increase in wages around 15 percent, while in North Carolina workers would only require a 5 percent wage increase. Wisconsin workers would move for the same salary. Reflecting the high disamenities associated with arctic living, Alaskan workers would accept a pay decrease of 6 percent to move elsewhere.

Evidence suggests that retirees also find these six regions attractive. According to the U.S. Department of Agriculture (1995), there are a number of retirement-destination counties, defined as counties experiencing 15 percent or more in-migration of people age 60 and older in the 1980's, in each of the 6 regions including Alaska.

[28] Although economists commonly would focus their valuative efforts on one's willingness to pay to see these amenities, an alternative perspective would look at one's willingness to accept compensation to forgo them. For a discussion of when to choose one perspective over the other, see Shogren and others (1994).

Table 6.3: Amenity Values for States Representative of the Six Case-Study Forests

State	Percent Increase (Decrease) in Wages Residents of this State Would Require to Move to a State with Average Amenities
Alaska	(-6%)
New Hampshire	13%
New Mexico	15%
North Carolina	5%
Oregon	17%
Wisconsin	0%

Source: ECONorthwest with data from Greenwood et al. (1991).

Another indication of the increased value resident are placing on quality of life is the increased demand for recreational opportunities. In a 1993 Update of the 1989 RPA Assessment, the Forest Service estimated regional demand and supply projections for outdoor recreation. Table 6.4 illustrates the recreational activities with the largest projected gap between supply and demand by 2040.[29]

Table 6.4: Outdoor Recreation Activities with the Largest Projected Percentage Gaps in 2040, By Region

Activity	North	Pacific Coast	Rocky Mountains	South
Cross-country skiing	55	338	139	29
Rafting/tubing	—	—	318	—
Day Hiking	43	115	30	46
Backpacking	16	266	143	28
Wildlife Observation	26	121	69	40
Visiting prehistoric sites	40	48	54	27
Photography	24	166	57	36
Visiting historic sites	32	53	61	24
Horseback riding	18	133	76	26
Sailing	—	101	102	20

Source: ECONorthwest with data from English et al. (1993)

[29] Excess demand presented below is computed on the assumption that prices and congestion remain fixed. In some combination prices, congestion, and degradation of quality (assuming a fixed supply) will occur such that the gaps disappear.

The highest percentage gaps occur in the Rocky Mountains and Pacific Coast regions with severe shortage of recreational opportunities occurring in cross-country skiing, rafting and tubing, backpacking, and wildlife observation. These predicted shortage indicate that competition for recreational opportunities is expected to be fierce. Although, the gaps are highest in the Pacific Coast and Rocky Mountain regions, significant gaps occur in the South and North regions, as well. Thus, the growing timber industry in these regions will become at greater odds with those who seek natural amenities.

D. Intrinsic Values Associated with Forested Ecosystems

There is a growing body of literature on the intrinsic values associated with the multiple aspects, such as the extent of biodiversity, of a forest ecosystem.[30] Each of the six region's forest ecosystems have many resources of intrinsic value. Although a complete listing of the resources is beyond the scope of this report, we highlight some of the more distinct features of the individual forest regions below, focusing on the unique features of the regional forest, the extent of biodiversity, and the risk of species extinction.

Pacific Northwest (Westside). This region's forests include a variety of distinctive forests from dense old-growth forests to open stands of young tree seedlings. Low- and mid-elevation forests in this region are among the tallest and most productive in the world. In some areas of this region, centuries-old trees rise to over 250 feet. Compared to estimated presettlement amounts, the amount of late-successional and old-growth forests have declined considerably.

The loss of the late-successional and old-growth forests has accompanied a decline in important indicators of the forest's biodiversity including the northern spotted owl, marbled murrelet, native salmon and trout stocks, and the quality of the remaining old-growth ecosystem. Both the northern spotted owl and marbled murrelet are federally listed as threatened species, and native salmon and trout in the region have been listed or are now under consideration for listing as a threatened or endangered species. Moreover, scientists have determined that an additional 185 species, excluding fish and nonvascular plants, could be at risk from the loss of late-successional forests in the region (Tuchman et al. 1996). A recent study of species endangerment patterns in the U.S. identified the Pacific Northwest as a region in which increased species endangerment is likely to emerge (Flather et al. 1994). Currently, the state of Oregon houses 30 animal and plant species listed as endangered by the U.S. Fish and Wildlife Service.

Southern Appalachian Highlands. The forested lands of Southern Appalachia are known for their high species diversity. More species of trees are native to the region than to any of the northern temperate regions in the world, and the Great Smoky Mountains have the most extensive virgin forest in the eastern U.S. The Southern Appalachias contain two of the areas of geographic and ecological significance that have been designated by the United Nations (there are 59 such areas worldwide). One is associated

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[30] See, for example, Gilbert et al. (1991); Gowdy (1997); Polasky and Solow (1995); Stevens et al. (1991); Stevens et al. (1994); Walsh et al. (1984).

with the Coweeta Hydrologic Laboratory and the other with the Great Smoky Mountains National Park.

The forested ecosystem of the Southern Appalachias houses a number of threatened and endangered species—28 animals and 11 plants listed as endangered species depend on the habitat found in the region's forests (Flather et al. 1994). In the state of North Carolina the U.S. Fish and Wildlife Service lists 50 animal and plant species as endangered. Dobson et al. (1996) identify Southern Appalachia as one of four areas in the United States with the greatest numbers of endangered species.

New England Northern Hardwood Forest. The hardwood forest of New England is a unique ecosystem not found elsewhere in the U.S. It is covered by a variety of hardwood species interspersed with wetlands, bogs, lakes, and rivers (Harper et al. 1990). The forest serves as a base for recreation for the 100 million residents of the eastern U.S. and Canada who are within a one-day drive (Hornbeck and Leak 1992). In the fall, the White Mountain National Forest is a popular destination for visitors interested in viewing the spectacular scenery during autumn coloration. Central New Hampshire contain the largest National Forest roadless area east of the Mississippi (Foreman and Wolke 1992).

Over 215 wildlife species are found in the northern hardwood stands: 61 percent birds, 25 percent mammals, and 14 percent amphibians and reptiles (Hornbeck and Leak 1992). New Hampshire houses 9 animal and plant species listed as endangered by the U.S. Fish and Wildlife Service. Species dependent on large tracts of wilderness, such as the wolverine, the panther, the lynx, and the pine marten have declined in number in the region. A recent study concluded that regions of high species endangerment in the eastern U.S., in general, are associated with forested ecosystems (Flather et al. 1994).

Southwest. The Mogollon Highlands, consisting of the Gila and Apache National Forests in west-central New Mexico and east-central Arizona, contain one of the key wilderness ecosystems in the U.S. More deciduous tree species (over 20) than anywhere else in the West, and the world's largest remaining Ponderosa Pine forest are found here. Arizona, however, bears the distinction of having lost more of its old-growth forest than any other Western state (Foreman and Wolke 1992). The wildlife in the Highlands is rich in diversity and includes mountain lion, black bear, Rocky Mountain big horn sheep, pronghorn, gila monster, Mexican spotted owl, northern goshawk, and bald eagle (Foreman and Wolke 1992).The arid Southwest region supports a large number of threatened and endangered species, particularly fish species (Flather et al. 1994). About 35 of the 80 (44 percent) of the endangered species in southern Nevada, Arizona, and southwestern New Mexico are associated with the region's forested ecosystems (Flather et al. 1994). In New Mexico alone, the U.S. Fish and Wildlife Service currently lists 37 animal and plant species as endangered. On the Gila National Forest, logging has destroyed habitat for the Mexican spotted owl and the northern goshawk (Foreman and Wolke 1992). The Gila, however, is considered one of the best potential sites for the reintroduction of several species including the grizzly bear, Mexican wolf, and jaguar.

Upper Midwest. The forests of the Upper Midwest contain the largest extent of virgin forest east of the Rockies, and the third largest roadless area in the lower forty-eight states, Boundary Waters Wilderness Area. Two major forest types, the Northern Boreal Forest and the Great Lakes, or Laurentian Forest, meet in the Boundary Waters Wilderness. Inhabitants of Boundary Waters include black bear, moose, lynx, osprey, bald eagle, pike, and trout. Thousands of lakes, beaver ponds, bogs, and marshes are distributed throughout the Wilderness area (Foreman and Wolke 1992).

Threat of species extinction in this region, while present, is on a smaller magnitude than other regions of the U.S. (Flather et al. 1994). The U.S. Fish and Wildlife Service lists fifteen animal and plant species in Wisconsin as endangered. The forest ecosystems support some of the best habitat remaining for the Gray Wolf in the lower forty-eight states and one of the highest concentrations of breeding songbirds in the U.S. (Foreman and Wolke 1992).

Interior Alaska. Perhaps no other state in the U.S. is more closely associated with wilderness and wildlife than Alaska. Interior Alaska is crossed by river valleys and interspersed with glaciers and imposing mountain peaks, including Mount Denali, the nation's highest. Moose, Dall sheep, grizzly bears, wolves, and herds of caribou roam the taiga (sparse black-spruce forests) and tundra of this region. The six-million acre wildlife reserve of Denali National Park is the gem of the Interior region and contains a large and diverse wildlife population. Gates of the Arctic National Park, encompassing 8.4 million acres, is situated at the northern end of Interior Alaska. Six national wild rivers are among the numerous waterways transecting this park. In the spring, the resident bird species in the park are joined by migratory species from Asia, South America, Europe, and the Continental U.S. In conjunction with the adjacent Noatak National Preserve and Kobuk Valley National Park, Gates of the Arctic comprises one of the world's largest parkland areas.

A recent study of patterns of endangered species in the U.S. did not indicate Interior Alaska as having any "hot spots" of threatened biodiversity for plants, birds, fish, or mollusks (Dobson et al. 1997). The U.S. Fish and Wildlife Service, however, lists six animal and plant species in Alaska as endangered.

Determining the intrinsic values associated with a forest ecosystem's resources, particularly biodiversity, is inherently more difficult than valuing economic goods and services that are traded in markets and for which prices exist. There are two main problems. The first is a deficiency of biological and ecological data needed to answer such questions as: What are the characteristics of species? What is the range of the species? What habitat changes harm or promote the species? The second is that even if we understood the biology and ecology, we still must answer the question: How can we assess the values associated with biodiversity? (Polasky 1993). The second question is particularly daunting because the lack of knowledge about the current usefulness of a species does not imply that the species is not of potential future value. For example, it is possible that through "biodiversity prospecting" a certain species initially believed to have little value may turn out to have great value as a pharmaceutical product (Simpson et al. 1996). If the species is lost through extinction, the economic well-being of society as a whole is diminished.

In trying to measure intrinsic values, economists often use what they call the contingent-valuation method. This method uses a survey of individuals to reveal how they would behave if forced to choose between more or less of a particular forest resource. In general, survey respondents are asked to reveal how much they would be willing to pay to have more of a resource, or, alternatively, how much compensation they would require before they willingly would accept less.

There is considerable controversy among economists regarding the accuracy and efficacy of contingent-valuation studies. Skeptics of the method question the extent to which respondents' hypothetical expressions of the amount of money they would be willing to pay or accept for a resource are consistent with the amount they would pay or accept if confronted with an equivalent, actual situation. Advocates of contingent valuation respond that there is no alternative to measuring intrinsic values in monetary terms and are working to demonstrate that the techniques are both theoretically and empirically sound.

Although the economic values associated with the six regions' forest ecosystems and biodiversity are difficult to measure, they are, nonetheless, important and deserve consideration in any decision involving the management of the forests. If we are to make good decisions about how to best use our forests, we need to have an idea about how much a forest ecosystem or preservation of species is worth. Whenever agencies, officials, or the public at large face decisions involving trade-offs between potentially conflicting uses of land and forest resources, they need to acknowledge the existence of the intrinsic values associated with the ecosystem and incorporate them into their decision-making process.

VII. CONCLUSIONS

In this chapter we summarize our findings and make recommendations for related future research.

A. Findings

Prior to this study, our experience in the Pacific Northwest led us to conclude that common approaches for assessing the economic consequences of forest-management decisions aimed toward accomplishing environmental objectives were seriously incomplete insofar as they focused on the short-run economic costs to extractive and development activities and overlooked a wide array of other, generally mitigating, consequences. A full accounting of the consequences must take into account the decision's effects on: (1) other commercial activities; (2) subsidies; (3) externalities; (4) consumption amenities that affect household-location decisions; and (5) the desire to protect the intrinsic values of the forest. Further, one must examine how the economy will adjust to the decision in the short, medium, and long runs. To weigh the different consequences, one must look at the value of the goods and services derived from the forest with and without the decision, the impacts on jobs, incomes, and related variables, and perceptions of the fairness, or equity.

There are any number of possible ways to organize the analysis of these concerns. The framework we have developed is useful because it is both technically rigorous and generally understandable by resource managers, political leaders, news reporters, and the general public.

We applied the framework to six case-study forests. It works well. This reinforces the conclusion that the ecosystem-economy relationship is complex in all these areas, i.e., forests are important to the economy for far more reasons than just the extraction or development of resources. To understand the economic consequences of forest-management decisions in each of the six case-study forests, and especially decisions affecting major extractive or development activities, one must look at all the competing demands. Using industrial timber production as the major indicator of extractive-development use, these findings apply where this use is declining (Pacific Northwest), growing (Southern Appalachians), or not yet existent (Interior Alaska). Our examination of the riparian bosque forest in the southwest indicates that the framework also applies to extractive use of water for irrigated agriculture and, by extension, other extractive or development activities.

There are wide disparities in data and analytical techniques for analyzing the different sources of demand for forest resources. Extensive data exist for some extractive-development industries, such as timber and some irrigated agriculture, but not for others, especially land development. Natural-resource economists have focused intensively for the past two decades on developing and applying analytical techniques, such as the contingent-valuation method, for estimating the value of the demand for protecting intrinsic values, such as those associated with endangered species.

Much less is known about the demands we label Types 2 and 3. Type 2 demands arise when one extractive-development use displaces another, receives subsidies, or imposes externalities. Type 3 are associated with forest amenities that influence the locational decisions of households. The shortcomings here are significant, and documentation of these demands currently relies heavily on little more than collections of anecdotes. Many, if not all, extractive-development uses of forests displace other commercial uses, receive subsidies (or exhibit price distortions from other sources) or impose externalities. As the American public becomes more mobile, the availability and management of quality-of-life amenities will exert a greater influence on the distribution of economic activity over the national and regional landscapes.

Despite the disparities in data and analytical techniques, what does exist supports these general conclusions:

- The timber industry, the primary extractive user of forest resources, provides the major demand for forest resources in all areas except Interior Alaska. Some variables indicate that this demand will grow in the future. Most important, prices for timber are expected to rise, although recent events indicate that reductions in the supply of timber may not trigger price increases as high as many analysts expected. Other variables indicate that the strength of timber's demand for forest resources will stagnate or shrink. Many people express their demand for extracting timber from forests by arguing, through political channels and elsewhere, that converting forests to timber creates jobs, incomes, and community well-being. Considerable evidence, however, indicates otherwise. Especially in the Pacific Northwest, timber-related jobs and incomes have been declining. Elsewhere, the levels of jobs and incomes per unit of forest converted to timber are not expected to increase and may decrease.

- The competing demands for forest resources are likely to increase relative to the timber industry's demand. Through markets, litigation, and political channels, pressure will build to restrict the subsidies and externalities associated with timber production and to prevent timber's adverse effects on consumer amenities, and to protect forest intrinsic values. The increase in these demands will be driven largely by powerful, fundamental economic forces, including public preferences for environmental protection, increased knowledge about subsidies and externalities, and increases in the population of retirees and other groups seeking to live near consumption amenities.

Our efforts to communicate these analytical findings revealed that most groups readily understand the core ideas. This is especially true of groups in the Pacific Northwest and persons who have been engaged in ecosystem-management activities that entail taking a broad look at the consequences of forest management. Groups most resistant to the ideas include those associated with irrigated agriculture in the West. Among these groups, especially in the Southwest, there often is strong resistance to ecosystem management and little recognition of demands for water that are not substantiated in the prior-appropriation doctrine.

Perhaps the most interesting communication challenge arises with bio-physical scientists and ecologists. We found that, although all of the scientists we spoke with were keenly interested in resource management and recognized the important role that economic issues play, efforts to talk with them about these issues often quickly ran aground for the lack of a common vocabulary. Basic terms, such as ecosystem management, value, and efficiency, can mean different things to economists and ecologists. With the development of common understanding about these and other terms, we found that our analytical framework, especially Figures 2.1 (*lens diagram*) and 2.2 (*competing-demands diagram*) were useful tools for exploring opportunities for making the concepts of multidisciplinary research more meaningful.

B. Recommendations

We make four general recommendations—three substantive and one communicative—for future research regarding the relationship between forested ecosystems and the nation's economic system.

Clarify Subsidies and Externalities of Major Forest Uses

As we explain above, we believe that the starting point for better understanding the relationship between forests and economies is to describe the competing demands for forest resources and to trace the effects of forest-management decisions on these demands. Our examination of the six case-study forests confirmed, however, that there is a wide disparity in the data and analytical techniques related to the different types of demand, making it easier to trace a decision's effects on some of the demands than on others. We, and others, strongly suspect that these disparities influence the outcomes of forest-management decisions.

Some of the most important data and analytical gaps are associated with (1) the subsidies to different major forest uses, especially extractive and development activities; and (2) the externalities of these uses. Outside some of our own initial work in the Pacific Northwest associated with decisions to protect at-risk species, we found no comprehensive assessment of the subsidies and externalities associated with timber production, grazing, mining, and forest development. The absence applies both in the aggregate and to specific forest-use events. Historically, most natural-resource economists focused on measuring the value, jobs, etc. associated with the production of timber and other forest-based commodities. Over the past two decades, there has been a greater emphasis on measuring less-tangible attributes, such as the demand for recreation and the existence value of particular species or habitats. In both instances, economists have largely overlooked the fact that the current pattern of forest uses is riddled with subsidies, externalities, and other major price distortions. Given the failure to provide them with a better explanation of these components of the full costs of current forest uses, the public generally has no option than to weigh forest-management alternatives in simplistic terms, such as comparing jobs versus owls.

We specifically recommend that NSF sponsor research to determine the full costs of timber production, irrigated agriculture, recreational development, and urban development associated with one or more of the LTER sites. Why the LTER sites and not elsewhere? To the extent that economists have examined the full costs of extractive industries or land development, they have focused solely on the infrastructure costs: police, sewer, water, schools, etc. They have not examined the ecosystem-related costs. The LTER sites offer the best opportunities for looking at both.

Clarify the Demand for Quality-of-Life Amenities

Across America, people are seeking to improve their quality of life and moving to areas with a high-quality natural environment. We identify this phenomenon as a major type of demand (Type 3) for forest resources. Although the fundamental theoretical concepts underlying this type of demand have been worked out, the actual mechanics are poorly understood. It is easy to conclude that clearcutting scenic forested hillsides will diminish the region's attractiveness for some households, but impossible to say by how much.

Further, it is easy to conclude that, eventually, the demand for particular forest amenities will lead to overcongestion of those amenities, but impossible to say when or by how much. The problem is especially acute where a state or community further encourages congestion by subsidizing the infrastructure costs of the households and firms that initially come to a place because of its natural-resource amenities.

We specifically recommend that NSF sponsor research to clarify (a) what forest amenities individually or collectively can influence household-location decisions; (b) the strength of the influence; (c) the economic and ecological consequences of different levels of congestion; and (d) the potential effects of alternative resource-management strategies. We recommend that this research be conducted through the LTER program to take advantage of ecologists' expertise regarding the nature of the amenities, the consequences of congestion, and the consequences of management strategies.

Clarify the Competing Demands for Water from Forested Ecosystems

We describe above the limited literature on the economics of water from forested ecosystems. No forest-manager or member of the public can currently determine the economic consequences of forest-management decisions that affect the amount, timing, or quality of water produced by forested watersheds. This is despite the fact that forests are the source of fresh water in much of the country, and the demand for fresh water is growing.

We recommend that NSF sponsor research to clarify the water-related costs and benefits associated with major forest-management activities. This recommendation overlaps with the previous two. We believe, however, that issues associated with water are sufficiently important that NSF focus on them.

Facilitate Better Communication Among Forest Ecologists and Economists

By definition, gaining a better understanding of the ecosystem-economy relationship requires marrying the analytical insights of ecological and economic disciplines. The stark reality, though, is that it often is extremely difficult to bring about this marriage. If NSF is to promote integrated, multidisciplinary research through its LTER program, it must do more than sponsor many research projects, each individually focusing on one discipline, but collectively covering many, and hope that the researchers, somehow, will connect in a meaningful way. We recommend that NSF also sponsor dialogue among ecologists and economists to increase the likelihood that they will identify opportunities for coordinating their efforts. Such a dialogue currently is minimal, at best, at each of the LTER sites we examined, and nonexistent across the sites.

Specifically, we recommend that NSF sponsor a program of conferences on ecological-economic issues. These conferences should especially focus on summarizing the ecological and economic knowledge regarding the three topics we discuss above: (1) subsidies and externalities of major forest uses; (2) quality-of-life amenities; and (3) forest water. In coordination with these conferences, we recommend that NSF also sponsor multidisciplinary research on these topics, so that the research proposals are informed by the results of the first round of conferences and, in time, the research provides the grist for future conferences.

Finally, we observe that, although our findings and recommendations stem from research of forested ecosystems and their affiliated economies, we believe they apply equally well to other ecosystems and their relationships with local, regional, and national economies.

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