7 Balancing Conflicting Values: Ecosystem Solutions in the Pacific Northwest of the United States and Canada

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Introduction

Ecosystem approaches to sustainable forest management in the Pacific Northwest of the United States and Canada have arisen in response to significant changes that have occurred in these societies over the past century or so (Interagency Ecosystem Management Task Force, 1995). One such change has been rapid population growth along the Pacific Coast, where the mild climate and growing regional economy have induced a high rate of immigration from other parts of the continent. Nearly all of the population growth during the past few decades has been in urban areas, and urban dwellers tend to have different expectations toward large-scale forest management than do rural, resource-dependent populations. Many of the new immigrants come from regions with less abundant natural endowments, and the landscape beauty and opportunities for outdoor recreation in the Pacific Northwest are often cited as major reasons for their immigration.

Another factor contributing to the adoption of ecosystem approaches on public lands is the increasing recognition by managers of public forest lands in the Pacific Northwest that other regions, in both the US and Canada, are increasingly able to meet US demands for softwood lumber. In the past, the perceived need to meet this demand had been a primary motivation for maintaining high levels of timber harvest on public forests in the Pacific Northwest.

The emergence of ecosystem approaches for managing forests in the Pacific Northwest is by no means a sudden event. In the United States, during the latter part of the 19th Century the role of the federal government changed gradually from disposer of land to holder of land, leading eventually to a situation in which federal agencies such as the Forest Service and the Bureau of Land Management became custodians of more than one-third of all US forest land. Much of the federally managed forest is concentrated in the West, and in the Pacific Northwest more than half of all forested lands are under federal ownership. In British Columbia, almost all forest lands are owned by the provincial government and are therefore public property, although they are managed under long-term "tree farm licenses" granted to private companies.

In both Canada and the US, demographic changes during the 20th Century resulted in a gradual evolution in public attitudes toward natural resources that increasingly emphasised stewardship: from single use to multiple use; from extraction to restoration; from disposal to recycling, reuse, and environmental protection. Healthy regional economies and attractive, healthy natural settings have so far gone hand in hand. The need to maintain both a robust economy and the spectacular natural landscape in the face of conflicting pressures has made the PNW a test-bed for the development of operational ecosystem management.

But how can the ecosystem approach be effectively operationalized? How can land managers and policy makers react to the painful dilemmas that arise when decisions must be made that could potentially have devastating impacts on ecosystem stability or on local economies? Land managers find themselves trying to find a balance between maintaining forest ecosystems and at the same time providing the forest products and services needed by society. Trade-offs are inevitable and necessitate formulating and using alternative land management strategies to provide an acceptable mix of commodity production, amenity use, protection of environmental and ecological values, and biodiversity.

The Pacific Northwest has a relatively long tradition of science-based forest management (Meidinger and Pojar, 1991; Kimmins, 1992; Peterson *et al.*, 1997; Duncan, 2000). Since the mid-1980s, forest managers within the region have increasingly become interested in management regimes that are compatible both with commodity production and also with ecological, social, and cultural values (Kohm and Franklin, 1997; Monserud *et al.*, 2003). Because much of the region's forest land is publicly owned, the choice of forest management regimes has been the subject of public debates that have often portrayed management choices as stark tradeoffs between the biophysical and socioeconomic components of ecosystems. This characterization has strongly affected forest management practices throughout the region, both in the United States and Canada.

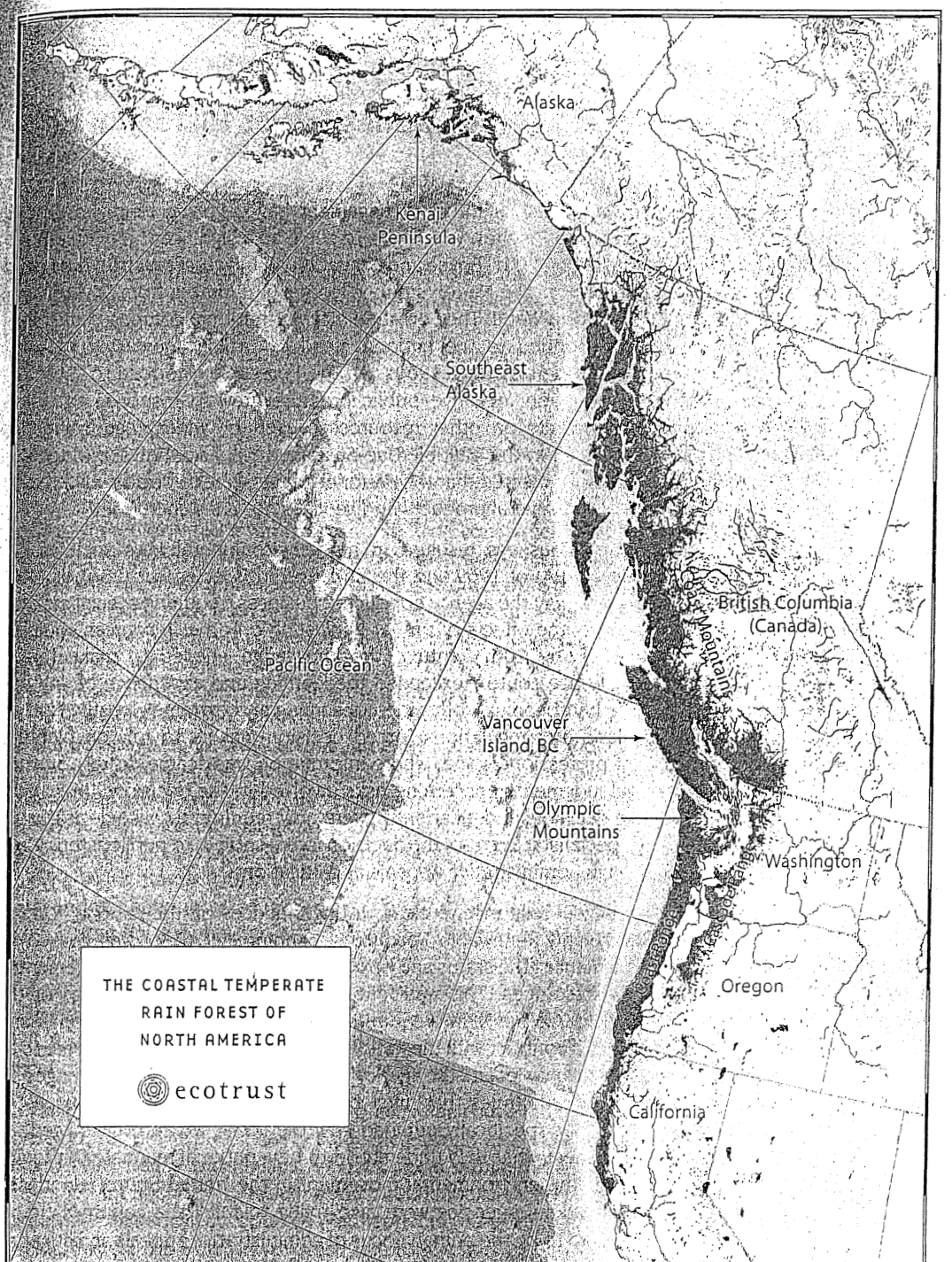
The evolution of science-based forest management and growing societal concerns about greater balance among the environmental, economic, and social consequences of land management have led to an increasing reliance on managing at the ecosystem level. The Convention on Biological Diversity of 1992, with its emphasis on ecological approaches, has contributed to the development of current strategies for sustainable forest management. This chapter outlines the evolution of these concepts in the Pacific Northwest Region of North America.

The Forests of the Pacific Northwest

The focus of this chapter is on the moist maritime forests of the Pacific Northwest (PNW). Collectively, this is the world's northernmost temperate rain forest (Walter, 1985). Geographically (see Figure 1), the region includes western Oregon and Washington (from the summit of the Cascade Range to the Pacific coast, including the Coast Range and the Olympic Mountains), coastal British Columbia (Coast Mountains), and island-dominated southeastern Alaska as far north as the Kenai Peninsula. It stretches southward almost to San Francisco, California. The east-west extent of this coastal forest varies as a function of climate and elevation; its width extends from a few kilometers at the northern and southern extremes to several hundred kilometers in the middle of its range. Much of the northern half of this range (British Columbia north of Vancouver Island to southeastern Alaska) is in a relatively undisturbed, natural state. The forest southward from Vancouver Island, British Columbia to northern California contains some of the world's most valuable and productive commercial timberlands. An important subset of the PNW is the Douglas-fir subregion (western Washington and Oregon), which is dominated by the fast-growing coastal Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). We refer to this subregion as the Pacific Northwest-Westside, or PNWW.

For the purposes of this chapter we regard the PNW in total as comprising the coastal redwood (*Sequoia sempervirens* (D. Don)) forests of Northern California, the Douglas-fir forests of western Oregon and Washington, and the vast coastal Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) forests of British Columbia and southeastern Alaska. Altogether these coniferous forests contain the highest quality wood-producing lands on the continent, and exhibit some of the greatest biomass accumulations and highest productivity levels of any in the world, temperate or tropical (Franklin and Dyrness, 1973; Fujimori *et al.*, 1976; Franklin and Waring, 1981; Walter, 1985; Franklin, 1988). The forests are valued for their scenery, recreational opportunities,

Fig. 1. The coastal temperate rain forest of the Pacific Northwest.



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watershed protection, and fish and wildlife habitat (Peterson and Monserud, 2002). The northern extent of the PNW rain forest (coastal British Columbia and southeastern Alaska) is largely unaltered (Everest *et al.*, 1997).

Setting the Stage, Part 1: Forest Management History in the United States

The USDA Forest Service's legal mandates for forest management have evolved from the original vision espoused by its first Chief, Gifford Pinchot, which was to serve as a significant provider of the nation's timber and wood products (Miller, 2001; Boyce and Szaro, 2004). In actual practice, the Forest Service functioned largely as a caretaker of the Nation's public forests until timber from private lands was in short supply after the end of World War II. The Forest Service, at that time composed mainly of professionally trained foresters, responded to the national need by rapidly increasing the area harvested on the national forests through the late 1960s. As the Forest Service rose to meet the challenge of increasing timber production, negative public pressure grew in response to visible alterations in the landscape and impacts on other resources caused by widespread harvesting activities. This pressure manifested itself in the Multiple Use-Sustained Yield Act (MUSY), which was enacted by the US Congress in 1960 and directed that the national forests were to be administered for "multiple use and sustained yield of the several products and services obtained therefrom".

The heightened environmental consciousness resulted in new environmental laws such as the National Environmental Policy Act (NEPA) of 1969 and the Endangered Species Act (ESA) of 1973. These laws fundamentally changed the way the agency conducted business, requiring specialists from disciplines other than forestry so that the effects of timber harvesting on other resources could be more fully analyzed. By the end of the 20th Century, the knowledge needed to make forest-management decisions in a multiple-use context exceeded the learning and experience of any one individual and pre-harvest analysis had become both time-consuming and extremely costly. Numerous and sometimes conflicting laws and regulations forced decision-makers to rely on planning documents prepared by teams of professionals and, where information was scarce, to rely on their team's technical and professional judgments concerning risks involved in the decisions. Managers, who once had been able to make decisions independently, were now required to base decisions on analyses carried out by teams of specialists. Even so, the decisions were subject to public scrutiny and could be delayed or blocked through administrative appeals and litigation.

Public pressure continued, especially in response to clear cutting practices on the national forests, and in 1974 the Forest and Rangeland Renewable Resources Planning Act (RPA) was passed by Congress, requiring periodic assessment of the status and opportunities for enhanced management of the Nation's publicly held natural resources. This was followed in 1976 with the passage of the National Forest Management Act (NFMA). The NFMA required each forest to develop comprehensive forest plans. Each plan was viewed as a contract with the nation detailing how the resources were to be managed, but at the same time they acknowledged the agency's professional flexibility to manage as it saw fit. Forest plans contained standards (rules that must be followed) and guidelines (suggested practices that should be followed) that specifically outlined how the forest would be managed. As Forest Service managers pushed to meet what they understood to be a national mandate to provide timber in ever-increasing quantities, the environmental movement in the United States relentlessly challenged those practices. Other federal agencies were also trying to fulfill the country's timber demand, but the Forest Service tended to be the primary focus of administrative appeals and litigation by environmental groups.

During the 1990s, Forest Service managers increased scientist involvement by asking for help with forest planning and the ensuing legal battles. Regional natural resource management planning efforts

that grew out of increased involved by scientists included the Forest Ecosystem Management Assessment Team (FEMAT, 1993) for northern California, Oregon, and Washington; the Interior Columbia Basin Ecosystem Management Project (ICBEMP) for eastern Washington, Idaho, and western Montana (Quigley and Bigler-Cole, 1997); the Sierra Nevada Ecosystem Project (SNEP, 1996); and the Tongass Land Management Plan (USDA FS, 1997a-1997c).

Setting the Stage, Part 2: Forest Management History in the US Pacific Northwest

The development of ecological approaches to forest management in the Pacific Northwest resulted from decades of conflict over the use and value of forests and their resources. These approaches attempt to involve all stakeholders in defining sustainable alternatives for the interactions of people and the environments in which they live. Similar approaches evolved in a number of places throughout North America but in no place was the process more controversial and contentious than in the Pacific Northwest.

European settlement of the Pacific Northwest began in the mid-1800s, although parts of coastal Alaska had been settled earlier by the Russians. At that time, forests were regarded as unlimited or as impediments to settlement. By the early 1900s, however, the general populace had begun to realize that forests represented a limited resource. One consequence of this was the establishment in the United States of federal forest reserves to protect forest resources, water quality and wildlife habitat. At that time, nearly all timber production came from private timberlands, and the major management issues were protection from fire, regeneration, growth and yield studies, and harvest practices. Until World War II, management of the federal timberlands focused largely on conserving forest resources. Following the war, a deliberate decision was made to increase the level of timber harvesting from public timberlands to help meet the growing demand for forest products as a means of supporting the booming regional population and rapidly expanding economy. From the 1940s until the late 1960s in the United States, there was general agreement among both federal and private land managers that timber production was the primary objective in the management of most forest land (Curtis *et al.*, 1998; Peterson and Monserud, 2002). Basic assumptions were that wood production in old-growth stands was essentially static (no net growth), and that insects and disease were diminishing the amount of usable wood in those stands. It seemed desirable, therefore, to replace old-growth forests with young, rapidly growing stands (USDA FS, 1963; Curtis *et al.*, 1998). In the Douglas-fir region, clearcut logging and broadcast burning were justified as mimicking the catastrophic, stand-replacing fires typical of the region before fire suppression began (Halpern, 1995). This led to adoption of a management system that relied on the financially efficient practice of clearcutting, burning, and replanting. At the same time, public concerns about fire protection and, later, restocking of cutover timberland, led the states of Oregon, California, Washington, and Alaska to adopt forest practice acts in 1971, 1973, 1974, and 1978, respectively. These rely on a combination of best management practices, logger and landowner education, and enforcement activities by state agencies.

Over the years, conflicts over differing forest values have intensified (Cissel *et al.*, 1999; Peterson and Monserud, 2002). The public has become increasingly aware that forests can produce more than wood (Behan, 1990; Beese and Phillips, 1997). Current public debate over management of public forests centers on interactions between wood production and the needs of wildlife, aquatic resources, biodiversity, and social acceptance (Peterson and Monserud, 2002). These debates culminated in the development of the Northwest Forest Plan (USDA and USDI, 1994a-1994b) for western Oregon and Washington, the new Forest Practices Code of British Columbia (1994), and the Tongass Land Management Plan (USDA FS, 1997a–1997c) for the Tongass National Forest in southeastern Alaska. Instead of the traditional goal of economically efficient wood production that relied largely on

even-aged management, the focus in these recent efforts is toward "old-growth" and multi-resource ecosystem management, attempting to provide habitat for threatened and endangered species, protect riparian zones to rejuvenate the freshwater and anadromous fisheries, and promote biodiversity (FEMAT, 1993; Clayoquot Scientific Panel, 1995). These changes also increased the interest in and need for science-based silvicultural practices and management regimes that will reduce conflicts among user groups while producing the many values associated with forest lands on a biologically and economically sustainable basis (Curtis *et al.*, 1998; Committee of Scientists, 1999).

Setting the Stage, Part 3: Forest Management History in the Pacific Northwest of Canada

The public ownership of 95% of forestlands in British Columbia is unique in the industrialized world. This predominance of public forests brings a special set of problems for regulating forestry practices (Mitchell *et al.*, 2004). The public has brought considerable pressure to bear for the diversification of silvicultural systems, resulting in the introduction of a results-based forest practices code. Passed in 1994, the code contains provisions for limiting the impact and extent of clearcutting and provides a context for testing the feasibility of partial cutting and "retention" silvicultural systems. The focus on silvicultural practices has resulted in the installation of a number of large-scale experiments in British Columbia (Daigle, 1995; Puttonen and Murphy, 1997). These include Date Creek (Coates *et al.*, 1997), Quesnel Highlands (Armleder and Stevenson, 1994), Lucille Mountain (Eastham and Jull, 1999), Opax Mountain (Klenner and Vyse, 1998), Sicamous Creek (Vyse, 1999) and the Montane Alternative Silvicultural Systems (MASS) Project (Arnott *et al.*, 1995). In total, these experiments represent a major public investment in research relating to the operational, economic and ecological impacts of alternatives to clearcutting.

A premise common to all of these trials is that the amount and the arrangement of retained forest structure will affect ecological values. By retaining diverse structures representative of pre-harvest stand conditions, including dead trees and coarse woody debris, diverse habitats will be conserved for the variety of organisms that underpin ecosystem functions (Franklin *et al.*, 1997; Burgess *et al.*, 2001). Because managing public forests for multiple ecological, social and economic values will require trade-offs, it would be desirable to make decisions based on measurement of the impacts of different silvicultural alternatives on those values. This type of science-informed approach has been taken by Weyerhaeuser Canada in its coastal operations, where research on the operational and economic feasibility of silvicultural alternatives to clearcutting conducted at MASS in part gave the company confidence to proceed with a plan to phase out clearcutting and move toward retention forestry. As the pressure for third-party certification of forestry practices increases, the demand for ecologically based criteria for making decisions about the amount and pattern of overstory retention will likely become more acute. The information needed to develop and apply such criteria is presently quite scanty for most of British Columbia's forest types.

The MASS Project has also contributed to partially resolving some of the clearcutting controversy in which highly active public groups in the nearby urban centres of Vancouver and Victoria have questioned the sustainability of even-aged management associated with clearcutting. The MASS Project demonstrated that partial-cut harvesting systems could be used in coastal forests, contributing to a closer alignment of ecological and economic factors. This helped the industry respond to intense public pressure, resulted in an increased public acceptance of changes in forestry practices, and created a niche for the application of scientific information to inform the debate on managing forests for multiple values.

A further development relating to forest management in British Columbia is an effort by the government to increasingly involve indigenous populations (referred to in Canada as First Nations

peoples) in the management of forests. This is reportedly being done partly to increase their participation in economic activities related to lands that the tribes had historically controlled, and partly on the assumption that they will take a more conservative approach (as compared to the forest industry) toward timber harvesting. The approach being taken is to preferentially offer tree farm licenses to First Nations groups that have been certified as competent to manage the forests. In at least one case the government is reportedly negotiating to buy back a large tree farm license currently held by a private timber company and offer it to a qualified First Nations consortium.

Policy Context

The policy context in the Pacific Northwest is set by three converging interests: shifting public recognition of the array of goods and services produced by forests; the growing debate about sustainable forest management; and recognition within the scientific community of the connectiveness among processes and outputs. These interests all shape the emerging concerns about how to achieve good stewardship of our forestlands, both public and private. Key in this is the role that scientific information can play to increase opportunities for producing compatible bundles of goods and services. These goods and services include wood, wildlife habitat, scenery, recreation, water quality (including water as a commodity), and riparian habitat; all provided in a manner that is socially acceptable and economically viable. This is consistent with the emerging emphasis on sustainable forest management and with concerns about ways to meet rising demands for goods and services from the forest in an environmentally acceptable manner. It also emphasizes the need for developing effective partnerships between scientists and managers involved in ecosystem management and decisionmakers charged with the political task of governing (see Lee 1993 for an expanded discussion of the role of civic science).

Contemporary Management Regimes in the Pacific Northwest

The Pacific Northwest is considered one of the premier regions for forest management in both the United States and Canada. Although the US portion comprises less than 5% of US timberland, between 1950 and 1985 it was often responsible for a quarter of the annual softwood harvest. Since World War II it has been a major region for timber management in both countries, as forestry activities were designed to convert the predominately old-growth forests into managed forests dominated by younger trees. Various forest management regimes have evolved as a function of changes in land owner objectives, the development of silvicultural information (including growth and yield information), and changes in the utilization of harvested timber.

Table 1. Forest land area in the US Pacific Northwest-Westside, 1997

Land class	Total	National Forest	Other Public	Forest Industry	Nonindustrial Private
		Million hectares			
Nonreserved					
Timberland	9.425	2.885	1.849	2.768	1.922
Other	0.279	0.016	0.069	0.049	0.146
Reserved – Total	1.255	0.700	0.623	–	0.002
Nonwilderness		0.069			
Wilderness		0.631			
Total forest land	10.959	3.602	2.541	2.817	2.070

Table 1 illustrates the wide diversity of ownerships that characterize the region. It is important to note, however, that unlike most other regions in the US and Canada, the forest ownerships in the PNW tend to be made up of large and relatively contiguous blocks of timberland. This has led to an interest in landscape-scale management approaches. The wide diversity of ownerships, public and private, has led to a patchwork mosaic of management regimes spread across the landscape. The variety of management regimes stems in part from differences in individual owner objectives, market conditions, biophysical productivity, and regulatory conditions within different parts of the region.

Table 2. Private land under various management regimes in the Pacific Northwest-Westside during the late 1990s.

Regime	Forest Industry	Non-industrial Private
	Percent of land base	
No genetic improvements, regenerate only	17	83
No genetic improvements, regenerate + commercial thinning + other [a]	17	0
No genetic improvements, regenerate + precommercial thinning	12	7
Partial cut	2	0
Regenerate with genetically improved stock + other	47	10
Conversion or rehabilitation [b]	0	0
Reserve areas	6	0
Harvest age (years)	43–55	40–60
Area (thousand ha)	2,767	1,924

[a] "Other" may include precommercial thinning and/or fertilization.
[b] Conversion or rehabilitation is replacing an existing understocked or undesired stand with a stand better matched to the site, or of higher commercial value.

Source: Haynes *et al.* (2003).

Characterization of Current Management Regimes

For much of the past century there has been vigorous debate about the management regimes that are most appropriate for the Pacific Northwest. Much of the debate focused on various individual practices but for the past five decades there has been tentative consensus on the basic set of practices that comprise the core of various management regimes. Given the increasingly diverse objectives among land owners, contemporary forest management is evolving to include greater flexibility both in the application of selected practices and in expected outcomes.

Stand-Level Management Intensities on Private Lands

Since the early 1960s the notion of management intensity has been used to characterize the relative level of investment per hectare made by different landowners. Higher management intensities generally cost more in the short run, but presumably yield a greater return on the investment in the long run. Table 2 summarizes results of a study of management intensities on private forestlands in the PNW-Westside subregion during the late 1990s. Allocations of land to the different regimes, or levels of

management intensity, were based on information obtained in some instances by directly questioning landowners and in other cases were developed by knowledgeable experts (see Haynes *et al.*, 2003 for details).

Management intensities differ among landowners. For example, industrial owners' management has consistently involved practices that include regeneration, some form of commercial thinning (CT), and sometimes precommercial thinning (PCT). Recently there has been a decline in intentions to pursue highly complex regimes such as Plant/PCT/Fertilize/CT. These regimes appear to have been replaced by one or two simpler treatment regimes (for example, Plant/PCT or Plant/PCT/fertilize). On nonindustrial private forest (NIPF) lands, management is largely restricted to securing regeneration with only limited use of other treatments. This is consistent with past studies indicating that NIPF lands were in relatively poor management condition (e.g., low conifer restocking after harvest). Recent surveys of NIPF timberlands show a large fraction of the land base in some form of partial cutting or selection management. It is not clear whether this implies a long-term objective of developing a multi-aged selection system or simply a sequence of heavy thinnings to postpone clearcutting.

Rotation age or age of harvest is one of the most closely scrutinised elements of the timber management regime. The limited information on the actual harvest-age behaviour of owners in the PNWW is summarised at the bottom of Table 2.

Federal Land Management in the US Pacific Northwest

Federal land management in the Pacific Northwest since 1993 has been guided by a comprehensive long-term policy for managing habitat for the northern spotted owl, a species protected under the Endangered Species Act (1973). This strategy, which has been called the Northwest Forest Plan (NWFP), was developed from a report prepared by the Forest Ecosystem Management Assessment Team (FEMAT, 1993). The NWFP set in place a connected reserve system with both terrestrial and aquatic components (see Haynes and Perez, 2001 for a summary of the science contributions). The federal land base was allocated among late-successional and riparian reserves, matrix lands (all federal lands outside of reserves, withdrawn areas, and managed late-successional areas), and adaptive management areas (AMAs). The AMAs were included because the plan was an evolutionary strategy using adaptive management to test and modify assumptions, develop opportunities for organizational innovation, and investigate collaborative approaches.

The land management strategy embedded in the NWFP is based on many of the components common among ecosystem management approaches. It uses a connected reserve system to maintain well-distributed habitat on federal lands for two old-growth-dependent bird species, the marbled murrelet and the northern spotted owl, both of which are protected under the Endangered Species Act (1973). The connected-reserve approach is also considered likely to reverse habitat degradation for at-risk fish species or stocks, which is important because in recent years the protection of habitat for native and anadromous fisheries in PNW forests has assumed greater significance. Concern over several species of threatened or endangered salmon, in particular, has been a major focus of the debate over forest management during the past few years.

The approach used in designing the connected reserves was based on consideration of relationships between plant and animal species thought to be closely associated with late-successional forests. The design of the connected reserve system also considered its likelihood of long-term persistence. The management regimes that were applied in both the matrix and late-successional forests were modified versions of those shown in Table 2 but involved extended rotation lengths and greater reliance on partial harvests to increase structural variation within the forests.

In general, three management regimes can be used to describe the present approach being used on the US National Forests (see Mills and Zhou, 2003 for details). The first regime allows a final harvest followed by regeneration, typically by planting seedlings. The second regime uses partial harvesting so that the stand will develop a broader range of structural characteristics over time, including both older and younger trees. Regeneration is accomplished either by underplanting or by favoring natural regeneration. The third regime allows no harvest. These stands are held in reserve, often for development into late successional old-growth habitat.

The Changing Regulatory Environment

One of the significant changes over the past 50 years has been the development of state (or provincial) and federal regulations that influence the design of forest management practices and control the applications of these and other practices. For the most part these regulations reflect the manifestation of public concerns about forest lands or forest conditions.

Early regulations evolved from public concerns, first about fire protection and later about restocking of cutover timberland. Significant regulatory events in the US include the Wilderness Act (1964) that lead to the formal designation of Wilderness on national forest and other federal lands (such designation removes land from the timberland base); the National Environmental Policy Act (1970) that requires analysis of environmental and economic impacts of significant actions; the Oregon State Forest Practices Act (1971) that set minimum standards for a wide variety of management practices; the Endangered Species Act (1973) that required the protection of endangered and threatened species and their habitat; the Washington Forest Practices Act (1974) that regulates practices related to growing, harvesting or processing timber; the National Forest Management Act (1976) that required management plans for each national forest; and the Northwest Forest Plan (FEMAT, 1993) a balanced policy for managing federal lands in the range of the northern spotted owl.

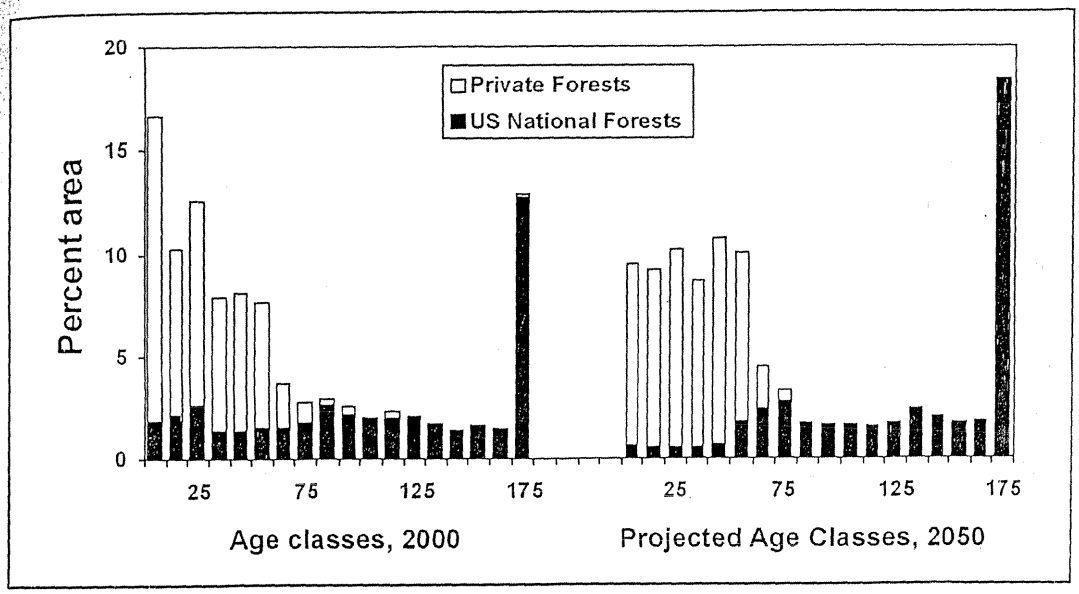
The current management regimes reflect this regulatory environment but there is constant debate about the possible expansion of various regulations, especially those related to forest management in riparian areas. In addition, there are also concerns about how some public policies either directly or indirectly impact forest land use. For instance, a topic currently being debated in Oregon is the issue of whether regulations that restrict certain types of development on private lands constitute a "taking" of land value that should be subject to compensation.

Private timberlands throughout the PNW region (including provincial lands under tree farm licenses in British Columbia) are subject to a wide array of regulations on reforestation, road construction and maintenance, timber harvesting, chemical applications, and slash disposal. Although these regulations vary to some degree because of local political differences, in general they are remarkably similar. The State of Washington has recently moved somewhat beyond the other political subdivisions of the region in that it now requires the development of comprehensive habitat conservation plans where forestry operations cover extensive parts of a single watershed. Such plans must be coordinated among multiple landowners if each has custody over a significant fraction of the watershed area.

Impact of Management Levels on Future Forests

The characteristics of future forests in the PNW will be the consequence, in part, of a myriad of decisions made by a highly diverse array of timberland owners. The forests will also be shaped by the

Fig. 2. Age class distribution by ownership for softwood forest types on timberland in the Pacific Northwest-Westside for 2000 (left), and projected for 2050 (right). The 175-year age class includes all areas with trees whose average age is 170 years or older.



various forest products industries that will arise to utilize the species and sizes of timber available and by public concerns as manifested in various regulations to protect non-market forest benefits.

We expect a resurgence of sawtimber harvest and lumber production in the Pacific Northwest resulting from expanding harvest levels on private timberlands. This expansion is a function of a maturing private timber inventory, large proportions of which will approach minimum harvest age (40 years) after 2010. In the context of total inventories across all ownerships, these changes in private timberlands and the gradual aging of inventories on national forest timberlands will lead to a more pronounced bimodal distribution of age classes as suggested by Figure 2. At the national level, such projections suggest that we "will be able" to meet US demands for softwood products by shifting the harvest onto more intensively managed private timberlands (mostly in the US south) while at the same time preserving large amounts of older western timber stands in the federal ownerships. In the Pacific Northwest, the bimodal forest resource base will exhibit a significant shortage of stands in the 40–80 year range. The majority of younger stands (less than 40 years) will be on private land located typically at lower elevations, and stands older than 80 years will be concentrated on public lands typically at higher elevations and in headwater areas. The bimodal distribution suggested by these projections raises concerns about whether there will be an adequate representation of age classes over the entire region to provide habitat for all forest-dependent species. Equally uncertain is whether such a distribution of age classes is consistent with long-term sustainability of the resource base.

Relationships between Ecosystem Management and Sustainable Forest Management

Sustainable forest management is an enduring issue that in the past decade has taken on increased importance out of concerns about resource overexploitation (Powers, 2001), sustainable development (World Commission on Environment and Development, 1987), and possible climate change effects

(Watson *et al.*, 1995; Schwalm and Ek, 2001). During its 200-year history, the concept of sustainable forest ecosystem management has been the focus of scientific and political discussion, with varying degrees of intensity – it tends to be promoted with vehement fervor during periods of social or economic crisis and less intensely during periods of stability (von Gadow *et al.*, 2000).

Sustainable forestry is difficult to define and quantify (Amaranthus, 1997; Schlaepfer and Elliott, 2000). In its broadest sense, sustainability is a deliberate management goal that implies an ability to maintain the productivity and ecological integrity of the forest in perpetuity (Monserud, in press). This statement includes the interactions among both temporal and spatial scales by expressing the need to consider the timeframe and the spatial extent of management goals. Clearly, measures of sustainability become increasingly complex as the scale increases from stand to landscape to region, and on to national and global scales. Almost all of the work with criteria and indicators of sustainability is at the national scale, or at the scale of an entire forest management unit (e.g., a national forest or a private forest ownership). Forest management, however, is implemented at the stand level, which introduces a profound scale effect (Hall, 2000).

Before the 1990s, most countries managed their forests under the principle of *sustained yield*, with a nearly exclusive focus on timber yield from forest stands or contiguous groups of stands (Tittler *et al.*, 2001). The selection of sustainable forestry practices depends on what one is trying to sustain, a choice often driven by utilitarian principles (Amaranthus, 1997). In response to rising social pressures for a wider variety of goods and services from the forest, the concept of sustainable forestry has expanded to include much larger areas and a broader set of forest uses. Wilson and Wang (1999) define *sustainable forestry* as comprising a host of management regimes to maintain and enhance the long-term health and integrity of forest ecosystems and forest-dependent communities, while providing ecological, economic, social, and cultural opportunities for the benefit of present and future generations. This is a multi-dimensional definition including biological, sociological, political, and economic factors (Perry and Amaranthus, 1997; Wilson and Wang, 1999). Although an all-encompassing definition is appealing, it does not lend itself easily to translation into action, especially at smaller scales.

The shift in attitude from sustained yield to sustainable forestry was triggered internationally by the Brundtland Report on sustainable development in 1987 (World Commission on Environment and Development, 1987) and later consolidated at the Earth Summit in Rio de Janeiro in 1992 with the adoption of the Forest Principles (Tittler *et al.*, 2001). In response, several initiatives and international agreements have attempted to quantify broad-scale sustainability (Mendoza and Prabhu, 2000; Tittler *et al.*, 2001), such as the Montreal Accord (Mihajlovich, 2001). The emphasis in the Montreal Process is on using criteria and indicators for judging if the collective actions of a myriad of land owners and managers represent progress towards sustainable forestry over broad areas, usually at the national scale. There have also been many parallel efforts to apply criteria and indicators for the assessment of the sustainability of individual timber concessions (Mendoza and Prabhu, 2000).

The development of forest certification programs by nongovernmental organizations such as the Forest Stewardship Council and the American Forest and Paper Association is another indicator of the shift in public attitudes and the need for landowners to demonstrate their commitment to responsible forest management. These programs develop principles and objectives or criteria for sustainable forest management that can be applied to a participant's forests. All such certification systems emphasise the use of forest planning, best management practices, and logger and landowner education to achieve sustainable forest management (see AF&PA, 1999).

In practice, much of forest management is conducted at the stand and landscape levels to meet the objectives of individual landowners or managers. Actions designed to promote sustainability of the forest resource seek to simultaneously produce multiple forest goods and services, maintain the ecological integrity of the forest resource, and reduce social conflict regarding management. The net

effect of actions by numerous landowners and managers are all complementary to (and likely a subset of) sustainable forest management as a whole.

Conclusions

This examination of the development of ecosystem approaches for forest management in the Pacific Northwest demonstrates the importance of recognizing that any forest management system, especially on publicly owned lands, will be socially acceptable only if it incorporates a thorough understanding of the social context within the region (and possibly even beyond the region, since some of the region's "forest constituents" may live elsewhere). Significantly, this means that forest management actions and outcomes *must* change over time, because society will inevitably change and as it does, its populace will demand changes in forestry objectives and in management practices.

Essentially all of the public forest management agencies within the PNW region have adopted ecosystem approaches to forest management as a guiding principle. Private forest owners, however, are guided more by individual objectives that may vary considerably among the population of owners. Furthermore, private forest owners tend to base management decisions on shorter-term market considerations.

Even so, the collective actions of the various owners within the PNW region appear to be leading to a situation that can generally be described as something close to area regulation. That is, the forests in the Douglas-fir region are becoming roughly evenly distributed across the age classes (and more importantly, across seral stages). As shown in Figure 2 there are differences in the distribution by ownership but in terms of broad forest conditions, the areas are distributed in roughly equal amounts across the various seral stages relevant to Douglas-fir forests. This situation is expected to remain relatively stable, given the expected market and processing options. These conditions also offer opportunities for compatible management systems that combine wood production with biodiversity conservation. This should make it possible to sustain flows of timber while at the same time preserving habitat and the various services derived from the forest's various structural components. At the regional scale, the diversity of ownerships, each with its own set of management objectives, helps provide the degree of variability that is essential in an ecosystem approach to forest management.

As a counterpoint to this generally positive outlook, it should be noted that the increasing reliance on science-based management cannot eliminate uncertainties associated with management outcomes. As one example, the success of the Northwest Forest Plan itself is vigorously debated among land managers and various public groups, each of which defines "success" as seen through its own lens. Perspectives on the success of the Plan are complicated by the extent of the legal battles that have stemmed from its implementation, an ironic outcome given that a major objective of the NWFP was to overcome the legal and administrative gridlock that had constrained management of the US national forests in the years leading up to its development.

A second example of an unanticipated outcome lies in the biophysical realm. Recently it has been determined that the barred owl, a larger and more adaptive bird that is not on the endangered species list, has expanded its range into the eastern part of the Pacific Northwest where it apparently is having a detrimental effect on the recovery of the northern spotted owl.

Such outcomes serve as reminders that forest management is a complex undertaking and that it is embedded in both social and biophysical systems that we only partly understand. Ecosystem approaches offer promise for building consensus and for helping stakeholders come to terms with the many competing demands for forest goods and services. Perhaps even more importantly, they also help retain flexibility so that we can adapt management prescriptions to fit our expanding knowledge and to remain compatible with the ecosystem changes that will inevitably arise over time.

forests in landscapes

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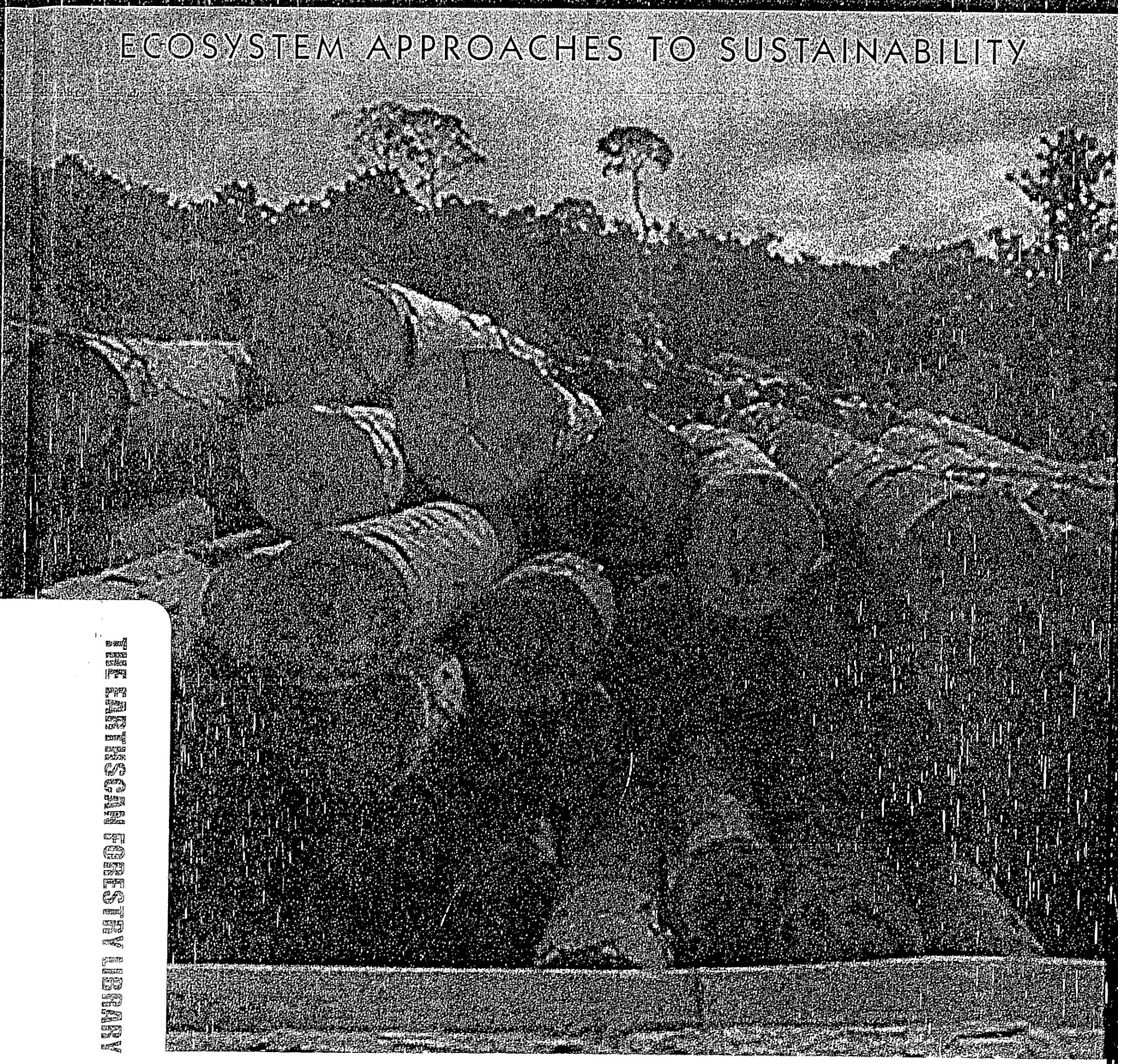

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