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Understanding Key Issues of Sustainable Wood Production in the Pacific Northwest

EDITORS

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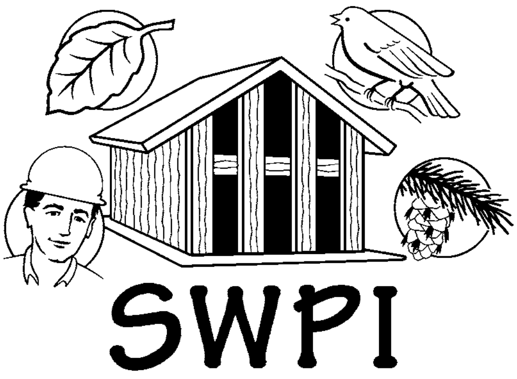

ABSTRACT

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Researchers involved with the Pacific Northwest (PNW)`Research Station Sustainable Wood Production Initiative have outlined some of the barriers and opportunities for sustainable wood production in the region. Sustainable wood production is defined as the capacity of forests to produce wood, products, and services on a long-term basis and in the context of human activity and use. The collective findings of these papers suggest that in the future, the region's wood supply will primarily come from private land, and the barriers and opportunities related to sustainable wood production will have more to do with future markets, harvest potential, land use changes, and sustainable forestry options than with traditional sustained yield outputs. Private lands in the PNW should be able to sustain recent historical harvest levels over the next 50 years, but regional changes in sawmilling capacity and uncertain market conditions may affect wood production in the region. Public perceptions of forestry, land use changes, and alternative forestry options are also discussed. These papers present preliminary findings and proposals for future work designed to help us understand the key issues related to sustainable wood production.

Keywords: Pacific Northwest, sustainable forestry, wood production, timber harvest, land use changes, economics.

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SECTION A: SUSTAINABLE MARKETS

SECTION B: SUSTAINABLE LAND USE

1. Sustainable Wood Production: What Are the Issues for the Pacific Northwest?

Robert L. Deal and Seth M. White

SUSTAINABLE FORESTRY, SUSTAINABLE WOOD production, and sustainability in general are major concerns of forest managers in the Pacific Northwest (PNW) and at the national and international levels (Aplet et al. 1993, Bruntland 1987, Floyd 2002, Maser 1994, Oliver 2003). Sustainability is difficult to define; it means different things to different people. In the words of Floyd (2002), defining sustainability is "like trying to define justice or democracy. There are many definitions and some consensus, but agreement over the specifics is elusive." Sustainability is a value-laden concept, but most people agree that the term generally includes economic, ecological, and social components. The World Commission (Bruntland 1987) has broadly defined sustainability as "development that meets needs of the present without compromising the ability of future generations to meet their own needs." **Sustainable forestry** is a little more specific. A useful definition by the Society of American Foresters (Helms 1998) is "the capacity of forests, ranging from stands to ecoregions, to maintain their health, productivity, diversity, and overall integrity, in the long run, in the context of human activity and use." Here, we further define **sustainable wood production** as the capacity of forests to produce wood, products, and services on a long-term basis, and in the context of human activity and use. Sustainable forestry is related to but different from **sustained yield**—the amount of wood that a forest can produce continually. Sustained growth and yield are important, but as the following papers will illustrate, the barriers and opportunities related to sustainable wood production in the PNW have more to do with future markets, harvest potential, land use changes, and sustainable forestry options than with traditional growth and yield outputs.

The PNW is one of the world's major timber producing regions, and the regional capacity to produce wood on a sustained-yield basis is widely recognized. Issues relating to the ecological, social, and economic frameworks of sustainable forestry, however, will play a major role in future wood production of the region. As the PNW is one of the principal timber producing regions in the United States, there has been public interest in assuring that forests are being sustainably managed as well as a desire by landowners and forest managers to demonstrate their commitment to responsible stewardship.

To address concerns about sustainable forestry in the region, the PNW Research Station is sponsoring a 3-year Sustainable Wood Production Initiative (SWPI). To identify and understand important issues for sustainable wood production, we conducted a series of client meetings and invited a wide array of forest landowners and managers representing forest industry, small private forests, state forestry, and others interested in growing and producing wood. The most pressing need mentioned by almost all forest landowners and managers was the need to identify and understand barriers to sustainable forestry. Our focus groups identified six major topics as priorities. These topics and the associated objectives of the SWPI are:

- Identify and understand the major economic, ecological, and social issues relating to wood production in the PNW in the broad context of sustainable forestry.
- Identify barriers to sustainable forestry and assess the impacts of market incentives and environmental regulations on sustainable forest management.
- Develop a regional assessment of resource trends and market conditions including the long-term economic viability of forestry in the region.
- Identify and assess niche market opportunities for small woodland owners in the PNW.
- Identify emerging technologies for wood products and summarize and synthesize new and existing information on wood technology.
- Develop a comprehensive communication strategy for reporting findings to a broad client base of land managers, researchers, and the general public.

We have divided the following papers into three broad categories including sustainable wood production, sustainable land use, and sustainable forestry options. Chapters 2 through 4 address sustainable wood production in the PNW and include future timber resources and harvest potential, the role of markets, and an assessment of the associated lumber manufacturing sector. In chapter 2, Adams and Latta broadly assess the timber resource and discuss harvest potential of several forest policy alternatives. In chapter 3, Haynes discusses the role that market prices have in forest management decisions and the potential impact of markets on sustainable forest management. In chapter 4, Perez-Garcia assesses trends in both lumber manufacturing and regional milling capacity.

Chapters 5 and 6 discuss land use changes and the overall effects of forest fragmentation on different forest resources. In chapter 5, Alig broadly assesses land use changes in the PNW and potential impacts of population growth and land use change on sustainable forestry. In chapter 6, Lewis and Plantinga assess some of the potential effects of forest fragmentation on wildlife and other resources.

The last four chapters include a broad range of forestry options relating to sustainable wood production. In chapter 7, Bradley et al. evaluate public perceptions of forest practices based on visual preferences and discuss some of the implications of these preferences on sustainable forestry. In chapter 8, Montgomery provides an overview of work to assess alternative costs for developing late-successional forest habitat and how the public might consider paying for these costs. In chapter 9, Zobrist et al. present a solution for addressing riparian zone management issues by using forest structure and economic criteria to create riparian management templates. And in the last chapter, Yadama and Shook examine the use of small-diameter trees combined with plastics as an emerging technology with potential for sustained economic development of local communities.

We realize that our three divisions within this report are arbitrary—each of the papers in its own way addresses one or more concerns related to the broad categories of sustainable wood production, sustainable land use, and sustainable forestry options. We hope that our attempt to organize the papers into a logical framework does not de-emphasize the important concept that these categories are in fact interrelated. Sustainable wood production in the PNW will most likely need to include careful planning for sustainable land use and various sustainable forestry options to ensure future forest resources to meet market demands.

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Section A:
Sustainable Markets

Bob Deal, USDA Forest Service

SWPI

2. TIMBER HARVEST POTENTIAL FROM PRIVATE LANDS IN THE PACIFIC NORTHWEST: BIOLOGICAL, INVESTMENT, AND POLICY ISSUES

Darius M. Adams and Gregory S. Latta[1]

ABSTRACT

This paper synthesizes information from four half-state studies and the fifth Resources Planning Act Timber Assessment to develop a broad assessment of Pacific Northwest (PNW) timber harvest potential. Our review suggests that private lands in the PNW should be able to maintain or exceed recent historical harvest levels over the next 50 or more years given unchanged policies and anticipated levels of private management investment. These results could be realized with stable to rising inventories and nearly stable real prices. Concentration of lands in younger age and size classes will continue in some cases for industrial owners and to a lesser extent on nonindustrial private forest lands. Shifts toward more intensive management will be gradual and relatively limited and have a modest impact on harvest over the next 50 years. New policies that act to reduce the operable land base of private owners should lead to roughly proportional reductions in private timber harvest. Withdrawals that focus on larger and older stands will have a much larger proportional near-term effect, given the general dearth of older timber in the private forest land base.

INTRODUCTION

CONTROVERSIES OVER TIMBER HARVEST LIE at the core of the current discussion of sustainable forestry in the Pacific Northwest (PNW). Efforts to sustain the levels of nontimber forest outputs will, in most cases, lead to reductions in timber harvest. With the near elimination of harvest on federal lands in the 1990s, private ownerships have become the mainstay of the region's future timber supply potential. Absent some major shift in federal land management policies, the region's future timber output will depend heavily on the growth potential of these private lands, the management decisions of private owners, and the regulatory restrictions placed on private actions by the state. This paper reviews recent studies to:

- Develop a view of what future private timber supply potential in the PNW might be, and
- Examine how certain types of public policies might affect that potential.

We consider four studies of Oregon and Washington by half-state[2] and results of the USDA Forest Service's fifth Resources Planning Act (RPA) timber assessment (Haynes 2003). The initial portion of this review summarizes some key measures of the current conditions of private timberlands in the region. We then outline projections of harvest, inventory, management investment, and age and size conditions of the future resource under the "base case" conditions of each of the studies. Public policy impacts are examined through comparative simulations of the effects of land base withdrawals.

Current Resource Conditions

To assess the future timber supply potential in the PNW, it is useful to begin with a consideration of the current conditions of the region's private forest resources. Current inventory data are drawn from Azuma et al. (2004a, 2004b) for western and eastern Oregon, MacLean et al. (1992) for western Washington, and McKay et al. (1995) for eastern Washington. At this writing (October 2003), we do not have an updated Washington inventory. As a result, there is about an 8-year gap between the latest Washington data (roughly 1990) and the latest Oregon data (roughly 1998). Despite the time lag, comparisons are still roughly indicative of current conditions and differences between the two regions. In describing current resource conditions we consider changes in the timberland base, trends in timber inventory, distributions of area by age class, and the intensity of timber management.

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[2] Adams et al. (1992) for western Washington, Bare et al. (1995) for eastern Washington, Adams et al. (2002) for western Oregon (see also Schillinger et al. 2003), and Adams and Latta (2003) for eastern Oregon.

Private lands in the Pacific Northwest should be able to maintain or exceed recent historical harvest levels over the next 50 or more years given unchanged policies and levels of private management investment. (Photo by Bob Deal, USDA Forest Service.)

Changes in the timberland base are a fundamental resource concern in assessing future harvest potential. For the PNW as a whole (fig. 2.1A), the private land base has declined over the past 50 years by nearly 4 million acres, owing primarily to a steady drop in nonindustrial private forest (NIPF) holdings (Smith et al. 2001). In the most recent decade shown in figure 2.1A, the total private sector loss has slowed to about 700,000 acres, but this is still a sizable decline. Losses in the NIPF group have occurred both on the west side and east side, although the largest reductions have been in western Washington and in the Puget Sound region in particular (MacLean et al. 1992).[3]

Trends in timber inventory are another way of looking at the ratio of growth to harvest—one of the key measures of the sustainability of forests by most definitions. As shown in figure 2.1B, there has been a long-term declining trend in growing-stock inventory on industrial forest lands. The NIPF inventory, in contrast, has grown in recent years, despite record harvests in the 1980s and 1990s, as large areas of young stands move into the ages of most rapid growth.

Age class distributions for forests managed on an even-age basis provide some insights into both past harvesting patterns and future harvest potential. Distributions for the west-side subregions by owner type are shown in figure 2.2. Relations between industry and NIPF in these charts are similar for half-states (east side or west side of the state).

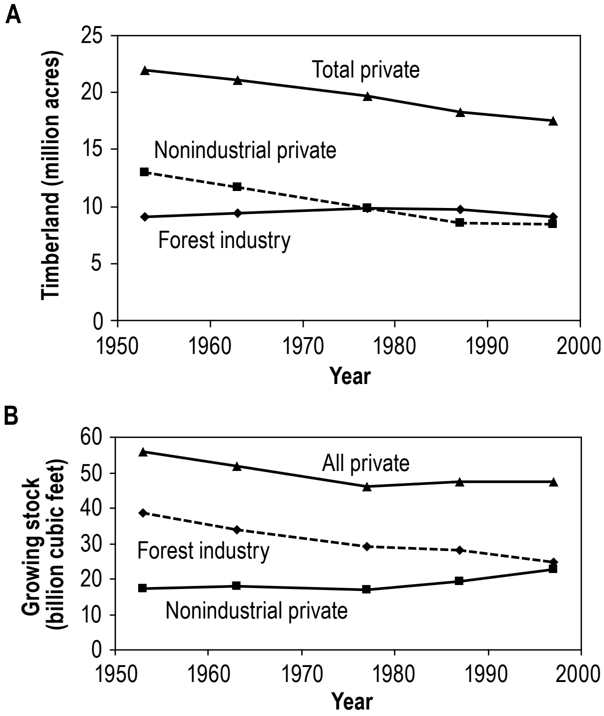

Figure 2.1—Private timberland area (A) and growing-stock inventory (B) in the Pacific Northwest (from Smith et al. 2001).

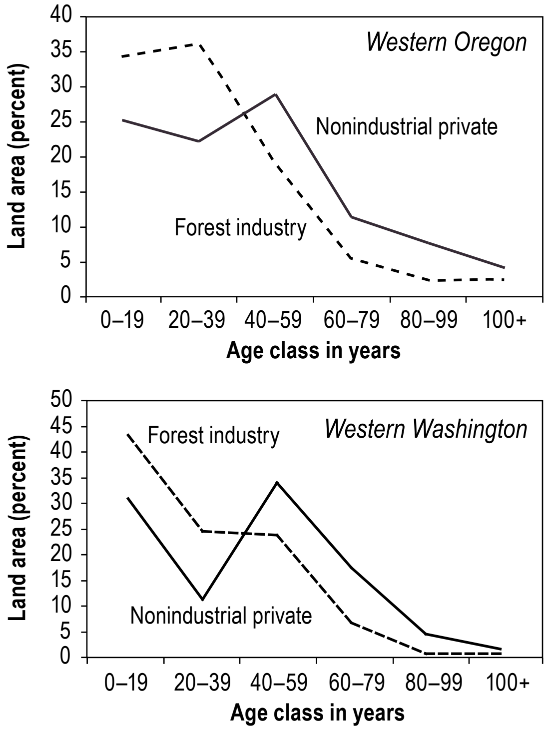

Figure 2.2—Age class distributions as a proportion of land area for private owners in western Oregon and Washington (from Adams et al. 1992, Adams et al. 2002).

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[3] PNW west side is known as the Douglas-fir region of western Oregon and Washington, and PNW east side is known as the ponderosa pine region of eastern Oregon and Washington.

Industry lands have about 90 percent of their area in stands less than 60 years old, whereas NIPF lands have about 75 percent of their area in stands of similar ages. Increases in the younger classes on industry lands indicate an increase in harvested area in recent years. If stands are presently being cut primarily in the 40-to-59-year age group, these distributions suggest that industry lands will have an increasing supply of stands reaching this age group over the next 20 years. The NIPF ownerships, in contrast, will see a decline in area advancing into this age group.

For forests managed by selection or partial cutting, diameter class distributions provide a better picture of current structure and future harvest potential. Figure 2.3 shows the fraction of total volume by 2-inch diameter classes for private owners on the east side. The structures are quite similar between the two states, with the modal classes roughly between 13 and 15 inches in both cases. From the more detailed ownership data available for eastern Oregon, we see that industrial lands appear to have greater proportions of their land in smaller classes, whereas NIPF lands retain most of the largest timber. Annual removals have taken on average 6.5 percent of eastern Oregon industrial inventory each year, and NIPF cut has averaged about 2.5 percent of inventory (measured as growing-stock volume).

A final aspect of the current state of private forest resources is the way in which they are managed—the level of management input or investment. Lands managed more intensively for timber should have higher growth and yields at comparable ages than less intensively managed lands. Figure 2.4 shows estimates of private land area on the west side by management intensity regimes (see Haynes et al. 2003). A much larger fraction of industry land is enrolled in the most intensive regimes, whereas more than 80 percent of NIPF land is managed with attention to regeneration only. Figure 2.5 shows management intensity distributions on the east side from two studies (Adams and Latta 2003, Bare et al. 1995) that use low-, medium-, and high-intensity classifications of even- and uneven-age regimes. In eastern Washington, although industry owners do have some land in the more intensive forms, the largest fractions in both types of regime are allocated to the lowest intensity for both ownerships—a contrast with the west-side results. In eastern Oregon, industry ownerships have higher fractions in the more intensive classifications.

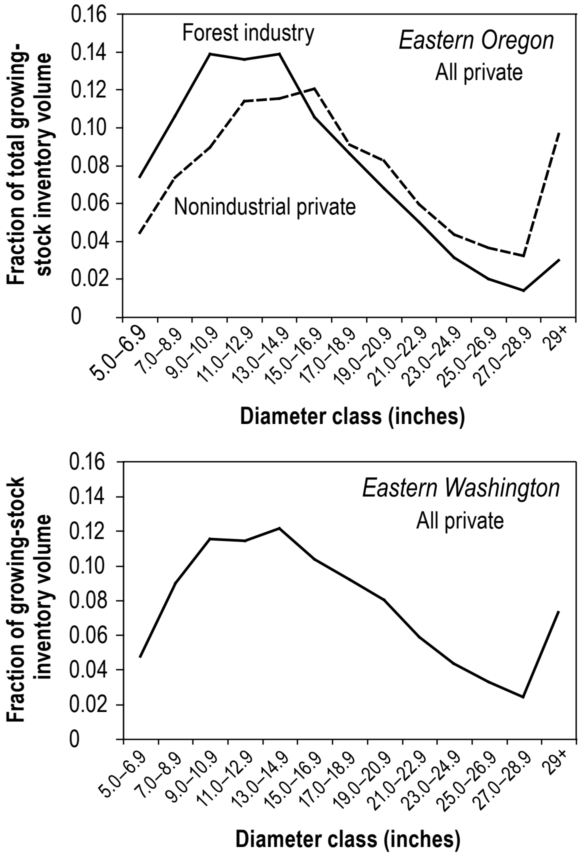

Figure 2.3—Size class distributions (fraction of inventory volume by class) for private owners in eastern Oregon and Washington (from Adams and Latta 2003, Bare et al. 1995).

BASELINE HARVEST PROJECTIONS

We are fortunate at this juncture to have four relatively recent studies that have examined the timber harvest potential of private lands in the PNW at the half-state level (see footnote 2 for citations) and the Forest Service's fifth RPA timber assessment (Haynes 2003) that provides projections for the west side and east side. Although there are some differences in projection methods among these studies, these differences are not so great as to preclude a useful comparison. Results are shown in figures 2.6A–2.6C (solid lines) and in figure 2.7.

Harvest Volumes

Reviewing the half-state projections reveals that all but one of the subregion-owner combinations appear able to sustain harvests at recent historical levels for at least the next 50 years. In many cases, the projected harvests are

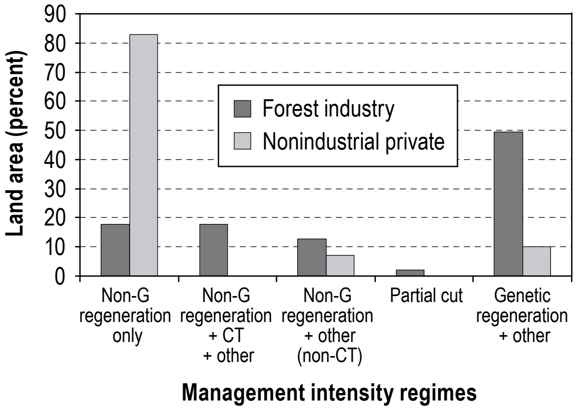

Figure 2.4—Distribution of private land area in western Oregon and Washington by management intensity regimes circa late 1990s (Haynes et al. 2003). Non-G is nongenetically improved planting stock; CT is commercial thin; other indicates other treatments also possibly included.

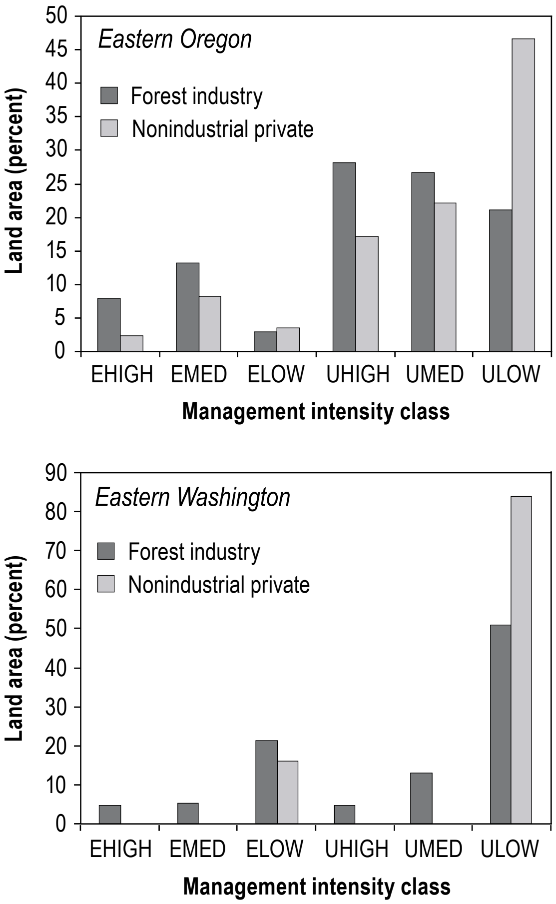

Figure 2.5—Distribution of private timberland by management intensity class in eastern Oregon and Washington. E = even-age management, U = uneven-age management, LOW, MED, and HIGH refer to degree of intensity (from Adams and Latta 2003, Bare et al. 1995).

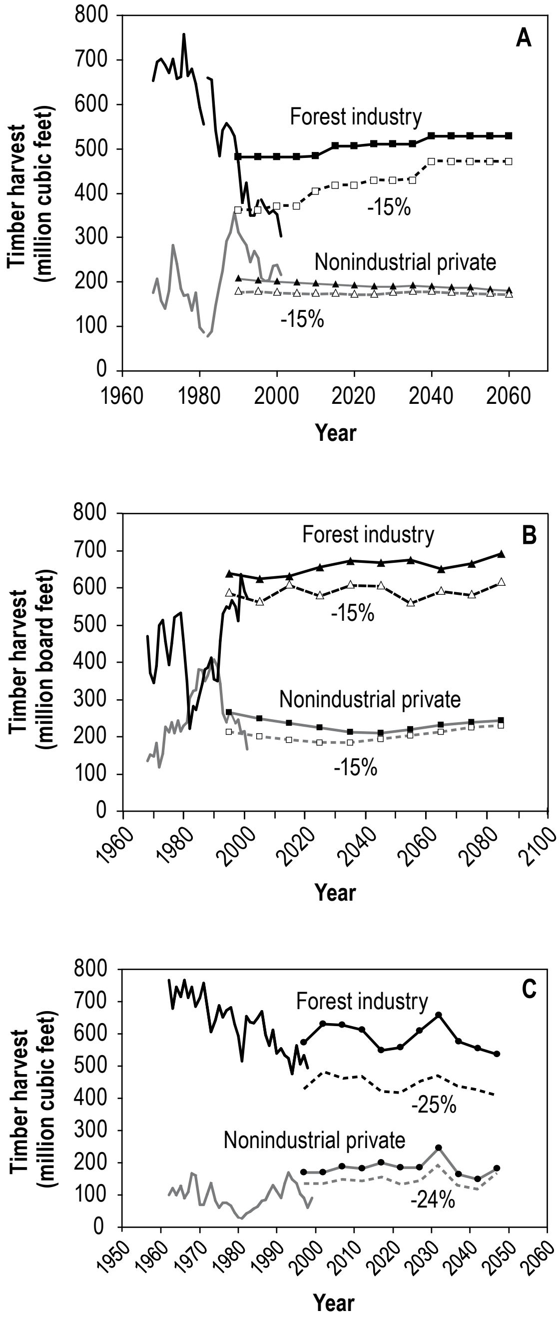

Figure 2.6—Historical and projected softwood timber harvest on private lands in western Washington (A), eastern Washington (B), and western Oregon (C) from various studies (see text). Solid lines are projections for the base case; dashed lines are projections assuming area reductions (in percentage amounts shown on charts).

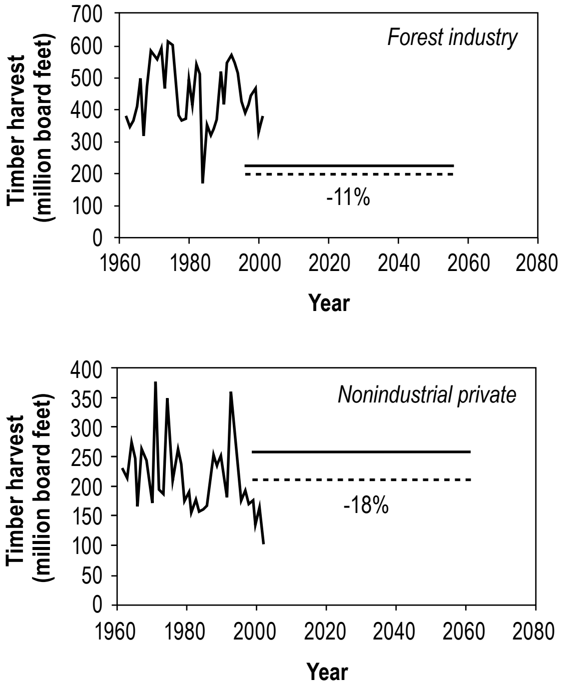

Figure 2.7—Historical and projected softwood timber harvest on private lands in eastern Oregon (projections from Adams and Latta 2003). Solid lines are projections for the base case; dashed lines are projections assuming 11 percent and 18 percent reductions in timberland bases for industrial and NIPF owners, respectively.

substantially higher than recent historical levels, matching or exceeding the 20-year historical average. In fact, in some cases the projected harvests are at or above historical peak levels.

The one exception to this increasing harvest projection is the eastern Oregon industrial ownership. Industrial inventory has been declining in eastern Oregon for at least the past 20 years while harvest has been relatively stable and mortality rising. In the most recent inventory cycle (1988–99), gross growth averaged 54 million cubic feet (MMCF) per year, mortality 11 MMCF per year, and removals 74 MMCF per year for a net annual inventory reduction of some 31 MMCF per year (Azuma et al. 2004b). Reflecting this long-term inventory reduction, projected eastern Oregon harvest drops to about half of the 40-year historical average (fig. 2.7). Recent projections for eastern Oregon by Sessions (1991) dropped well below those from an earlier study by Beuter et al. (1976), in part because of the inventory decline. The most recent study reported here (Adams and Latta 2003) shows an additional 30-percent decrease below the projections reported by Sessions (1991).

Effects of more intensive management—

Assumptions about increasingly intensive management are likely to be important in achieving the “base case” results reported for the west-side studies. The eastern Washington study does not allow changes in management intensity classes (MICs) over the projection, whereas the eastern Oregon study shows shifts toward less intensive MICs for even-aged stands. Both the western Washington and Oregon studies do assume shifts in management from lesser to more intensive forms on both ownerships. These shifts are fairly substantial in the western Washington industry case but less so for western Oregon industry. The western Washington study offers some insights into the impacts of its MIC shift assumptions through a sensitivity test in which no MIC shifting is allowed on industry lands. Harvest levels are virtually unchanged during the first 25 years and only about 7 percent lower by the 50th year. Because the largest growth gains from more intensive management are likely to come through changes in planting stock, early stand density control, and fertilization early in a stand’s life, this relatively small gain by the 50th year (roughly one rotation) is not surprising. Most of the harvest volume over the first 50 years of the projection will come from stands already established, with limited opportunities for accelerating growth.

Age/size distributions—

Maintaining the harvest levels shown in figures 2.6A–2.6C also entails a further concentration of stands in the younger and smaller age/size groups in most subregions and ownerships. We can infer that average stand size is declining in the two east-side areas studied given the declining trends in the quadratic mean diameter (QMD) of the timber harvested (see discussion below) and because harvests in both studies are restricted to trees larger than 9 inches. In the western Washington study in about the 50th year of the projection, inventories have roughly equal area in each age class from new regeneration up to 40 or 50 years of age and with no volume in older classes (an extreme result of the projection method). The western Oregon study, in contrast, shows limited change in the age structures for both owners. Industry lands are already heavily concentrated in younger classes (the percentage of area in stands less than 60 years rises from 90 to 92 percent). For NIPF lands, the widespread adoption of partial cutting allows an expansion in areas for stands greater than 60 years because of the older residual trees in the partially cut stands.

AGE AND SIZE OF HARVESTED WOOD

In all of the studies, the average age and size of timber harvested decline over the projection. On the west side, average clearcut harvest age is 60+ years in the initial projection period, but by 30 years into the projection, clearcut harvest age is reduced to only 40 to 50 years. In the western Oregon industry case, this transition happens very quickly as there is little volume at ages greater than 50 years. In eastern Washington, the QMD of harvested timber for all private owners falls from a 15- to 21-inch range to an 11- to 17-inch range after the 50th projection year. In eastern Oregon, harvest QMD rises from 10 to 13 inches to 12 to 14 inches as a result of lower harvests and rising inventories.

Growing-Stock Inventories

With the exception of the sequential look-ahead analysis[4] in western Washington, all of the studies show stable or rising inventories for their respective regions and owners, hence a rough balance of growth and harvest. In the western Washington case, the sequential even-flow approach that was used leads to inventories that decline at decreasing rates and approach some steady state in the long term. It is likely, however, that a strict even-flow projection would also yield stable to rising inventories as found in other regions, but we are unable to say because inventories were not reported for this case.

Timber assessment projections—

Further analysis of timber harvest projections of private lands in the PNW can be derived from the Forest Service's fifth RPA timber assessment (Haynes 2003). The underlying model here is an economic representation of national product and regional log markets over time, not a volume flow analysis. Thus, it provides information on prices as well as harvest and inventories. Its harvest patterns will not follow the typical even or sequential flow trajectories but move with fluctuations in prices and inventory.

Harvest projections from the RPA timber assessment shown in figure 2.8 are generally consistent with the half-state studies just reviewed. The NIPF owners on both the west side and east side have some potential for increasing harvest. East-side industry harvest is a mix of declining cut in eastern Oregon and potential for stable to increasing harvest in eastern Washington. West-side industrial harvest shows no major rising or falling trends, again consistent with the potentials portrayed in the half-state studies. The stable to rising inventory trends in figure 2.9 are also broadly consistent with what we've discussed in the half-state studies. Note that even with rising cut on NIPF lands, inventories continue to grow until some 40 years into the projections. The PNW real or deflated stumpage prices are shown in figure 2.10 together with those in key competing U.S. regions. Prices for west-side PNW are essentially

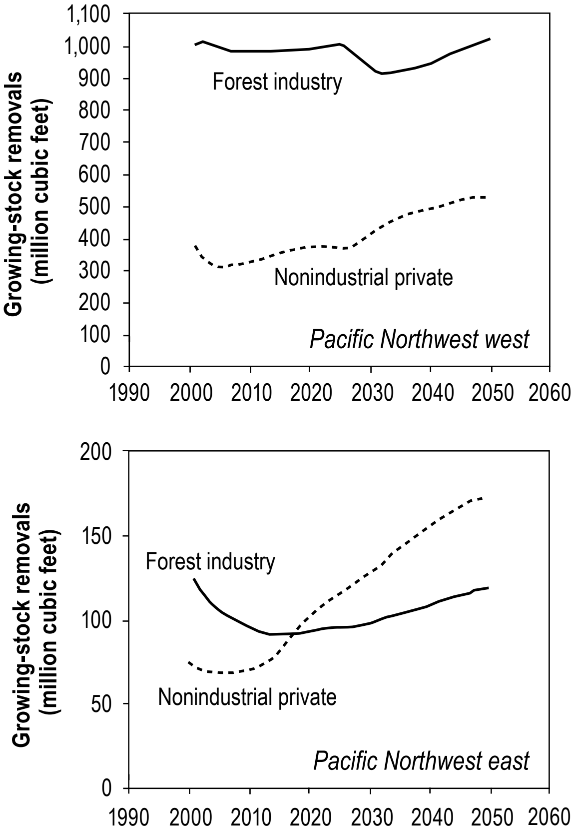

Figure 2.8. Projected private softwood growing-stock removals for Pacific Northwest west and east from the fifth RPA timber assessment (Haynes 2003).

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[4] In a harvest scheduling problem, the planning period is divided into some number of basic time intervals (e.g., a 100-year planning period may comprise twenty 5-year time intervals). The model that computes the schedule projects the harvest and inventory from one basic time interval to the next. Strict even flow is the highest uniform harvest volume that can be maintained over some planning period with no variations above or below this level in any time interval. In sequential even flow, a "look-ahead" period is defined as some number of time intervals (but smaller than the planning period). The strict even flow is computed for the first look-ahead period starting in the first time interval. This harvest is taken only in the first time interval of the look-ahead period and the inventory projected to the next time interval. The strict even flow is again calculated for look-ahead period, and again the cut is taken only for the first time interval in the look-ahead period. The process continues in this sequential fashion until the harvest for the last time interval in the planning period is computed.

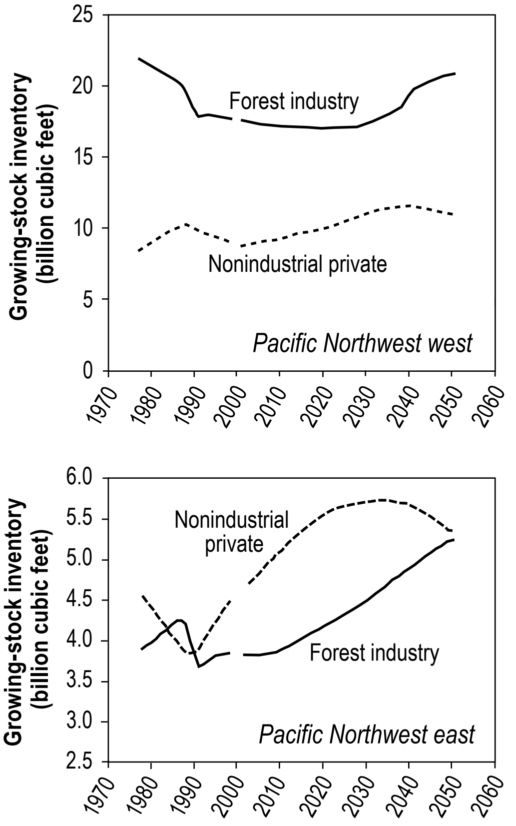

Figure 2.9—Historical and projected private softwood growing-stock inventory for Pacific Northwest west and east from the fifth RPA timber assessment (Haynes 2003).

stable until late in the projection. Prices for east-side PNW (combined in the interior West category) rise slowly over the next two decades, then stabilize.[5]

EFFECTS OF PUBLIC POLICIES ON HARVEST POTENTIAL

There are many public policies and regulations that influence the harvesting and management decisions of private forest landowners. To provide a limited demonstration of how sensitive the foregoing harvest projections might be to changes in public policies, we examine a hypothetical case where the policy acts to reduce the operable land base. Such an effect might be realized, for example, when management is restricted in riparian zones, sensitive habitat areas, or sites with unstable soils and slopes—all recent concerns in the PNW. All the half-state studies include some type of land base reduction scenario, although the details differ by study. In the Oregon studies, lands within 100 feet of all streams were assumed to be restricted from harvest entry, resulting in about a 25-percent reduction in the private timberland base. In the western Washington study, timberland area was reduced by

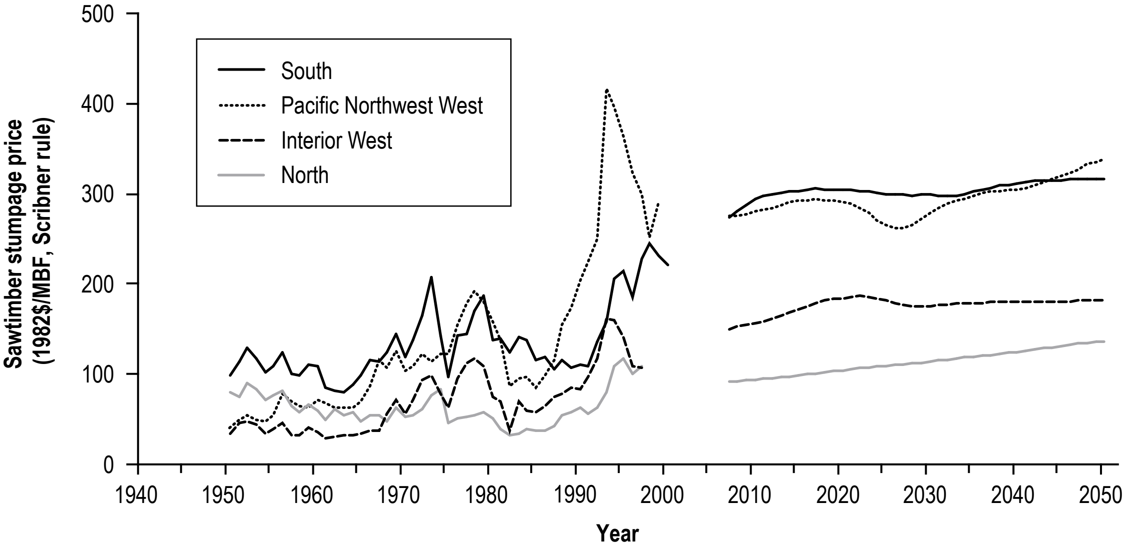

Figure 2.10—Historical and projected real softwood sawtimber stumpage prices for Pacific Northwest west, interior West (contains Pacific Northwest east), and other U.S. regions from the fifth RPA timber assessment (Haynes 2003). Prices are in 1982 dollars per thousand board feet, Scribner log rule.

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[5] Both the western and eastern Oregon studies also include price projections as part of their market model analyses. These studies show essentially stable prices over the next 50 years, again roughly consistent with the RPA results.

15 percent with more than 60 percent of the set-aside acres coming from timber 70 years and older. The eastern Washington study removed 15 percent of timberland area proportionally from all forest types and zones.

Results from the various studies are shown as the dashed lines in figures 2.6A–2.6C. In the western Washington case (fig. 2.6A), the average harvest reduction over the projection for industrial owners nearly matches the area set aside, with 17 and 15 percent reductions, respectively. Initially, this decline in harvest is far larger for industrial landowners because the withdrawals are concentrated in older timber that is scarce in the industrial base. Immediate loss of this timber leads to an exaggerated harvest response. We note that an analysis of the imposition of minimum harvest ages in the western Oregon study (Adams et al. 2002) produced similar results for the same reasons.[6] Harvest impacts on western Washington NIPF owners average only about half of the area lost, roughly 8 percent reduction, as they have far larger areas of older timber. In both cases, impacts decline with time. This latter result is due largely to the harvest projection method that allows greater reductions in the inventory in later periods.

In eastern Washington (fig. 2.6B), again the percentage reduction in industrial harvest is close to the proportion of area removed, with 16 and 15 percent reductions, respectively. Reserved land is drawn proportionally from all age and size classes, so for industrial land the pattern of harvest reductions is roughly uniform over time with no large initial change (as in the western Washington case). The NIPF harvest averages 9 percent reduction in this case, again lower than the proportion of land base lost. This result, as Bare et al. (1995: 137–138) note, was owing to a relaxation in the harvest flow constraints to render the solution feasible. Otherwise we would expect a harvest reduction roughly proportional to the area loss.

In both western and eastern Oregon studies, harvest reductions are very nearly proportional to area reductions, even though the land lost is concentrated in streamside zones. In western Oregon, industrial and NIPF land areas fall by 25 percent and 24 percent, respectively, while average harvests fall by 24 percent and 25 percent. In eastern Oregon, industrial area loss is about 11 percent and harvest declines by about 12 percent, while NIPF area falls by 18 percent and cut by 19 percent. This suggests that the current age and size distributions of lands in the riparian zones are roughly representative of the inventories of these owners as a whole. If, in contrast, they were to contain disproportionate volumes of larger and older timber, we would have expected larger near-term harvest reductions similar to the western Washington study.

DISCUSSION

Viewed broadly, the foregoing review suggests that private lands in the PNW, and its half-state subdivisions, should be able to sustain at least recent historical harvest levels over the next 50 or more years given unchanged policies and the anticipated levels of private management investment. The historical declining trend in industrial harvest on the west side could be arrested, and the potential for continued growth in NIPF harvest in all regions is great. Furthermore, these trends could be realized with stable to rising inventories—growth would be at least as large as harvest. Accompanying such a trend, we can expect continued concentration of industrial lands in younger age and smaller size classes and a continued decline in the average age and size of timber harvested. This will be less true on NIPF lands and is expected only to a modest extent in the western Oregon subregion. Part of the ability of private lands on the west side to sustain harvests derives from an expectation of further intensification of management with increased reliance on planting rather than natural regeneration, early stocking control, application of fertilizer, and to a lesser extent, the use of commercial thinning. These studies suggest, however, that shifts toward more intensive management regimes will be gradual, relatively limited, and have a relatively minor impact on harvest potential over the next 50 years. We do not anticipate a wave of intensive forest plantations with genetically modified trees managed on short rotations. Also, based on information from the Forest Service's fifth RPA timber assessment, we expect that all this might transpire in a market with relatively stable timber prices.

Finally, the collected simulations suggest that new or revised policies that act to reduce the operable land base of private owners should lead to roughly proportional reductions in private timber harvest. This would be true so long as the land losses were distributed proportionally across forest types, age classes, and site qualities in the ownerships. In Oregon, at least, this would also be true

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[6] A minimum harvest age, as the name implies, is a lower bound on the age at which a stand can be harvested. Stands below this age would be ineligible for harvest. Increasing the minimum age renders more and more of the inventory inaccessible for harvest.

even if the losses were concentrated in riparian zones alone. And in all regions, withdrawals that focus on the larger and older stands will almost surely have a much larger than proportional near-term impact, given the general dearth of older timber in the private forest base.

METRIC EQUIVALENTS

When you know:	Multiply by:	To find:
Acres	0.405	Hectares
Inches	2.54	Centimeters
Feet	.3048	Meters
Million cubic feet	.028	Million cubic meters

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3. WILL MARKETS PROVIDE SUFFICIENT INCENTIVE FOR SUSTAINABLE FOREST MANAGEMENT?

Richard Haynes[1]

ABSTRACT

The renewed interest in sustainable forestry raises questions about the role that market prices have in influencing management decisions made by individual landowners and managers. Evidence from the Douglas-fir region suggests that landowners and managers have relied on sustained upward changes in timber prices to provide incentives to increase the intensity and extent of timber management practices. But we face a future of relatively stable prices, and some advocates of more intensive forest management are concerned that expectations of lower returns for various forestry practices may lead landowners, each with their own objectives, to respond to various market signals in ways that are not supportive of sustainable forest management.

INTRODUCTION

THE UNITED STATES AND CANADA ARE signatories to the Montreal Process for Sustainable Forest Management, which is one of several frameworks that seek to balance environmental, economic, and equity considerations of forest management from a societal viewpoint (Mihajlovich 2001, Tittler et al. 2001). These frameworks generally attempt to place the debate about sustainable forest management in the context of broader societal goals for sustainable growth (Mendoza and Prabhu 2000).

The various frameworks for assessing sustainable forest management assume that each country will develop national implementation programs. In the United States, however, this has not happened because most (71 percent) U.S. timberland is privately owned and there is little consensus among landowners about the need for or the content of such an implementation program. Here implementation will instead be determined by numerous management decisions made by individual landowners and managers. These decisions will be influenced by a mix of market incentives and regulatory actions. The variability in these decisions introduces uncertainty in assessing progress toward sustainable forest management. This is especially the case where prices might provide insufficient incentive for what some proponents of sustainable forest management believe are necessary forest practices.

The purpose of this paper is to explore the evidence for the concerns that markets might not provide sufficient incentive for sustainable forest management. I assume that an operational definition of sustainable forest management includes, among other attributes, management actions to ensure that timber growth equals or exceeds harvest and that inventories are stable or rising.

Another way to state this purpose is to consider at what point weak timber prices would become a barrier to making progress toward sustainable forest management. The experience in the Douglas-fir region of the Pacific Northwest (west side) will be used to set context for the issue. This is a region where, starting in the 1930s, advocates for managing timberlands argued for sustained yield management (which they saw as restricting possible harvest levels) on public timberlands as a means to increase stumpage prices[2] to a level that would provide incentives for more intensive forest management or more timber production on private timberlands (Mason 1969). It is also a region whose history demonstrates the power of markets in altering forest resource conditions and the processing sector.

The Douglas-Fir Region

Current forest conditions in the Douglas-fir region are a function of both markets for various forest products and various regulatory actions (past and current). This area is one of the major timber-producing regions in the world and is recognized for its productive timberlands, forest management institutions, well-organized markets, and large-scale timber processing industries. The stumpage price series shown in figure 3.1 is often used to illustrate changes in forest products markets and recently as an

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[2] Value of standing timber, most often estimated based on the value of timber harvested during a specified period.

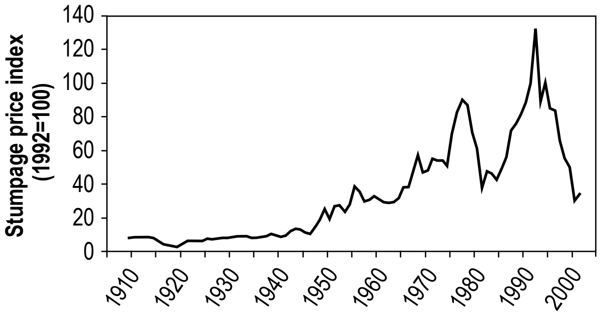

Figure 3.1—Oregon and Washington stumpage price index, 1909–2002.

inducement for those considering investing in timberland. It shows changing stumpage prices that reflect changes in the available resources, the processing sector, and end product markets. Figure 3.1 reveals periods of stability as well as periods of growth and volatility. It provides evidence of the returns landowners have seen from investments in forest management. In the case of the Douglas-fir region, real (net of inflation) prices have increased roughly 3 percent per year[3] since the early 1900s. The general history of rising prices suggests that timber is relatively scarce and that changes in various market factors may alleviate the price increases. This behavior is expected, as these are relatively free markets comprising numerous producers and consumers making decisions based on understanding of available information. Rising prices should encourage consumers to substitute nonwood material in some uses such as residential construction (e.g., steel studs for framing) because the real prices of the substitute are less than wood prices. Rising prices should also encourage landowners and managers to increase the intensity or extent of land management to produce more timber (to the point where timber prices become stable).

Events have influenced timber prices (shown in fig. 3.1) and shaped the perceptions of land managers. For example, before World War II, efforts to limit harvests from public timberlands resulted in relatively stable prices. The elimination of World War II price controls, rapid economic adjustment, and expansion in demand led to increases in prices following World War II. By the late 1950s, the increases in public harvests and slowdowns in economic growth limited the growth in stumpage prices. In the next three decades, however, prices were highly volatile as harvest levels increased, available timber declined, and structural shifts took place in the economy; there was rapid inflation in commodity prices and then a severe recession in the early 1980s. In the 1990s, the reductions in federal timber harvest, loss of both lumber and manufacturing productive capacity, and the reductions in exports following the economic slowdown in Asian countries acted to reduce stumpage prices.

Conversely, the increasing diversity in the mix of forest products had an upward effect on stumpage prices (see Haynes 1980). Stumpage owners benefited (in higher prices and returns from forest management activities) from the strong role that diverse and highly competitive producers in the Pacific Northwest played in both domestic and export markets.

In spite of these sometimes contrary changes, rising stumpage prices induced landowners and managers to apply forest management regimes leading to improved stand conditions such as higher stocking levels of selected species, greater uniformity of trees, etc. In addition, during the last two decades, the growing value of nontimber forest products has been recognized, and some landowners have modified management regimes to take advantage of joint production opportunities (Alexander and McLain 2001, Kerns et al. 2003).

Figure 3.2 shows both the post-World War II and the expected future situations. The projections of regional softwood stumpage prices are from *An Analysis of the Timber Situation in the United States: 1952–2050* (called hereafter the fifth RPA [Resources Planning Act] timber assessment) (Haynes 2003). Overall, the rate of stumpage price growth is expected to slow to 0.6 percent over the next 50 years. A higher rate of increase is expected in the near term as we transition from existing stands to more intensively managed timberlands. Once this shift is complete (say after 2020 in both the Douglas-fir region and the South), little growth in stumpage prices is expected, and prices in the Pacific Northwest will remain at or below those in the South until after 2040.

Another factor influencing the lower rate of increase in stumpage prices and changing land management objectives is the changing mix of forest products. Figure 3.3 shows the historical and projected proportions of harvest, by product, from the fifth RPA timber assessment (Haynes 2003). The projections show the mix of log markets in the Douglas-fir region returning to less diverse conditions similar to those of the 1950s and 1960s. Options may persist for some utilization in panels and other products, and log

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[3] The actual rate of increase in real prices between 1910 and 2002 was 2.97 percent per year.

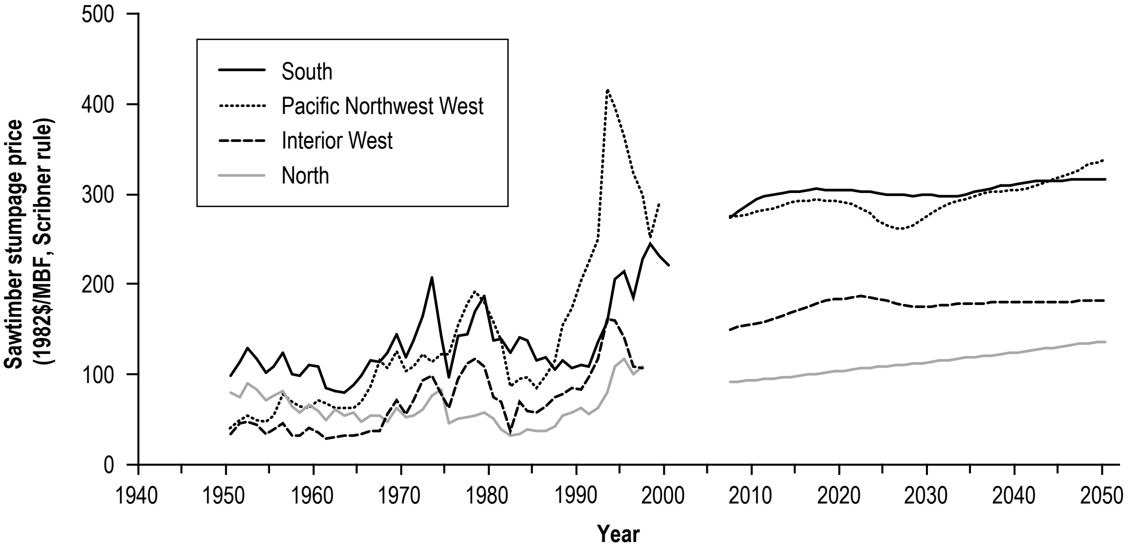

Figure 3.2—Softwood sawtimber stumpage prices in 1982 dollars per thousand board feet, Scribner log rule, by major U.S. region, with projections to 2050.

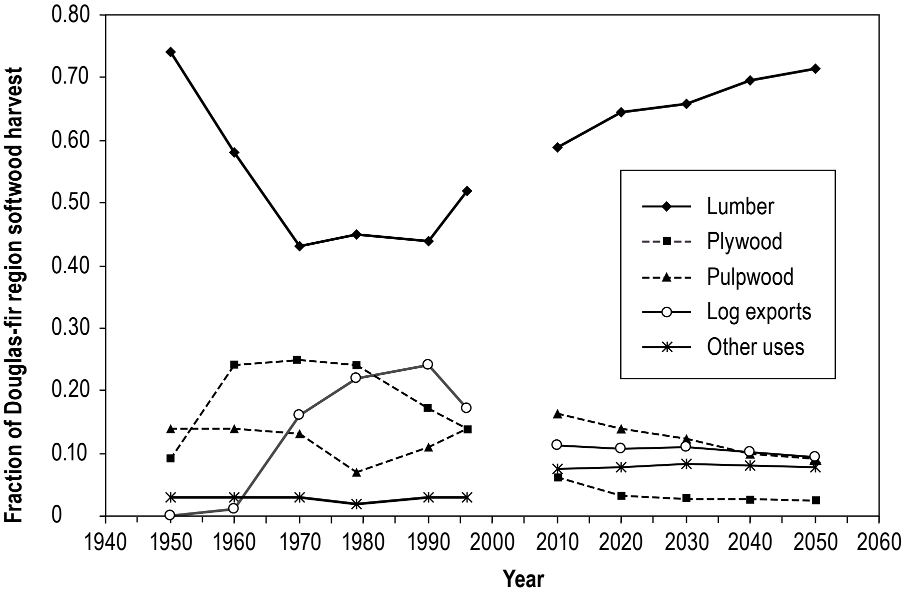

Figure 3.3—Proportions of the Douglas-fir region (western Oregon and Washington) softwood harvest by product category: history and projections from 2000 RPA timber assessment (Haynes 2003).

exports, but softwood lumber output accounts for a rising share of log production and use—reaching 70 percent of the total by 2050. Softwood harvest volumes (table 3.1) may rise slightly more than 50 percent by 2050 compared to 1997 owing primarily to expansion on private lands. At the same time, competition from other domestic regions and continued pressure from imports will limit growth in product and stumpage prices.

There are several lessons that can be summarized from the experience in the Douglas-fir region.

- Changes in the end uses (see fig. 3.3) help shape the expectations of timberland owners for the types of products that might be derived from stands. Land managers need to consider future markets, as they

Table 3.1—Softwood removals, harvest, growth, and inventory for the Douglas-fir region and United States timberlands,[a] 1952–97, with projections to 2050

	Historical							Projections				
Item and owner	**1952**	**1962**	**1970**	**1976**	**1986**	**1991**	**1997**	**2010**	**2020**	**2030**	**2040**	**2050**
	Million cubic meters											
Douglas-fir region												
National forest:												
Removals	10	16	15	15	15	8	2	1	2	2	2	3
Harvest	10	17	14	14	19	8	2	1	2	2	2	3
Net annual growth	5	6	7	6	9	9	22	24	22	20	19	18
Inventory	1,348	1,351	1,288	1,249	952	952	1,456	1,754	1,967	2,161	2,334	2,493
Other public:												
Removals	4	8	10	12	12	6	5	5	5	5	5	5
Harvest	4	8	10	12	12	7	5	5	5	5	5	5
Net annual growth	5	9	10	11	14	11	14	14	15	16	17	18
Inventory	569	561	556	543	555	459	545	662	769	885	1,009	1,139
Forest industry:												
Removals	33	26	36	37	35	26	19	28	28	26	27	29
Harvest	35	28	35	36	35	31	18	28	29	27	27	29
Net annual growth	10	11	13	17	26	23	23	27	27	28	30	31
Inventory	927	776	673	623	570	508	500	487	482	487	554	591
Nonindustrial private:												
Removals	9	6	7	6	6	11	9	9	10	12	14	15
Harvest	9	6	7	6	7	12	8	9	10	12	14	15
Net annual growth	8	9	10	10	12	12	11	11	12	14	15	13
Inventory	269	270	292	240	288	316	293	285	308	346	368	357
Total, Douglas-fir region:												
Removals	56	55	69	70	67	50	34	43	45	45	48	51
Harvest	59	58	65	68	72	59	33	44	46	46	48	52
Net annual growth	28	34	40	44	61	55	70	77	79	81	84	82
Inventory	3,113	2,958	2,809	2,654	2,365	2,235	2,794	3,213	3,572	3,948	4,357	4,694
United States												
Removals	220	215	260	283	322	308	287	273	305	333	355	379
Harvest	213	207	246	269	320	311	286	279	312	340	363	387
Net annual growth	219	272	321	354	355	339	384	446	460	469	474	464
Inventory	12,232	12,741	13,031	13,228	12,830	12,745	13,707	15,552	17,233	18,724	20,039	21,022

Note: Douglas-fir region includes western Oregon and Washington.
[a] Only timberland available for management is included in data.
Source: Haynes 2003.

will determine the value of the stands currently being managed.

- Many of the management actions in the Douglas-fir region have been motivated by the perceived price premium for Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) stumpage and products. This premium has largely disappeared because of reductions in the log export market as well as changes in the mix of products (and grades) produced in the region. Log exports drove up prices in the Douglas-fir and nearby regions for all landowners (see fig. 3.1). Because of this premium, stumpage prices for the Pacific Northwest exceeded other regions, especially from the 1970s through the 1990s when log export volumes were large (fig. 3.3). During this period, stumpage prices averaged 22 percent higher than prices in the South (see fig. 3.2).
- The Pacific Northwest is expected to remain an integrated producer of forest products. However, the future mix of industries has a growing component of lumber production oriented toward domestic markets for commodity grades. This also contributes to the

loss of the price premium once given to Douglas-fir for higher quality (grades) of lumber.

- The implication of these changes is that market incentives will favor the transition to managed stands that produce relatively uniform logs (both quality and size) with reduced opportunities for logs that do not conform to processing standards (such as large [greater than 24 inches (60 cm) in diameter] logs).
- Increasing management on a small proportion of the timberland base enables large increases in both timber harvest and inventory volumes on a base of relatively constant area (see table 3.1).

An Economic View of Stumpage Markets

Stumpage markets are like all markets; they are a loosely defined spatial area within which producers and consumers are in communication with one another, where supply and demand conditions operate, and exchange of title to timber is transferred. In the communication process, prices are established as a function of simultaneous changes in underlying demand and supply forces in a complex system of interrelated commodity and factor markets. One of the factor markets is the stumpage market because stumpage is one factor in the production of goods such as lumber, plywood, or paper.

Derived demand in the factor markets is often more inelastic than that for the final product resulting in wider price swings for relatively small changes in quantities. This tendency toward excessive price volatility sometimes leads economists to say that these markets are inefficient.[4] In the case of stumpage markets, however, there are attributes about logs that contribute to some of the perceived market inefficiencies. For example, although it is often argued (see Adams and Haynes 1991) that arbitrage opportunities[5] are sufficient to ensure consistency among prices for different sources of stumpage within and among markets, the nature of stumpage itself reduces the substitutability of, say, a thousand board feet of logs in Portland, Oregon, with a thousand board feet of logs in Portland, Maine. High transport cost relative to their value acts to prevent logs flowing long distances. In addition, differences in perceived quality (often associated with the nature of products made from the logs) are often reflected in differences in local or regional markets.

Another important aspect of markets is the relative responsiveness of both stumpage consumers and suppliers to changes in expected stumpage prices. Table 3.2 (from Adams and Haynes 1980, 1996) summarizes the stumpage price elasticities for private timber. For the most part, stumpage prices are extremely inelastic (i.e., unresponsive to changes in supply). Other than for the Douglas-fir region, these estimates have remained relatively unchanged over the past three decades. The consistency in estimates also suggests that modifications in landowners' objectives relative to producing timber are slow to change.

Table 3.2—Stumpage price elasticities of private timber supply by U.S. region, sample period averages

	Industrial		Nonindustrial	
Region	**1980**	**1995**	**1980**	**1995**
Pacific Northwest, west side	0.26	0.44	0.06	0.42
Pacific Northwest, east side	.16	.17	.18	.40
Pacific Southwest	.26	.44	.12	.14
Northern Rocky Mountains	.06	.25	[a]	.18
Southern Rocky Mountains	.06	.78	[a]	.51
North Central	.99	.28	.31	.67
Northeast	.32	.34	.99	.31
South Central	.47	.32	.39	.29
Southeast	.47	.19	.30	.29

[a] Not estimated in 1980, instead an elasticity of 0.06 was estimated for all private landowners in the Rocky Mountains.

Source: Adams and Haynes 1980, 1996.

DISCUSSION

Prices and markets for various types and sizes of timber have influenced the goals for land management and the evolution and application of various management regimes. As shown in figures 3.1 and 3.2, forest product prices are often characterized as highly volatile but increasing faster than the overall rate of inflation. In the Douglas-fir region (as well as in the South), rising prices for timber products led to the adoption, by those owners sensitive to financial returns, of relatively systematic forest management regimes consisting of practices that tend to speed development of well-stocked forests (see Haynes et al. 2003 for a history). At the same time, rotation ages for these managed forests

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[4] Efficient markets for relatively homogenous products are described by economists as those in which prices reflect all publicly known information about the product, products are highly liquid (can be converted quickly to cash), and where there are low transaction costs.

[5] The premise of price arbitrage for stumpage markets is that prices for different species and sizes will differ in some fixed proportion reflecting differences in location, technical properties, or differences in consumer tastes. The opportunities for substitution in how wood is used helps equalize prices between species and sizes.

have dropped, leading to more frequent entries and a greater proportion of the forest in relatively young stands (stands 20 years or less). This increases the financial returns to those (individuals, companies, and various publics) who own timberlands. Current and expected trends show private timberland owners continuing to invest in active timber management, subject to increasing regulations of various forest practices (see Haynes 2003). Public lands, on the other hand, are expected to be managed for diverse goals—many not involving the marketplace—reflecting increased recognition of the benefits of many nontimber forest goods and services.

In the United States, we frequently debate the role that prices play in private timberland management. In periods of weak stumpage markets (e.g., for some hardwoods or for small softwood trees in the West) there is concern that landowners and managers will not implement certain forest practices, such as thinning to reduce fire risk. In the case of private timberlands, relatively low returns to forestry also may lead to changes in land use as landowners seek higher returns by converting to agriculture or residential developments (see Ahn et al. 2002, Haynes 2003, Kline and Alig. 2001, and USDA FS 1988, for additional details). At the same time, the lack of perceived effectiveness of markets to increase quantities of timber supplies (or other forest outputs) in periods of rising prices and perceived scarcity causes concern among advocates of intensive timber management (see Cubbage and Haynes 1988 for a summary). These doubts have often prompted the establishment of public and private programs designed to increase timber production with the intention of slowing the expected rises in timber prices.

The recent downward changes in expectations for long-term returns for forest management (see fig. 3.2) will raise questions in some managers' minds about the incentives for sustainable forest management. From their perspective, the issue is how to practice forest management to produce a range of goods and services in a sustainable way that also meets their financial expectations. This concern has long been recognized as the heart of the forest management question (see Baker 1950, Davis 1966, Davis and Johnson 1987, Davis et al. 2001). The concern about financial aspects is a fundamental component of how forest management decisions made by numerous landowners and managers contribute to sustainable forest management. Simply put, forest management has to demonstrate that it can pay for itself on private timberlands before we can assume that forest landowners will implement practices thought of as contributing to sustainable forest management. The importance of financial returns also means that many of the benefits of forest management need to accrue to those who pay the costs. Landowners lack the incentive to implement costly practices that have mostly broad societal benefits.

CONCLUSION

Forest management advocates are slow to acknowledge that markets can act as a barrier to sustainable forest management. Expectations of low returns for various forestry practices may lead myriad landowners, each with their own objectives, to respond to various market signals in ways that are not supportive of sustainable forest management. For many years, upward changes in timber prices have provided incentives for landowners (both public and private) to increase the intensity and extent of timber management practices. These price changes, which are also a function of changes in wood quality, have provided incentives for the development (or contraction) of various forest products industries.

The projections of relatively constant real prices (fig. 3.2) for the next five decades will provide an incentive for those landowners with a strong propensity to manage for timber production (industrial landowners, large private landowners, timberland investment organizations, public timberland managers) but by themselves will not engender a lot of enthusiasm among the majority of landowners who display a lower propensity for active timber management. Put another way, relatively stable price expectations are necessary for intensive timber management but not necessarily a sufficient condition for sustainable timber management.

What does this mean in the context of sustainable timber management? Simply put, it means that the majority of timberland will be lightly managed while a small minority of acres will be heavily (or actively) managed (on relatively short rotations). The net effect is that prices, although not a barrier, will not provide a strong incentive to intensify timber management by many landowners. Because of this, advocates for intensive timber management may find themselves supporting more regulation rather than relying on markets to ensure what they perceive as progress toward sustainable forest management across a broader area of forest land.

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4. A PRELIMINARY ASSESSMENT OF THE LUMBER MANUFACTURING SECTOR IN WASHINGTON STATE

John Perez-Garcia[1]

ABSTRACT

Forest products operations in Washington have changed dramatically since the first mill survey was conducted in 1968. Among trends observed are a decline in sawmill numbers, an increase in the Class A sized mills, less public timber dependence, greater out-of-state log uses by sawmills, and a shift in log export activity from the Olympic Peninsula to the Lower Columbia economic area. We propose developing a database of sawmills in Washington characterizing their timber use in the past and likely use in the future. The database will serve to integrate analyses of the timber supply situation in Washington and policy alternatives regarding management for social, economic, and environmental objectives.

INTRODUCTION

THE PACIFIC NORTHWEST (PNW) RESEARCH Station is undertaking an analysis of timber supply and milling infrastructure in the state of Washington. Such a study has not been completed since the early 1990s when plot measurements were last done (Adams et al. 1992, Bare et al. 1995). The recent completion of the field survey of inventory plot measurements by the Forest Inventory and Analysis (FIA) unit of the USDA Forest Service for Washington makes such an update possible. Many current biological, economic, and social issues warrant an updated timber supply analysis. Recently implemented forest practice regulations, large differences in industrial and small nonindustrial ownerships, and forest health and sustainability concerns make the analysis of the timber supply situation in Washington timely. Similar efforts for Oregon provide an opportunity to produce an integrated supply analysis for Washington and Oregon.

The breadth of the PNW Station research proposal includes:

- An analysis of the timber supply situation in Washington,
- An analysis of technological changes in milling and their effects on timber demand, and
- An analysis of policy alternatives regarding management for social, economic, and environmental objectives.

Coordination with researchers at the University of Washington's Center for International Trade in Forest Products, Oregon State University, and PNW Research Station to assure consistency in the analysis is an integral part of the study.

This paper provides a preliminary report on the second bullet point listed above. We summarize and provide preliminary information on existing mill surveys and include discussions that we have had with various individuals associated with the lumber manufacturing sector in Washington state. We report on existing mill data and determine data gaps of a survey that assesses technological changes in the milling sector and their effects on timber demand.

EXISTING MILL SURVEYS

The Washington Department of Natural Resources (DNR) has conducted mill surveys in the state of Washington since at least 1968, when it published its 1968 mill survey (Bergvall and Gedney 1970). Throughout the next four and one-half decades, the department has continued to carry out a periodic survey every 2 years, with the exception of 1994 when the survey was only partially completed and not published. These periodic surveys in Washington have maintained consistency in many of the mill survey questions, which is of value to our study examining the changes in the milling sector over time. Our study uses selected mill surveys from 1968, 1978, 1988, and 1998 to characterize the development of the milling sector in Washington and its use of available log supply. The 1998 survey report is in draft form, and the DNR is concurrently preparing to publish the 1998 and 2000 survey data. It has also collected data for the 2002 survey. Data from these surveys are reported

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for the following economic areas (Bergvall and Gedney 1970; Bergvall et al. 1979; Larsen 1992, 2003):

Economic area	County
Puget Sound	Island
	King
	Kitsap
	Pierce
	San Juan
	Skagit
	Snohomish
	Whatcom
Olympic Peninsula	Clallam
	Grays Harbor
	Jefferson
	Lewis
	Mason
	Pacific
	Thurston
Lower Columbia	Clark
	Cowlitz
	Klickitat
	Skamania
	Wahkiakum
Central Washington	Chelan
	Grant
	Kittitas
	Lincoln
	Okanogan
	Yakima
Island Empire	Asotin
	Columbia
	Ferry
	Pend Oreille
	Spokane
	Stevens
	Walla Walla

The Inland Northwest Wood Products Research Consortium in cooperation with Washington State University Department of Natural Resource Sciences surveys the eastern Washington forest product sector (Schlosser and Blatner 2002). These periodic surveys provide data on mill production and shipments, as well as employment and payroll. The DNR has also conducted a marketing survey on its log purchasers (Tweedale, personal communication, Assistant Division Manager, Product and Leasing Division, DNR, Olympia, WA). The marketing survey contains data on mills and other timber purchasers that participate in Washington timber sales. The purpose of this new survey is to assist the state in the development and improvement of its timber marketing program for prospective buyers, taking into consideration the high quality of long-rotation state timber. An ongoing research project being undertaken by the Rural Technology Initiative at the University of Washington includes a survey of existing and potential DNR timber sale purchasers.

NUMBER OF SAWMILLS, THEIR CAPACITY AND LOG USE

According to the 1998 sawmill survey, there were 76 sawmills in operation (Larsen 2003), a marked reduction since 1968 when the total number of sawmills was 212. The sector has been experiencing a consolidation of mill capacity, as evidenced by the size of mills in operation (see fig. 4.1). Mill size classification has remained consistent throughout the past four decades. Class D mills process less than 40 thousand board feet (MBF) of lumber tally capacity per 8-hour shift. Class C mills have a capacity of 40 to 79.9 MBF. Class B mills have a capacity of 80 to 119.9 MBF, and Class A mill capacity is 120 MBF and greater. In 1968, there were 24 Class A mills or 11 percent of the total number of mills. By 1998, there were 46 Class A mills or 59 percent of the 76 sawmills in operation. A quarter of the Class A mills (12) were located in the Puget Sound Economic Area in 1998, and over a third of them (17) in the Olympic Peninsula Economic Area. The Lower Columbia

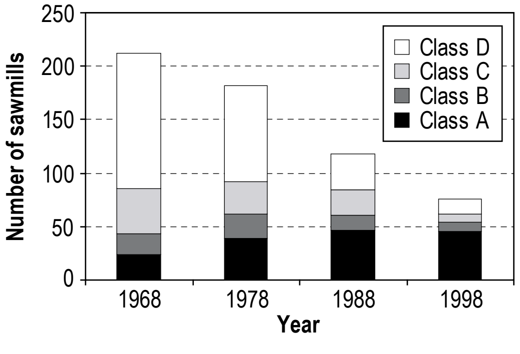

Figure 4.1—Number of sawmills by class in four Washington Department of Natural Resources mill surveys. Mills are classified by increasing capacity from D to A; see text for definitions. Source: Bergvall and Gedney 1970; Bergvall et al. 1979; Larsen 1992, 2003.

area had 12 mills. The Inland Empire and central Washington area had five mills of Class A size. In 1968, no large mills were located in the Inland Empire. The largest decline in mill number has occurred in the smallest class, Class D. In 1968 there were 127 Class D mills in operation, and only 14 in 1998. Over 90 of these mills closed operations before 1988.

Mill operations are affected by many factors. During the past four decades, the sector has experienced demand and supply changes with associated low and high product prices, an expansion and contraction of the international log exporting sector and a subsequent growth in interstate log distribution, and the loss of available federal, other public, and private timber. These and other factors have led to dramatic changes in the structure of the sawmilling sector in Washington. For example, the 1980s were characterized by low national lumber prices owing to the expansion of lumber imports from Canada and an increase in lumber production from the Southern United States. Low lumber prices produced low margins and may have been a factor in the closure of many of the smaller mills in the 1980s.

A prominent change observed over these past four decades has been the decline in the amount of timber harvested. This by itself would have decreased mill numbers, but the major decline in timber harvest occurred during the 1990s. Harvest levels in 1968 totaled 6.9 billion board feet (BBF), and were nearly identical in 1988, with a harvest of 7.0 BBF (Larsen and Nguyen 2002). In 1998, however, timber harvests totaled only 4 BBF with the largest decline in harvest occurring in the public sector.

Table 4.1—Timber harvests by economic areas and ownership

	1968	1978	1988	1998
	Thousand board feet, Scribner log scale			
Central Washington:				
Private	290,502	386,217	324,427	318,375
Public	368,643	277,275	345,062	65,773
Total	659,145	663,492	669,489	384,148
Percentage private	44	58	48	83
Inland Empire:				
Private	247,674	314,633	332,203	363,407
Public	190,166	147,757	167,123	66,083
Total	437,840	462,390	499,326	429,490
Percentage private	57	68	67	85
Lower Columbia:				
Private	773,895	981,428	700,159	464,384
Public	615,802	398,746	489,737	119,356
Total	1,389,697	1,380,174	1,189,896	583,740
Percentage private	56	71	59	80
Olympic Peninsula:				
Private	2,217,273	2,099,997	2,482,502	1,519,706
Public	911,122	945,803	896,041	328,292
Total	3,128,395	3,045,800	3,378,543	1,847,998
Percentage private	71	69	73	82
Puget Sound:				
Private	856,445	714,029	837,457	652,876
Public	497,394	516,794	470,661	123,320
Total	1,353,839	1,230,823	1,308,118	776,196
Percentage private	63	58	64	84
Washington state:				
Private	4,385,789	4,496,304	4,676,748	3,318,748
Public	2,583,127	2,286,375	2,368,624	702,824
Total	6,968,916	6,782,679	7,045,372	4,021,572
Percentage private	63	66	66	83

Source: Bergvall and Gedney 1970; Bergvall et al. 1979; Larsen 1992, 2003.

In central Washington, private timber harvest increased 10 percent from 1968 to 1998 (table 4.1). A greater private harvest offset a small part of the 82-percent decline in public timber harvest. The Inland Empire area saw a larger percentage increase in the private timber harvest with a 47-percent increase from 1968 to 1998. This increase, combined with the nearly equal log imports from out of state, offset the 65 percent decline in public timber output. The trend in timber harvest in western Washington differs drastically. Private timber harvest was constrained and not able to offset lower public timber harvest. By 1998, in the Lower Columbia area, the second largest source of public timber in 1968, public timber harvest had dropped 81 percent. The largest source of public timber, the Olympic Peninsula, declined 64 percent compared with the 1968 harvest. Public timber harvests were reduced by 75 percent in the Puget Sound area. At the same time, the private sector harvest decrease ranged from a quarter of the 1968 harvest level in the Puget Sound area to 40 percent in the Lower Columbia area. Statewide, public and private timber harvests in 1998 were 42 percent less than 1968 levels. Most of the decline occurred during the last decade. By 1998, the private sector was providing over 80 percent of the total harvest in each economic area of the state.

The reduction of public and private timber harvest affects the operation of mills. Over time, milling capacity will adjust to reflect changes in timber type, volume, and sourcing areas. The DNR mill surveys report log trade among the economic areas, and we present these log flows in table 4.2. As in the case of public timber harvest presented previously, many of the more dramatic changes in log flows occurred during the last decade. In 1998, a much greater proportion of the logs came to mills from counties outside its economic area boundary than in 1968 (table 4.2). A greater percentage of logs coming from outside a mill's economic area implies a higher log input cost to the mill, because transportation distances are greater. It is believed that increases in transportation costs, combined with greater competition for shrinking log supplies during the 1990s, led to higher delivered-log prices. Increases in lumber prices through the mid 1990s helped sustain the most competitive mills. Many of the smaller operations, however, appeared to have suffered losses during this period.

Table 4.2—Log trade among economic areas

	1968	1978	1988	1998
	Thousand board feet, Scribner log scale			
Central Washington:				
Logs from out of state	—	656	1,850	10,420
Logs from Puget Sound	—	—	—	18,020
Logs from Lower Columbia	34,543	22,147	9,726	36,124
Logs from Inland Empire	77,815	64,940	57,745	128,768
Logs from Central Washington	507,462	414,345	320,090	175,416
Within-area percentage	82	83	82	48
Inland Empire:				
Logs from Central Washington	4,445	15,337	21,532	9,244
Logs from out of state	33,455	23,258	36,533	113,289
Logs from Inland Empire	367,912	296,056	359,281	228,047
Within-area percentage	91	88	86	65
Lower Columbia:				
Logs from Inland Empire	—	—	70	—
Logs from Puget Sound	2,936	—	4	2,940
Logs from Central Washington	71,673	20,791	28,507	4,352
Logs from out of state	150,411	102,934	278,072	100,421
Logs from Olympic Peninsula	223,428	197,693	144,111	120,446
Logs from Lower Columbia	806,447	1,126,582	850,743	518,171
Within-area percentage	64	78	65	69
Olympic Peninsula:				
Logs from out of state	478	4,605	10,772	24,261
Logs from Central Washington	19,396	1,854	-	22,284
Logs from Lower Columbia	20,496	44,834	44,350	53,392
Logs from Puget Sound	23,040	144,237	111,670	281,291
Logs from Olympic Peninsula	2,054,391	2,158,083	2,521,740	1,007,994
Within-area percentage	97	92	94	73
Puget Sound:				
Logs from out of state	24,698	44,900	21,832	24,226
Logs from Lower Columbia	31,965	3,991	2,000	115
Logs from Central Washington	38,729	76,644	148,504	33,942
Logs from Olympic Peninsula	585,126	622,948	333,642	172,034
Logs from Puget Sound	1,622,966	1,548,044	1,641,406	824,473
Within-area percentage	70	67	76	78

Source: Bergvall and Gedney 1970; Bergvall et al. 1979; Larsen 1992, 2003.

Table 4.2 reports log flows for 1968, 1978, 1988, and 1998. Although operations in the economic areas of eastern Washington–Central Washington and Inland Empire–were able to offset part of the public timber harvest decline by using private timber, it came at the higher expense of using a greater proportion of logs from outside of the economic area. Logs from the Puget Sound area were reportedly used in the Central Washington area in 1998. Logs were also imported from out of state. The Inland Empire area also provided a substantially higher portion of Central Washington area demand. Mills in the Inland Empire area were more dependent on logs from out of state. Imported logs made up nearly one-third of all logs milled in the Inland Empire area in 1998. During the last decade, the western Washington economic areas—Puget Sound, Olympic Peninsula, and Lower Columbia areas—were less dependent on logs from out of state generally. An exception was the Olympic Peninsula area, where mills used a greater volume of logs from out of the area—27 percent in 1998 up from 3 percent in 1968.

Table 4.3 presents the percentage of logs used by lumber producers, log exporters, pulp and board manufacturers, and other sectors. Other sectors include pole, posts, pilings, shingle, and shake operations. In the eastern Washington areas, lumber manufacturing is the major sector using 50 percent or more of the logs consumed. The operations in the Central Washington area have gradually evolved to include operations other than sawmilling. Different trends exist in western Washington areas. In particular, log exporting enterprises, once dominant in the Olympic Peninsula area, have declined. Log exporting now dominates the Lower Columbia area where it accounts for as much log volume as the sawmilling sector. In the Olympic Peninsula area, lumber manufacturers now use 60 percent of the log volume consumed. Another trend evident in table 4.3 is the decline of the pulp and board sector in western Washington.

Table 4.3—Log use by forest products enterprises

	1968	1978	1988	1998
Central Washington:				
Lumber (percent)	100	68	55	50
Log exports (percent)				
Pulp and board (percent)				
Other sectors (percent)	0	32	45	50
All sources (MBF[a] log scale)	566,852	545,075	389,411	368,199
Inland Empire:				
Lumber (percent)	64	89	91	57
Log exports (percent)				
Pulp and board (percent)				10
Other sectors (percent)	36	11	9	33
All sources (MBF log scale)	450,300	291,532	417,346	351,130
Lower Columbia:				
Lumber (percent)	50	43	37	43
Log exports (percent)	15	34	35	43
Pulp and board (percent)	4	1	2	
Other sectors (percent)	31	22	27	13
All sources (MBF log scale)	1,263,375	1,448,132	1,301,507	746,327
Olympic Peninsula:				
Lumber (percent)	29	37	31	60
Log exports (percent)	37	44	50	13
Pulp and board (percent)	20	4	12	13
Other sectors (percent)	13	14	7	14
All sources (MBF log scale)	2,117,801	2,353,613	2,688,532	1,389,220
Puget Sound:				
Lumber (percent)	42	41	43	67
Log exports (percent)	26	44	45	27
Pulp and board (percent)	22	6	6	3
Other sectors (percent)	10	10	6	3
All sources (MBF log scale)	2,303,484	2,296,527	2,147,384	1,054,790

[a] MBF = thousand board feet.
Source: Bergvall and Gedney 1970; Bergvall et al. 1979; Larsen 1992, 2003.

FUTURE DEMAND FOR TIMBER

An estimate of future global demand for wood fiber is based on a gross domestic product of 3.5 percent and two historical trends in consumption of wood fiber (Perez-Garcia 2003). Consumption is estimated to reach between 2.0 and 2.8 billion cubic meters (m^3) over the next five decades, adding from 0.5 to 1.3 billion m^3 by the end of the 50-year period. Many states anticipate meeting this growing demand for wood products, including Washington and Oregon. Focusing on softwood saw logs, the U.S. South is projected to contribute an increase of 17.7 BBF annually followed by Canada (7.1 BBF) and the U.S. West (including Washington) (1.8 BBF) by the end of the next four decades.

The United States is the largest market for softwood lumber in the world and is projected to continue to be so over the next four decades. There is an associated derived demand for saw logs required to produce the projected lumber consumption (and structural plywood as well). Worldwide, an additional 190 million m^3 (33.6 BBF) of softwood saw logs are estimated to be harvested by 2040 (fig. 4.2). Under this scenario, the U.S. South would expand its annual harvest by over 100 million m^3 (17.7 BBF) followed by Canada with over 40 million m^3 (7.1 BBF). The U.S. West would respond with about 10 million m^3 (1.8 BBF) annually. This volume increase would imply new capacity expansion for the U.S. West of seven to eight Class A mills.

SURVEY DEVELOPMENT AND DATABASE CREATION

The brief look into historical data on mills in Washington and a projection of future demand provides an introduction to data needs for an assessment of the changes in the milling sector likely to occur and its effect on timber demand.

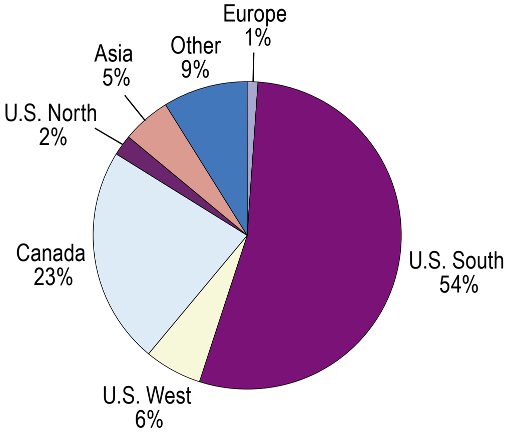

Figure 4.2—The distribution of saw log harvest volumes required to meet the projected 2040 global demand for softwood lumber. Source: Perez-Garcia 2003.

Some relevant conclusions about historical trends and their implication for our future study include the following:

Mill numbers provide an interesting story historically. However, capacity changes may provide a quite different outlook. Mill consolidation and technological change information is included in DNR mill surveys but was not adequately analyzed in this preliminary study. Information on 8-hour shift capacity, operating days, and headrig technology must be included to adequately assess technological change in the sawmilling industry in Washington.

The Lower Columbia area is now an exporter of logs, and has been for a least a decade. How does the demand for timber in Oregon affect milling capacity decisions in Washington? The broader implication as evidenced by imports of logs to the Inland Empire suggests that the log flows of different states are increasingly intertwined. Historical notions of timbersheds may be obsolete. Other questions emerge including, Should Oregon mills be included in the survey to assess technological changes in the milling sector in Washington? How about Oregon timber supply?

The Olympic Peninsula has diverted previously exported logs to its sawmilling industry. Is this trend complete? What is the outlook for log exports from the Olympic Peninsula region? We may ask the same questions for the Lower Columbia area, which has increased its exports of logs south. Plywood logs have also been diverted to lumber mills. What about chip manufacturers?

The Inland Empire area uses a greater percentage of out-of-state timber than other areas and provides logs to the Central Washington area, suggesting an increase in the interregional and interstate transportation of logs. Are these trends going to continue, or have we seen stabilization in the number of logs imported from other Western States?

Other questions arise from this preliminary review of sawmill surveys as well. Is the shift from public to private timber complete, and what will be the future of Washington's smaller mills? These mills represent a declining yet still significant number in the state. What will be the role of such mills in the region's sawmilling sector?

The Washington DNR has implemented a marketing survey of log purchasers asking, in addition to mill questions, questions concerning participation in state timber sales. Some of the information that has been collected relates to the study questions raised above. These questions include, for example, requests for characteristics of timber sales that buyers prefer and would like to see in the future. The combination of this survey, along with information obtained from other sources has led to the design of a preliminary database for use in our project. Our work plan includes the continued development of the database, completing the information on all sawmills in Washington and paying particular attention to issues we raised above for sawmills in particular areas.

METRIC EQUIVALENTS

When you know:	Multiply by:	To find:
Thousand board feet (MBF)	5.67	Cubic meters
Billion board feet (BBF)	5.67	Million cubic meters

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Section B:
Sustainable Land Use

Ralph Alig, USDA Forest Service

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SWPI

5. LAND USE CHANGES THAT IMPACT SUSTAINABLE FORESTRY

Ralph J. Alig[1]

ABSTRACT

Land use is dynamic in the Pacific Northwest. This will affect the region's progress toward sustainability at the same time that population is expected to increase. The United States is expected to add around 120 million people, an additional 40 percent, to its population in the next 50 years. The Pacific Northwest is expected to experience above-average population growth, including some people moving in from other regions. This will likely intensify land use pressures. In the most recent national comprehensive survey, the rate of conversion of rural land to developed land increased, with forest land being the largest source. More people on the national and regional landscapes will impact sustainability options for agriculture, forestry, residential communities, biodiversity, and other land-based goods and services. By illustrating potential development scenarios and their resulting effects on forest land, research can assist forest managers, policymakers, and land use planners in evaluating and anticipating potential effects of population growth and resulting land use change on forest productivity in both the Pacific Northwest and the United States.

INTRODUCTION

IN 1997, FORESTS COVERED ONE-HALF OF THE Pacific Northwest. These forests are being converted to other uses as the population grows. More people on the national and regional landscapes will affect sustainability options for forestry and other land uses that rely on the land base, such as agriculture, residential communities, and reserved areas. A key question is how society can make positive progress toward sustainability in the face of population growth. Potentially, many paths could lead to societal improvements. However, dynamics of the land base and society along with complexity of economic-environmental-social relationships can complicate efforts at attaining sustainability. Different sustainable "futures" are possible, but each is associated with tradeoffs that affect quality of life for people, such as different price levels and economic benefits faced by consumers, amounts and quality of habitat for wildlife and aquatic resources, and living and recreational space.

This paper provides a retrospective of land use changes and associated socioeconomic changes in the Pacific Northwest (Oregon and Washington). It also synthesizes findings from recent studies about relationships of those land use changes to human activities, which affect sustainability aspects on the mosaic of land uses and land ownerships in the region. This includes examination of policies intended to enhance stewardship of some of the world's most productive forests and help society adjust to changing demands for land and renewable resources.

LAND BASE CHANGES OVER TIME

Land Use Changes

Over the long term, deforestation in the region has exceeded afforestation. From 1952 to 1997, forest land area in the Pacific Northwest declined by 2.5 million ac (1.0 million ha) or 5 percent (Smith et al. 2001). Some of this land was used for urban and infrastructural developments, and other areas were cleared and converted to agriculture. In the most recent USDA surveys, the largest use for converted forests has been urban and developed use (Smith et al. 2001, USDA NRCS 2001).

The most recent National Resources Inventory (NRI) by the USDA NRCS (2001) indicated that the annual rate of deforestation increased. Between 1992 and 1997, more than 30,000 ac (12 141 ha) of nonfederal forests in the region annually were converted to developed uses, a 26-percent increase over the rate for 1982 to 1992. The rate increased in both Oregon and Washington, with the larger increase (33 percent) in Washington (USDA NRCS 2001). Rate of development increased with population growth and more economic activity.

Between 1982 and 1997, approximately 400,000 ac (162 000 ha) of nonfederal forested land was converted to developed uses, such as residential areas

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(USDA NRCS 2001). Drivers of the conversion include population growth and income changes (e.g., Alig et al. 2003, 2004; Kline and Alig 2001). The populations of Oregon and Washington have increased faster than the national average over the last decade, mostly around urban areas. The development and population increases were concentrated along the I-5 corridor; for example, Portland was one of the fastest growing cities in the United States in the 1990s. Across the Columbia River, developed area in Clark County, Washington, also grew significantly, as did developed land in the Puget Sound area of Washington. Urban sprawl and livability are issues receiving increased attention around the Nation, with more than 75 percent of U.S. residents now living in cities (USDC Bureau of the Census 2002).

Over the longer period surveyed by the USDA Forest Service (e.g., Azuma et al. 2002), Washington lost 8 percent of its forest land between 1952 and 1997 (fig. 5.1), more than four times Oregon's rate (Smith et al. 2001).[2] Most forest land losses have been on nonindustrial private forest (NIPF) ownerships. Because NIPF owners tend to own a significant share of lower elevation forest land within riparian areas (Bettinger and Alig 1996), forest land losses on NIPF lands often impact aquatic ecosystems.

From 1952 to 1997, timberland[3] area in the Pacific Northwest declined by 3.7 million ac (1.5 million ha) or 8 percent. These reductions are larger than for forest land because reclassification of forest land from timberland to a reserved or lower productivity class can affect the area of timber land relative to forest land. Although no single measurement adequately describes the productivity of forest land for uses other than timber production, an estimate of biological productivity is sometimes useful in helping to determine the forest's capacity for other uses. About 80 percent of all Pacific Northwest forest land, or 41 million ac (17 million ha) qualified as timberland in 1997, with 12 percent reserved (i.e., withdrawn from timber use), whereas 8 percent did not meet the productivity standard for timberland.

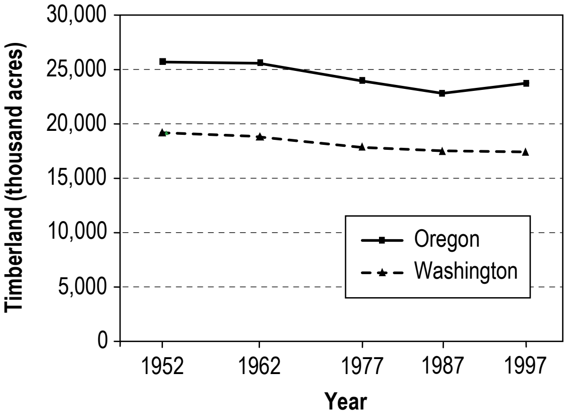

Figure 5.1—Area of timberland for Oregon and Washington, 1952 to 1997 (Smith et al. 2001).

Land use changes also affect the overall forest productivity for the region. Low-elevation forests on the west side of the Cascade Range crest are the forest lands most often converted to other uses, and represent some of the most productive forests in the world. Five counties on the west side—King, Snohomish, Pierce, and Clark in Washington, and Washington County in Oregon—gained more than 100,000 people between 1990 and 2000. McClinton and Lassiter (2002) indicated that more than 130,000 ac (52 600 ha) of forest soils in a medium productivity class were converted to nonforest uses and away from timber production between 1982 and 1997 in western Washington. This represents enough forgone timber to build approximately 1.3 million homes every 60 years.[4]

Profitable use of land for forestry and related investments such as tree planting are affected by the likelihood of conversion of forest land to developed uses (Kline and Alig 2001). Tree planting in the Pacific Northwest has increased in recent years, somewhat offsetting deforestation. Area of annual tree planting in the Pacific Northwest has more than doubled from 1960 to 1999. Most of this represents reforestation, and such investment in tree planting was largely on forest industry lands and in response to increased timber harvest activities and regeneration opportunities. Timber harvest for the region increased from about 2.5 billion cubic feet (71 million cubic meters) in 1962 to around 3 billion

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[2] Net changes (area into forest minus area out of forest) are typically much smaller than gross changes (area into forest plus area out of forest). For a national study, Alig et al. (2003) indicated that gross change in forest area was 14 times the net change in forest area.

[3] Timberland is defined as forest land capable of producing at least 20 cubic feet per acre per year of industrial wood in fully stocked natural stands and that has not been withdrawn from timber use (Smith et al. 2001).

[4] This assumes productive forests on medium or site III land that can produce 100,000 board feet per acre (including milling overrun) at age 60 in western Washington (Anderson et al. 1994), and that houses on average require about 10,000 board feet of lumber.

(85 million cubic meters) in 1990 (USDA Forest Service 1965, Smith et al. 2001).

Land Use Policies

Effectiveness of growth management efforts and other land use policies are issues warranting attention in sustainable forestry discussions. Human populations in Oregon and Washington have increased faster than the national average in recent years, and projections suggest that the population of Pacific Northwest west side in particular will continue to grow substantially (fig. 5.2), causing more conversion of forest land to developed uses. Americans' incomes have grown substantially (in real terms or constant dollars) in recent decades, and average per capita personal income in the Pacific Northwest has increased more than 75 percent over the last 30 years (USDC Bureau of the Census 2002). Projected increases in discretionary income will increase demands for renewable resources, but may also lead to further conversion of forests for developed uses.

Land use policies adopted by the states to address urban sprawl and other land use changes include Oregon's approach, which zones farmland and forest land for protection from development, and attempts to concentrate growth within urban growth boundaries (Kline and Alig 1999).[5] As noted earlier, the rate of development of rural lands has increased over the NRI survey periods, and land is being developed at a higher rate than the growth in population. Amount of land developed per additional person has increased over time in the region. The dwelling density also continues to increase within the forest, mixed forest, and agriculture dominant land uses classified by the USDA Forest Service (Azuma et al. 2002).

Studies of the effectiveness of policies to deal with such growth have relied heavily on the enhanced availability of data on land use conversions. In an initial study, Kline and Alig (1999) examined how well Oregon's land use planning program has protected forest and farm lands from development since its implementation in 1973. They relied on plot remeasurement data from the USDA Forest Service's Forest Inventory and Analysis (FIA) unit (e.g., Azuma et al. 2002). They developed an empirical model of land use before and after the program. They based it on socioeconomic factors, land rent, landowner characteristics, and the location of land within forest and exclusive farm use zones mandated by the program. Their results suggest that Oregon's land use planning law has concentrated development within urban growth boundaries since its implementation; however, the effect of the law on the likelihood of development of land in forest and exclusive-farm-use zones was not statistically significant.

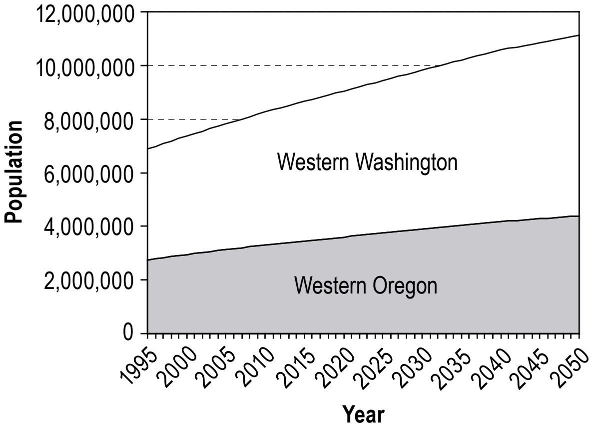

Figure 5.2—Projected population for western Washington and Oregon, 1995 to 2050 (adapted from Kline and Alig 2001).

In a recent update, Kline [in press] used new data on housing counts to revisit the question of the effectiveness of Oregon's land use law. By using counts of structures per acre, Kline found less development in farmland and forest use zones since the law was developed. He projected that Oregon's land use law had saved about 65,000 ac (26 000 ha) of forest land from low-density development and about 36,000 ac (15 000 ha) from the more developed class. Kline indicates that this analysis, based on estimates of building density, provides empirical evidence that Oregon's land use law had some effect in preventing development of forest lands.

Ownership Changes

The main ownership change between traditional forest ownership categories has been between forest industry and NIPF owner classes. Forest industry land is owned by companies for the purpose of timber production. The NIPF lands make up the remainder of the private forest land base. Forest industry owns most of the private timberland in the Pacific Northwest region, and generally manages forest land intensively for timber production. Land exchanges among private owners have been more common than exchanges between private and public owners (Zheng and Alig 1999). For example, FIA surveys in western Oregon indicated a

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[5] Washington has the Growth Management Act, but my literature search did not identify any studies evaluating the act similar to evaluations of Oregon's land use law.

net shift of 750,000 ac (300 000 ha) from NIPF to forest industry owners from 1961 to 1994. In western Washington, preliminary findings suggest that about one-third of private forest land changed ownership between 1989–1990 and 1999–2001 (Gray 2003). With mergers, acquisitions, and other institutional changes (Best and Wayburn 2001), significant changes also occurred within the industrial ownership category (e.g., combining Willamette and Weyerhaeuser companies in 2002). Changes in private ownership can result in notably different land management, particularly as some private owners respond to market changes prompted by reductions in federal timber supply.

The diverse NIPF owner category also continues to change in composition. Along with this, forest fragmentation and parcelization and other factors may result in more noncorporate individual owners (e.g., Butler et al. 2004, Lewis and Plantinga (chapter 6 of this report), Sampson 2000), and they are likely to have smaller tract sizes on average. The number of forest owners in the Western United States increased by 67 percent between 1987 and 1994 (Birch 1997). Accompanying changes in tract size may be changes in the values and perceptions of forest landowners, some of whom are new arrivals to the region. New owners sometimes bring different land management attitudes compared to traditional owners, with changing values often the result of exurbanization, with urban residents moving to rural settings.

A long-standing issue in forest resource supply studies is the likely behavior of private owners and how this behavior may be affected by incentives and institutional factors. For working forest lands to be sustained, most lands need to be profitable, and the most profitable marketable commodity from forest land is timber. Forest fragmentation and parcelization can affect profitability because of economies of scale and fixed costs that are invariant to treatment area. In addition to changing characteristics of the owner population over time, changes in ownership objectives may affect the resources. The larger, publicly owned companies are affected by shareholder expectations and pursue acceptable rates of return on investment within a changing institutional environment of incentives and regulations. The NIPF owners, in particular, possess multiple objectives, causing them to respond to socioeconomic forces and policies in complex and sometimes unpredictable ways. Nontimber services likely could be enhanced effectively by targeting incentive programs toward select groups of NIPF owners (Kline et al. 2000). “Neighborly concerns,” restrictions on land management and loss of flexibility, and whether owners live on their forested property also can affect behavior.

Many factors affect NIPF land management behavior in various ways. Responses to public intervention depend upon the NIPF owners’ objectives; intended versus actual outcomes of public programs may not match if owners’ motivations are not sufficiently factored into intervention planning. As to the question of whether many NIPF owners might harvest sooner because of increasing regulation, a survey by Johnson et al. (1997) showed that a majority did **not** say that possible future regulations were important in their most recent harvest decisions. However, many significant differences between large- and small-acreage owners showed up in the Johnson et al. study (1997) and Kline et al. (2000) findings. For tree planting decisions, NIPF owners tend to give greater weight to upfront costs than to time-distant timber revenues (Alig et al. 1990). The NIPF owners are older on average than the overall population; this raises questions about who will eventually take their place, with implications for rural communities, timber supply, and the environment.

Land Management Intensity

An increasingly important consideration for forest policy analysts is the potentially significant impact that population growth and resulting land use changes will have as forests are converted to residential and other developed uses. Forest lands located near low-density residential and other development could become less productive because of fragmentation into smaller management units and changes in the characteristics and management objectives of newer, more urban-oriented forest owners. Propensity of NIPF owners to harvest timber and manage for commercial timber production may be negatively correlated with population densities. Further, development has the potential to increase wildfire risk associated with increased human habitation and activity in forests. Kline et al. (2004) indicate that to date the density of nearby development has not measurably affected timber-harvesting activities of private forest owners in western Oregon. However, density of development near forest land may have a small but measurable negative impact on the likelihood that forest owners will thin existing stands of planted trees. Their results suggest that although increasing building densities may have had a limited impact on timber harvesting thus far, they have the potential to reduce investment in forest management activities in the future.

PROJECTIONS

Projections are that the Pacific Northwest's share of total population will increase, as the Nation's population expands. Timberland area in the region is projected to be reduced by about 1 million ac (400 000 ha) between 1997 and 2050 (Alig et al. 2003). Projections suggest significant expansion of low-density and urban development in the future, with the proportion in western Oregon expected to nearly double by 2055 (Kline and Alig 2001). Although the majority of new development for residential, commercial, or industrial uses is projected near existing cities, greater development also is indicated in forested areas, suggesting greater numbers of people will be living in proximity to western Oregon's forest lands in the future. Probabilities of development are a function of socioeconomic and location factors, ownership, and geographic and physical land characteristics (Kline and Alig 2001, Kline et al. 2001).[6]

The west side of the region is likely to experience the most growth (fig. 5.2), and projected total reductions in areas of forest land from 1997 to 2050 are 1 percent in western Oregon and 1 percent in western Washington (Kline and Alig 2001). Urban areas on the west side are projected to increase by about 20 percent. The largest timberland change is a 2-percent reduction for NIPF timberland. Projected percentage reductions for farmland (4 percent in western Oregon and 13 percent in western Washington) are larger than for forest land, largely because farmlands tend to be closer to existing cities.

IMPLICATIONS FOR SUSTAINABLE FORESTRY OPTIONS

From a long-term conservation perspective, population growth and other socioeconomic changes could considerably affect sustainable forestry options. The U.S. population may double by 2100, growing to more than 500 million people (USDC Bureau of the Census 2002), and the Pacific Northwest is expected to experience above-average population growth. If the population increases as projected, accompanied by a rise in personal income, the result could be a net loss of several hundred thousand acres of timberland in the region over the next several decades (Kline and Alig 2001). In a landscape comprising a mosaic of major land uses, sustainable forestry will be competing with other interests, such as agriculture or residential uses. The forest-urban interface is characterized by expansion of residential and other developed land uses onto traditionally forested landscapes in a manner that threatens forest lands as productive socioeconomic and ecological resources.

Future improvements in land management and policymaking could be facilitated by better understanding of how systems function, and this will require both enhanced data collection and research. Monitoring land use changes would be enhanced by regional snapshots every 2 or 3 years. Enhanced data on the distribution of humans and settlements on the landscape would augment the discrete land use characterization approach (e.g., Kline 2003, Kline et al. 2003), given that socioeconomic and ecological processes are sensitive to a range of human habitation. Regional data on historical building densities would allow broader application of studies such as those by Kline (2003, in press) and Kline et al. (2003, 2004) regarding population densities and intensity of timber management and production activities. Consistent regional coverage would also allow examination of possible spill-over effects among states regarding certain land use policies.

Total timber volume in the Pacific Northwest has increased on a timberland base that is 5 percent smaller than the one in 1952. Demand for wood products is expected to keep growing, driven by the same population increases and economic development that affect demands for other major land uses. However, intensified timber management on the supply side represents some of the largest projected changes involving private timberland (e.g., Alig et al. 1999, 2002), and could act to moderate or temper upward pressure on future wood prices. Private timberlands have the biological potential to provide larger quantities of timber in an environmentally sound manner than they do today (e.g., Alig and Adams 1995). However, the real potential of forest owners to gain revenue from forest land will affect their capability to maintain ownership, much less make further investments in the property. This includes other potential sources of revenue outside of timber and real estate development, such as carbon credits, recreation, or other services. Haynes (chapter 3 of this report) discusses whether timber markets will provide incentives for sustainable forest management and investment issues; many of the opportunities for intensified forest management can be undertaken with positive economic returns, but changing social and institutional aspects may

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[6] The projections by Kline and Alig (2001) were used in the 2000 Resources Planning Act assessment in support of analyses of production possibilities for multiple resources from the region's forest land base (USDA Forest Service 2001).

affect actualization. Most timber management intensification opportunities in the United States are in the South and the Pacific Northwest west side. Further, more forests around the world are actively managed today as compared to earlier decades and include an expanding area of productive forest plantations that will affect future timber prices (Haynes 2003). Sustainability analyses can be enhanced if both land use and land investment options are examined, along with social attitudes toward private forests. Analyses should be explicit with respect to timing of tradeoffs, in addition to the growing attention given to spatial details, such as the effects of more people locating on forested landscapes (e.g., expanded wildland-urban interfaces that affect fire management).

Selected findings from land use change research germane to the sustainability issue are:

- Long-term trends in forest area and timberland area are downward, with the region losing 3 percent of forest land and 8 percent of timberland since 1952. Amount of per capita forest land has dropped from 13.9 ac (5.6 ha) in 1952 to 5.5 ac (2.2 ha) in 1997.
- In recent years, a large majority of converted forest land in the Pacific Northwest has been developed versus shifted to agriculture. Acres leaving the forest land base typically have quite different forest resource attributes than those entering.
- Most forest land conversion has been on NIPF lands, which are often important in riparian zones.
- Projections are for another 4 million people to be added to the region’s population by 2050. This could result in about 1 million ac (400 000 ha) of timberland being converted to other uses.
- The amount of developed area per new person in the region has increased over time.
- One measure of forest investment in private timberland has been annual tree planting, which more than doubled in area from 1960 to 1999.
- Private timberlands have the biological potential to provide larger quantities of timber than they do today; a growing area of productive tree plantations will provide a larger share of the Nation’s timber harvest, and this can allow some other forest lands to be used increasingly for nontimber purposes.

Implications of socioeconomic changes and land use dynamics warrant consideration in forest sustainability analyses. Broadly, the challenge for land managers is to implement strategies that provide the range of goods and services expected from forests. “Sustainable forest management,” like “sustainable development,” is an attractive but vague goal (Haynes 2003, chapter 6). Any operational definition of “sustainability” will be a reflection of values and therefore is subject to change. Biophysical, ecological, and socioeconomic components all warrant consideration. Further, given our fixed land base, future sustainability deliberations should include broad consideration of relationships among major uses of our land and aquatic resources (e.g., effects of an increasing area of developed land and pressures on remaining forest land), so that the many future decisions by a diverse set of owners potentially can lead to an improved environment-economy linkage.

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METRIC EQUIVALENTS

When you know:	Multiply by:	To find:
Acres (ac)	0.405	Hectares
Cubic feet (ft^3)	.0283	Cubic meters

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6. RESEARCH METHODS TO ADDRESS THE ECONOMICS OF FOREST HABITAT FRAGMENTATION

David J. Lewis and Andrew J. Plantinga[1]

ABSTRACT

Forest fragmentation poses threats to wildlife, particularly birds, in many parts of the United States. We describe an economic approach to analyzing forest fragmentation that integrates econometric models of land use, simulations with high-resolution land cover data, and models of bird species abundance. We conclude by discussing the application of these methods to the Pacific Northwest region.

INTRODUCTION

IN MANY REGIONS OF THE UNITED STATES, the area of forest land has been stable or has increased in recent decades. Although regional trends in forest area have been beneficial for some wildlife species dependent on forest habitat, the populations of others (e.g., songbirds, amphibians) continued to decline even in regions that gained forest area. For example, according to a recent estimate by the National Audubon Society, over one-quarter of the bird species in the United States have declined significantly in population over recent years. A problem for many species (e.g., Neotropical migrant songbirds) is forest fragmentation—gaps in forest cover that result when formerly contiguous forest is broken into two or more parcels by land conversion for uses such as agriculture and residential housing (Askins 2000).

A recent geographic information system analysis of the fragmentation of continental U.S. forests indicates that most forested parcels in the Lower 48 States are found in fragmented landscapes (Ritters et al. 2002). Heavily fragmented landscapes have fewer interior parcels; i.e., forested parcels that are at least a certain minimum distance from the nearest edge. Such interior parcels provide the best habitat for many sensitive species (Askins 2000, Robbins et al. 1989, Robinson et al. 1995). For example, interior-forest songbirds require habitat that is 200 m from the nearest nonforest edge (Temple and Cary 1988). However, approximately 62 percent of forest in the Lower 48 States is located within 150 m of the nearest edge, which suggests that fragmentation of U.S. forest is so pervasive that edge effects influence ecological processes on most forested lands (Ritters et al. 2002).

In response to the possible ecosystem effects of fragmentation, there have been proposals to manage the spatial pattern of a region's forests to minimize fragmentation. Ritters et al. (2000) suggested that policies should be constructed to fill in forests in "perforated" conditions. A region may be considered perforated if it is heavily forested and heavily fragmented (defined in terms of the number of interior parcels) by some nonforested use. Robinson et al. (1995) suggest that large regions in North America should be identified and either retained (if unfragmented) or reforested to increase interior forest acreage. They suggest that the focus of a fragmentation policy should be on rural regions rather than urban areas because a large unfragmented region can act as an ecological source (e.g., breeding grounds) for populations of birds, whereas other areas (e.g., urban) can act as sinks that depend on bird immigration to maintain population levels.

One obvious challenge in such large-scale conservation planning is that much of the land in the United States is privately owned. Standard economic theory tells us that landowners will make land use decisions based on private economic returns and that public goods such as the wildlife benefits from interior forest will not be fully considered in the decision calculus of private landowners. As such, it may be desirable to use land use policies to encourage the private provision of public benefits associated with interior-forest parcels. Implementation of effective and efficient policies designed to limit or reduce forest fragmentation requires an understanding of the current economic environment shaping landowner choices as well as the likely response by landowners to policies designed to address fragmentation.

This report describes an economic approach to analyzing forest habitat fragmentation and exploring land use policies designed to achieve related wildlife conservation goals. The

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methods proposed here integrate econometric models of land use, simulation methods with spatially explicit data, and wildlife statistics and models. The next sections describe the methodological approach in general terms and application of these methods to the Pacific Northwest region.

RESEARCH METHODS

Econometric Land Use Models

Econometric models of land use are used to quantify the relationship between private land use decisions and economic and physiographic factors. The basic methodology for estimating these models has been developed and refined under earlier Forest Service-sponsored cooperative research (Ahn et al. 2001, Mauldin et al. 1999, Plantinga and Ahn 2002, Plantinga et al. 1999). The analysis of forest fragmentation will build, in particular, on the work of Lubowski et al. (2003), who studied land use transition probabilities for six major land use categories (cropland, pasture, forest, range, urban, and Conservation Reserve Program). Each of these transition probabilities (e.g., the probability that pasture land is converted to forest) is expressed as a function of economic returns to alternative uses and land characteristics, as well as unobserved parameters. These parameters are then estimated with data on plot-level land use decisions from the National Resources Inventory (NRI) (USDA NRCS 2001), county-level average economic returns to each alternative use, and plot-level land quality. The latter variable measures the suitability of the land for agricultural production. The interaction between the land quality variable and the returns variable may account for plot-level variation in returns.

Once the parameters have been estimated, the econometric model of land use transitions can be used to estimate the response by private landowners to financial incentives designed to encourage afforestation or retention of land in forest. For instance, we can estimate how the probability that land shifts from pasture to forest changes when landowners receive a subsidy for afforestation. For a given NRI plot, this is done by increasing the economic returns to forest by the amount of the subsidy, substituting the higher returns into the function for the pasture-forest transition probability, and evaluating the resulting expression. We would expect the subsidy to increase the probability of land moving from pasture to forest, although the effects may differ depending on the land quality of the plot. These differential effects are captured in the econometric model because the probabilities are functions of plot-level land quality.

The location of individual NRI plots is not disclosed for confidentiality reasons. The NRI database reports only the county in which a plot is located. As such, if we want to use the econometric model to study how policies affect land use patterns, then our only choice is to aggregate plot-level changes to the county level or higher.[2] However, to study forest fragmentation we need to characterize the spatial configuration of land uses at a much finer spatial scale. For this reason, we turn to simulation methods, as described in the next subsection.

Simulation methods

High-resolution land cover maps and simulation methods can be used to resolve the difference between the scale of the econometric model and the scale needed for fragmentation analysis. The econometric results provide sets of land use transition probabilities specific to each land quality class and county. It is reasonable to assume that a common set of probabilities apply to all parcels of a given quality within a county. This is so because the key economic factors that determine transition probabilities (e.g., commodity prices) exhibit little variation within a county. For the purpose of the simulations, one can view the estimated transition probabilities as a set of rules that govern land use changes within a county. For example, if the value of the pasture-to-forest transition probability is 0.10, then the rule is that 10 out of every 100 parcels of pasture land within a county should shift into forest use over a given period (in the NRI data, this is 5 years).

The simulations will make use of high-resolution (e.g., 1 km^2) land cover maps. These data divide a landscape into a grid and, for each cell in the grid, indicate the dominant land use category. The simulations involve changing the use of cells in a way that obeys the rules indicated by the transition probabilities. Of course, this can happen in many ways. For example, if there are initially 100 cells in pasture within a county, then there are approximately 6.3×10^{19} ways to select 10 of these parcels for conversion to forest that satisfy the 0.10 rule. Clearly, it will be infeasible to enumerate all of the possible landscapes that satisfy the

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[2] Each NRI plot represents a certain number of acres. Suppose a given plot is in pasture initially. Then, the product of the initial pasture acres and the pasture-forest transition probability gives the number of acres moving to forest (as represented by this plot). Aggregating these acres over plots within a county yields a county estimate of the acres moving from pasture to forest.

transition rules. However, by generating a large number of landscapes, we can hope to characterize the distribution of land use changes.

The simulations will be accomplished by using cellular automata, which is a spatially explicit form of finite-state automata. In cellular automata a group of cells are defined across space, where each cell faces a set of transition rules that depend on the current state of the cell as well as the state of neighboring cells. In our application, the current land use defines the state of each cell. Cellular automata are flexible and can be used with multiple states (i.e., forest, agriculture, urban, etc.) and landscapes of varying size. By repeatedly simulating land use transitions, we generate a distribution of potential outcomes. When land use policies are introduced, the underlying probabilities (or econometrically based sets of rules) change, and we obtain a different distribution of potential outcomes associated with each policy (e.g., different levels of afforestation subsidies). Each of these hypothetical landscapes corresponds, in general, to a different spatial pattern of forests.

The simulation approach will allow us to explicitly compare the effects of different land use policies on the spatial structure of a region's forest. For example, a policy that targets parcels to convert based on economic cost only (i.e., a "least-cost acreage" policy that minimizes the total cost of achieving a given acreage target) may create a substantially different landscape than a policy that targets the creation of "interior" forest patches. The tradeoffs between these policies arise from both economic costs and environmental benefits. For example, a least-cost acreage program may be the least costly approach to sequestering carbon, but it may not be the least costly way to meet wildlife and biodiversity goals. This is because a least-cost acreage policy is only concerned with a net increase in forest, not the location of the new forest. In the case of maximizing wildlife goals, a land use policy targeted toward the creation of "interior" forests may prove more efficient, yet in general will be more expensive to implement.

The tradeoffs involved between alternative land use policies may also differ considerably by the magnitude and spatial distribution of forest on the initial landscape. For example, least-cost acreage policies may be more successful at creating interior-forest patches on landscapes with a greater amount of initial forest cover. This is due simply to the fact that any converted parcel has a greater likelihood of being next to a forest patch when initially the landscape is heavily forested. On the other hand, for landscapes with very little initial forest cover, any particular parcel is less likely to be adjacent to forest patches, thus making the likelihood lower that a least-cost acreage policy would result in interior-forest parcels. Simulation modeling will allow us to quantify and evaluate the nature of the tradeoffs involved on a variety of landscapes.

Modeling Impacts on Bird Species

Although the simulation methods can characterize the spatial distribution of forests under different policy regimes, ultimately we want to understand the implications of forest fragmentation for particular wildlife species. We focus on impacts on bird species; as noted above, forest fragmentation is believed to have serious consequences for many birds, and the available data sets on birds are particularly rich. However, with the appropriate data, these methods can be applied to other species of interest.

Models of bird densities can be developed for a large range of species. The basic data on birds are from the national breeding bird survey (BBS) administered by the U.S. Geological Survey and the Canadian Wildlife Service, and interpolated to produce incidence surfaces for each species (Yang et al. 1995). A second data layer consists of land cover types at the 1-km^2 scale, as described above. A third consists of climate data as bird distributions are ultimately limited by climatic constraints. These data are used to construct forest fragmentation indices for each of the 640-km^2 hexagonal units, which measure the degree of continuity in the forested landscape. The fragmentation indices and the incidence surface is then used to measure the relationship between forest fragmentation and species abundances, with controls for covariates such as climate and land cover (e.g., O'Connor and Jones 1997). That is, each value of the index can be associated with an abundance measure for a particular species.

Building on previous research in Hayes and O'Connor (2001) and Matthews et al. (2002), the models of land use and bird abundance will be combined and used to identify the effects of policies designed to reduce forest fragmentation. As discussed above, the combined econometric and simulation techniques generate a large number of hypothetical land use patterns, each of which implies a spatial pattern of forests and, thus, a particular value of the fragmentation index discussed above. In principle, one could compute the fragmentation index for each iteration of the simulation and, thus, define a corresponding distribution of effects on bird species abundance.

Unfortunately, this approach appears to be too computationally burdensome. Many of the variables used to predict species abundance depend on the spatial pattern of land use (e.g., mean patch size of forest within a 640-km^2 hexagon), and these would need to be recomputed for each iteration of the simulation and each hexagon before being used to make abundance predictions for a large number of species. Further research is needed to identify feasible ways to link the results of the simulation analysis to bird population measures. The most promising approach is one of preliminary perturbation and calibration of landscape response: samples of the landscape change patterns generated by the simulations would be used to recompute the predictor statistics used in the bird models; these statistics are then treated as responses to the inputs driving the simulations (the transition matrix, initial fragmentation metrics for the area, etc.); the response surface is then used to estimate the change in wildlife predictor variables likely to result from this change, and these estimates will be used to predict the expected change in each species' abundance. This approach is likely to give adequate accuracy because bird distributions (as distinct from the locations of individual territories) typically integrate over land cover conditions over some tens of square kilometers. For example, it matters little to an area-sensitive species whether a large enough forest stand is here or 5 km away (although having to go 50 km away would indeed reduce local bird abundance). The effectiveness of these predictions can be checked by explicit recalculation of all the predictor metrics for a sample of the Monte Carlo runs and comparison of their values to the estimated ones, and the resulting deviations can be combined with the sensitivity of the species abundance to that predictor to determine the likely error in the bird predictions. Alternatively, the geographical focus of the analysis could be reduced to reduce the computational size of the problem.

APPLICATION TO THE PACIFIC NORTHWEST REGION

According to NRI statistics, between 1982 and 1997, 155 400 ha of forest were converted to urban use in Oregon and Washington, mostly on the west side of the Cascade Range crest. During the same period, there was an active margin between forest and agricultural uses. Approximately 57 870 ha were converted from forest to agricultural use (cropland, pasture, range), while 116 200 ha were converted from agricultural use to forest. The changes, in terms of total acres, were similar on the west side and east side. In percentage terms, the changes are fairly small (e.g., the 138 000 ha of forest converted to urban uses on the west side represented a 2.1 percent decline in total forest acreage), although similar to those at the national scale. Nevertheless, even small changes in forest area can have significant implications for wildlife habitat depending on the spatial distribution of these changes.

The methods discussed above can be readily applied to the Pacific Northwest region. Plot-level land use and bird incidence data can be obtained from the NRI and BBS databases. High-resolution land cover and land quality data are increasingly available. For example, in Oregon these data are available as part of the Oregon Rural Lands Database (Oregon Department of Land Conservation and Development [n.d.]). Figure 6.1 provides an example for Marion County, Oregon. The top panel shows the spatial distribution of the major land use categories, and the bottom panel depicts land quality, where lighter colors indicate land more suitable for agricultural production.[3]

Two issues will need to be addressed in applying these methods to the region. One is the matter of scope. It is unclear whether we will be able to analyze the entire two-state region, or whether we will have to emphasize case studies. For example, we might focus the analysis on several counties that cover a large degree of the range of economic, physiographic, and biological conditions. The scope will likely be determined by computational constraints (e.g., how many land use simulations we can feasibly run). The second issue is whether the econometric land use and bird species models need to be tailored to the Pacific Northwest region. Although we would use data specific to the region, another possibility is to use these data to re-estimate the model parameters. At present, the models are fitted to national data. Some analysis will be needed to determine if the national model appears to represent regional relationships.

CONCLUSIONS

The ultimate goal of this research is to derive distributions of bird species abundance. An example is provided in figure 6.2. As shown, the distributions would indicate the probability, *P(A)*, that each abundance measure, *(A)*, is achieved. Provided we can map each simulated landscape

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[3] The eight land quality categories in figure 6.1 are the land capability class ratings. See U.S. Department of Agriculture (1973) for details.

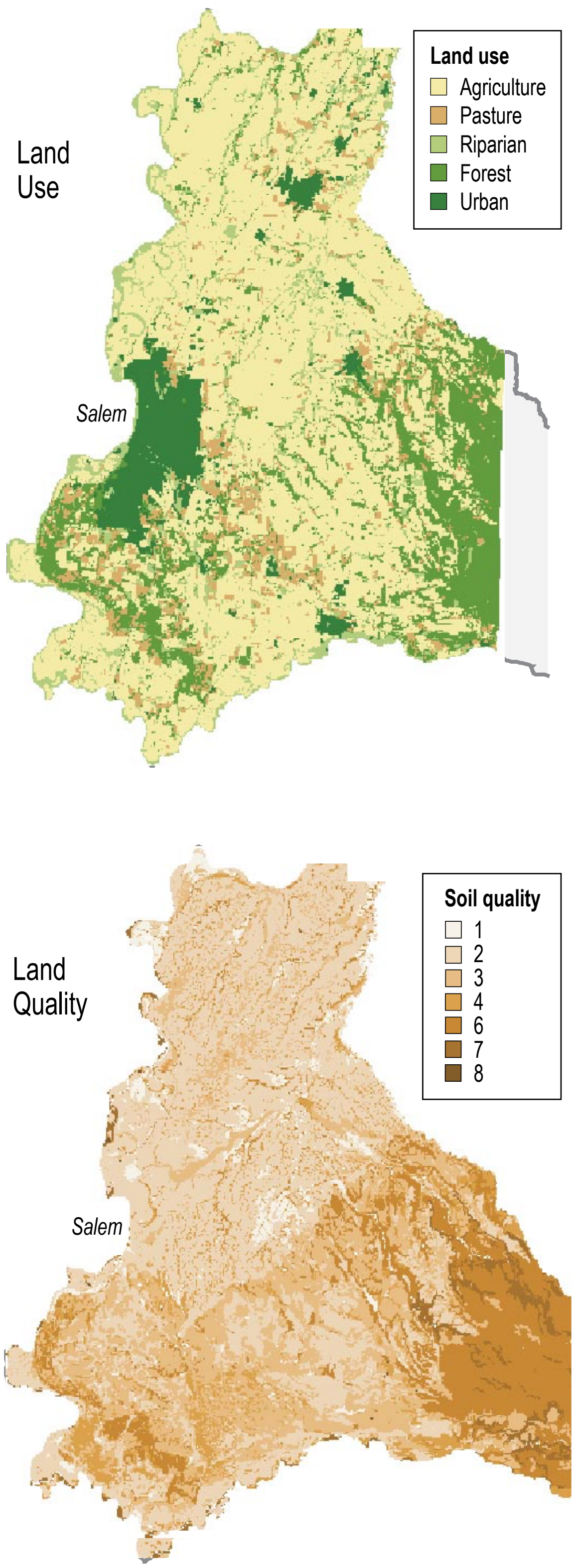

Figure 6.1—Land use and land quality maps for Marion County, Oregon. Soil quality 1 is the most suitable for agricultural production, with higher numbers indicating decreasing suitability.

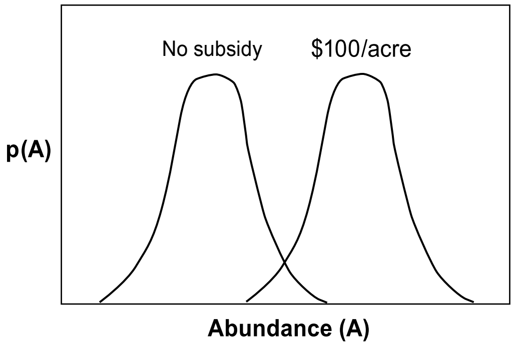

Figure 6.2—Probability distributions of species abundance.

into a species abundance measure, the distribution would be constructed by simply computing the percentage of times we record a given abundance measure. These distributions could be defined for regions (e.g., the Pacific Northwest), or for subregions (e.g., counties). They could also be derived for individual species or for groups of species. The distributions would also be affected by land use policies. For example, figure 6.2 shows that the abundance distribution shifts to the right with a $100 per acre subsidy. We are particularly interested in comparing how distributions change with different types of policies. In particular, how do the results differ for least-cost acreage policies and policies targeting interior forest? We also can compare the results under alternative baseline assumptions. For example, different trends in urbanization might affect the cost and effectiveness of forest fragmentation policies. By focusing on the distribution of species abundance, we can indicate not only the central tendency (e.g., the expected outcome) but also the likely range of outcomes.

ACKNOWLEDGMENTS

The authors acknowledge helpful comments from Claire Montgomery and JunJie Wu.

ENGLISH EQUIVALENTS

When you know:	Multiply by:	To find:
Meters (m)	3.28	Feet
Hectares (ha)	2.47	Acres
Kilometers (km)	.6215	Miles
Square kilometers (km^2)	.386	Square miles

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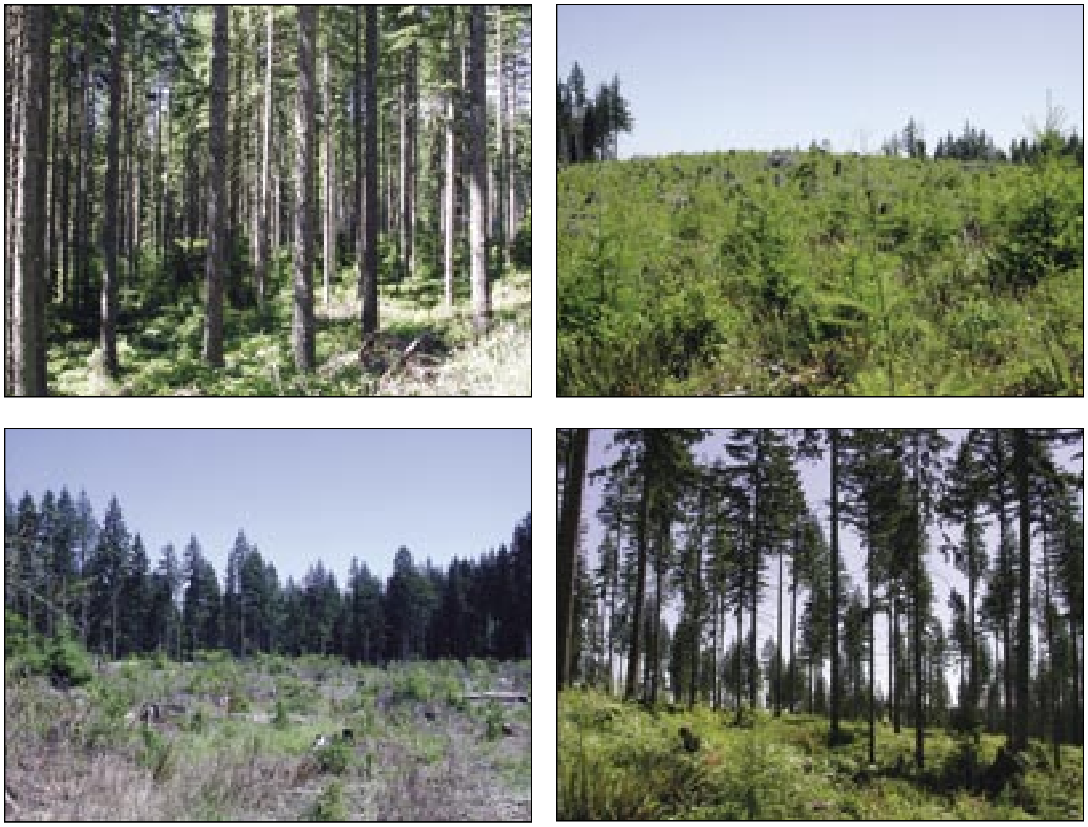
Section C:
Sustainable Forestry Options



Gordon Bradley, University of Washington

The upper left scene is a thinning (respondents to questionnaire had a strong preference for this type of treatment), upper right is a clearcut (low preference), lower left is a patch cut (medium-low preference), and lower right is a two-age stand (medium preference).

SWPI

7. SEEING THE FOREST FOR THE TREES: VISUAL RESOURCES RESEARCH IN THE CAPITOL STATE FOREST

Gordon Bradley[1]*, Anne Kearney*[2]*, and Seth M. White*[3]

ABSTRACT

Forest management involves meeting the demands of multiple forest values including human perceptions of forest treatments. The authors of this chapter have synthesized the results and management implications from a previous study in the Capitol State Forest, with special emphasis on sustainable wood production in the Pacific Northwest. Respondents representing various interest groups (forestry, education, recreation, and environment) were asked, via a mail-in questionnaire, to rate photographs of forest scenes. In general, all respondents preferred less intensive treatments that were closer to what they considered natural conditions, but foresters had a higher preference for more intensive treatments than other groups. By knowing people's preferences for forest scenes, managers can incorporate the value of human perceptions in their forest plans and management activities.

INTRODUCTION

WHAT SHOULD A FOREST LOOK LIKE, OR what are the most desirable features of forests? These questions may seem naïve at first glance, but they turn out to be difficult questions to address, and their answers depend on the person being asked. A forest should be green, no doubt, and for most people that means trees arranged in a certain pattern on the landscape. But how green? How many trees? And what pattern of arrangement? Should the forest have trees of several species and in multiple age classes? And what about forestry treatments like clearcutting, patch cutting, group selection, and thinning? What impact do these practices have on the way people perceive the forest? Finally, do different groups of people (foresters and environmentalists, for example) have preferences for different types of forest scenes? The answer to the apparently simple question—What should a forest look like?—turns out to be more complex at second glance.

The Sustainable Wood Production Initiative and collaborators are working to address some of these questions and their management implications in the Pacific Northwest. This chapter is a synthesis of ongoing research on public perceptions of forest management carried out in the Capitol State Forest near Olympia, Washington. The initial results of the study were recently published in another USDA Forest Service publication (Bradley et al. 2004); this chapter highlights the results of that study in the context of identifying and understanding key issues relating to sustainable wood production.

THE CAPITOL STATE FOREST STUDY

Visual impact research at the Capitol State Forest is a collaboration between the Washington Department of Natural Resources, the USDA Forest Service Pacific Northwest Research Station, and the University of Washington College of Forest Resources. By using undergraduate and graduate students as initial test subjects, researchers developed a method of showing photographs of different forest scenes to people and asking them to rate the images according to preference (see photographs on page 43). In the world of visual resources management, this type of rating system is termed a perception-based study (British Columbia Ministry of Forests 1981). This method is just one way to measure people's preferences. Other techniques include measuring preferences for physical attributes such as vegetation, sky, and water (Zube et al. 1975); measuring preference for traditional land cover types such as residential, industrial, forest, and agriculture cover; or using an information-based approach, a method that evaluates whether the informed respondent would choose to explore a given forest scene in greater detail (Kaplan and Kaplan 1989). In the Capitol Forest study, forest scenes represented different forest

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management treatments including clear-cutting, patch cutting, group selection, repeated thinning, two-age, and no treatment. Photographs were shown to different groups of people including people from urban and rural areas, foresters and educators, the environmental community, and forest recreationists.

The findings of Bradley et al. (2004) suggest that for most timber harvest practices, preferences are generally ordered in a similar fashion for all groups of people. People prefer scenes that are "green," having a more natural appearance without large and recent clearings. However, research from the Capitol State Forest also revealed that there is a significant difference between the preferences of foresters and all other groups when it comes to the most intensive timber harvest practices, especially for clearcutting. One immediate management implication is that forest practices resulting in greater tree retention, smaller openings, and rapid green-up will serve to reduce the visual impact of timber harvest practices. An associated implication is that it may be difficult to win broad public support for intensive forest practices, and the results suggest that there may be diminished confidence in forest managers as stewards of the land. To change public sentiment regarding intensive forest management practices, the forest industry will likely need to improve the visual quality of their treatments, especially in visually sensitive landscapes such as travel corridors.

CONCLUDING REMARKS

The authors of previous chapters have shown that sustainable wood production in the Pacific Northwest depends on more than just traditional concepts of sustained growth and yield including forest markets, harvest potential, land use changes, and alternative forestry techniques. Another important factor, and an emerging area of forestry research, is the idea that human perceptions of forest management practices may have substantial implications for how we manage forests. Public and professional perceptions toward forestry treatments are likely to play an important role in strengthening society's trust of the field of forest management.

Of course, the management of visual aspects of forestry is simply one of a number of important considerations for sustainable forestry. Others include economic and engineering efficiency, worker safety, fish and wildlife habitat, soil stability, and measures of ecosystem function. In many cases, meeting visual resource management targets is complementary to other targets of sustainable forestry—managing for the visual landscape may coincide with managing for the ecological, social, and economic landscape. To meet the demands of multiple forest goals, treatments can accommodate diverse perspectives; research from the Capitol State Forest addresses the question of human perceptions in order to complete the picture.

So what **should** a forest look like? Research in the Capitol State Forest continues to address this question. The answer may not only be complex but may also change through time or with more available information about the forest. Much of the work by Bradley et al. (2004) described in this chapter is related to simple preference ratings of individual scenes. Interesting questions remain about why people have preferences for certain timber harvest practices, how preference ratings may change as forests mature, or how preference ratings may change when people are given information about the costs and benefits of different forest management practices. Ongoing research continues to address these and other questions as they arise, and works to integrate human values into how we manage our forests.

ACKNOWLEDGMENTS

This research is one component of an integrated, long-term research study developed and implemented by the Silviculture and Forest Models team, Resource Management and Productivity Program of the USDA Forest Service, Pacific Northwest Research Station (PNW), and the Washington State Department of Natural Resources to test silvicultural options for managing young-growth forests (Curtis et al. 2004). Financial support was provided by the PNW Resource Management and Productivity program and the Focused Science Delivery Program.

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8. A PROPOSAL FOR EVALUATING ALTERNATIVE APPROACHES TO IMPLEMENTING SUSTAINABLE FORESTRY PRACTICES IN WESTERN OREGON

Claire A. Montgomery[1]

ABSTRACT

Sustainable forestry standards include criteria for the extent of area of forest successional stages. This paper describes two previous studies that searched for cost-effective management strategies to increase the area of private forest in western Oregon that has structural attributes associated with old-growth conifer forest. One study used a heuristic optimization algorithm to search for stand management regimes that met older forest structural criteria with minimum impact on the value of timber production. The other study used a timber supply model to search for strategies to meet regional targets for area of private forest that meets older forest structural criteria within given time horizons with minimum impact on the value of timber production. A proposal is described that would extend the previous studies to analyze alternative approaches for implementing management for older forest structure on private land in western Oregon. The proposed research will use the timber supply model to simulate approaches based on regulations and on incentives. The approaches will be evaluated on the basis of forest conditions that occur at the end of the analysis period and effect on the value of timber harvest.

INTRODUCTION

Sustainable forestry means different things to different people, but it is increasingly understood to include forest benefits and uses other than wood production. For example, the Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montreal Process Working Group 1998) include indicators that describe the structural composition of the forest (e.g., Indicator 2—extent of area covered by different forest types and age classes or successional stages—under Criterion 1—conservation of biodiversity). Dwindling area of old-growth forest has been of particular concern in the Pacific Northwest and has been an important driver of federal forest policy in the region. For example, the Northwest Forest Plan established extensive areas of late-successional reserves in which it is hoped old-growth forest will develop over time (FEMAT 1993).

A future consideration is, will conservation practices that minimize impacts to other forest uses be better received by a society that values both wood production and conservation? (Photo courtesy of H.J. Andrews Experimental Forest staff, USDA Forest Service.)

Some silviculturists and ecologists are concerned about the effectiveness of the federal reserve approach to increasing old-growth forest area (Carey and Curtis 1996, Tappeiner et al. 1997). Forest stand conditions on reserved sites are

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different from those of the stands that grew into the natural old-growth forests with which we are familiar. Stands on reserved sites are more densely stocked and may not develop the structural attributes (such as large trees and multiple canopy layers) that define old-growth forests, developing instead into dense, overstocked forests with increased risk of fire, insects, and disease. These silviculturists recommend a more active approach that involves multiple thinnings with relatively large volume removals in each entry (Barbour et al. 1997, Carey and Curtis 1996, McComb et al. 1993). This encourages rapid growth in the remaining trees and multiple-level canopy development. The resulting stands may not substitute perfectly for natural old-growth forest, but they may provide many of the same habitat, recreation, and ecosystem services that people value in old-growth forests.

It is unlikely that extensive thinning to aid the expansion of old-growth area will occur on federal forest land in the near future. Although the recently passed Healthy Forests Restoration Act of 2003 will facilitate thinning on federal forest land, its primary purpose will be fire-risk reduction and, hence, it will be concentrated near communities and limited in scale. The Oregon Department of Forestry included active management for older forest structure in the management plans for the state forests (Oregon Department of Forestry 2001a, 2001b), but state forests compose only about 5 percent of the forest land area in western Oregon. Active management may be acceptable to private forest landowners, who hold 45 percent of the forested area in western Oregon, because it can contribute to forest structural objectives while generating revenue from timber harvest. If appropriately managed, these lands may provide an opportunity to implement an active management alternative to the federal reserve-based strategy, thereby offsetting some of the risk associated with the federal approach.

To the extent that it leads to deviation from optimal commercial timber management, active management for older forest structural attributes does reduce income for landowners who undertake it, albeit by a lesser amount than a reserve-based approach would. It also reduces the supply of wood to manufacturers and the supply of wood products to consumers. Minimizing the cost of conservation is in the interest both of landowners and a society that values both wood and conservation.

If private lands are to be managed to meet regional conservation objectives, it will be necessary to induce private landowners to do so. There are many strategies that can be considered for implementing older forest structural management including further regulation, market-based incentives, and direct payments to landowners. Each has its merits; each has its drawbacks. A systematic comparison of outcomes under each of the strategies would help policymakers design policies that are effective and economical.

In this paper, we describe a proposal to use a regional model of private timber supply in western Oregon (Adams et al. 2002) to simulate existing and potential regulations and incentive programs. The proposed research builds on two previous studies that identify cost-minimizing strategies for older forest structure (OFS) management in western Oregon. It will compare various approaches to inducing OFS management on private land to the cost-minimizing approaches identified in those studies.

Older forest structural criteria are described in the next section. In the third section, the two previous studies are described. One study used heuristic optimization methods to search for cost-minimizing OFS management strategies at the stand level (Latta and Montgomery, in press). The other used a regional timber supply model to search for cost-minimizing OFS management strategies at the regional level (Montgomery et al. 2003). The proposed research is described in the fourth section.

OLDER FOREST STRUCTURE

In the state forest management plans, the Oregon Department of Forestry defined five forest stand structure classes for managed forests based on stand attributes that develop over time. These classes are intended to serve as guidelines for managing structurally diverse forests. The fifth management class, OFS, has stand attributes commonly associated with old growth and includes the following criteria:

- Two or more cohorts or distinct canopy layers.
- Twenty or more live trees per hectare with diameter at breast height (d.b.h.) exceeding 81 cm.
- Fifteen or more standing dead trees per hectare with d.b.h. exceeding 30 cm and two or more with d.b.h. exceeding 61 cm.
- Between 42 and 65 m^3 of sound down logs per hectare.

The Oregon state forest plans also identify target forest land base distributions for the five stand structure classes. Target ranges for the OFS class are 20 to 30 percent of the forest land base in northwest Oregon and 10 to 30 percent in southwest Oregon. These are on the low end of the estimated historical range of 30 to 70 percent for the Coast Range (Teensma et al. 1991, Wimberly et al. 2000).

PREVIOUS STUDIES

Cost-Minimizing Management for Older Forest Structure at the Stand Level

Latta and Montgomery (in press) used a random search heuristic similar to Bullard et al. (1985) and an individual tree simulation model, ORGANON (Hann et al. 1997), to search for cost-minimizing old-forest management regimes for a wide range of stand types that occur on private land in western Oregon. The basic data describing private forested land in western Oregon were obtained from the most recent timber inventory compiled by the USDA Forest Service Forest Inventory and Analysis (FIA) unit (Azuma et al. 2004). The FIA inventory defines 1,260 inventory plot units in western Oregon, each representing about 2630 ha on average, based on homogeneity of forest attributes.

Using the heuristic algorithm, the authors chose from a set of possible management activities to develop management regimes that maximize land and timber value while meeting all of the OFS criteria described above, except for sound down logs (owing to modeling limitations), for 30 years prior to clearcut harvest. Up to three OFS management regimes were identified for existing stands on each of the 1,260 inventory units with maximum years to clearcut timber harvest constrained to 65 years, 95 years, and 155 years. Management regimes for OFS were also identified for the regenerated stands that would replace existing stands after clearcut harvest. Possible management activities included doing nothing, planting, precommercial thinning, up to three proportional commercial thinnings of trees aged 20 to 110 years, removing between 10 and 70 percent of the standing volume, and clearcut harvest.

The individual-tree simulation model, ORGANON, was used to track d.b.h., height, and mortality for each tree in the stand. This information was used to evaluate the first two criteria for OFS. The number of cohorts was the number of 9-m tree height classes with at least 10 percent of the total stand stocking. A snag model, based on Graham (1981) and Cline (1977), was used to evaluate the criteria for standing dead trees or snags. If all other criteria were met, but fewer than required snags were generated by the model, then selected live trees were counted as snags and harvest volumes were reduced accordingly.

The OFS management regimes for the 858 inventory units classified as stocked conifer units, as well as opportunity cost estimates, are summarized in Latta and Montgomery (in press). The algorithm was not successful in identifying OFS management for every inventory unit for the shorter time horizons. For example, regimes were identified for 59 percent of the stocked conifer units for the medium time limit and 17 percent of the units for the short time limit. These were concentrated on high-site units with well-stocked, older stands.

The OFS management activities identified by the algorithm were consistent with recommendations by silviculturists and ecologists for repeated thinning with relatively high volume removals to speed the development of stand structural attributes associated with old-growth forest in the Pacific Northwest (Bailey and Tappeiner 1998, Hayes et al. 1997, Tappeiner et al. 1997). For example, the algorithm almost always (97.5 percent of the time) prescribed three thinnings for regenerated stands, occurring, on average, every 20 years, beginning at age 40 and removing, on average, 63, 56, and 40 percent of the standing volume. Unfortunately, it is not feasible to test the OFS management regimes on the ground. As a result, it is uncertain whether the prescribed treatments will indeed result in the desired OFS attributes and, if so, how closely managed stands can substitute for natural old-growth forest. However, there are concerns about the alternative reserve approach as well.

The algorithm was also used to develop intensive management regimes for each of the inventory units. In contrast to the OFS management regimes, the intensive management regimes involved no commercial thinning at all for 70 percent of the conifer units and, for the remainder, one commercial thinning that removed an average of 40 percent of the volume at an average age of 30 years.

Stand-level opportunity cost was estimated for each inventory unit as the difference between the land and timber values under intensive management and under OFS management. The average opportunity cost for OFS on regenerated conifer stands was $366 per hectare or 30 percent of maximum land and timber value. This cost arises primarily from postponing clearcut timber harvest beyond financial maturity. It varied widely for existing conifer stands, but averaged $3,254 per hectare or 32 percent of maximum land and timber value. All else constant, the stand-level cost of OFS was lowest in the Klamath region and highest on the west side of the Coast Range. Douglas-fir was the highest cost forest type. Cost increased with site index and, for existing stands, with stand age and percentage of normal stocking.

Cost-Minimizing Regional Management for Older Forest Structure

Montgomery et al. (2003) used a regional timber supply model to search for cost-minimizing OFS management at the half-state level. The model was originally developed to estimate potential sustainable timber harvest levels on private forest land in western Oregon (Adams et al. 2002). It chooses the assignment of forest area to management prescriptions that maximizes the discounted sum of producer and consumer surplus in the log market in western Oregon. By doing so, it simulates the market determination of timber harvest levels and log prices over the time horizon of the model. It was adapted for this study by including the stand-level OFS and intensive management regimes developed by Latta and Montgomery (in press). The model was constrained to meet targets for the extent of forest area that satisfies the OFS criteria described above within specified time limits. The model was solved repeatedly for a range of area targets beginning with 0 percent and increased in 5-percentage increments until the model failed for two time limits (120 years and 95 years). It was also solved repeatedly for a range of time limits beginning with 120 years and decreased in 5-year decrements until the model failed for three area targets (20, 40, and 60 percent).

The model provides a method for quantifying tradeoffs between the area and timing of alternative targets. For example, the analysis estimates that a target of 20 percent of private forest area with older forest structural attributes within 95 years could be achieved at an aggregate loss to forest landowners and lumber and plywood manufacturers of $294 million (in 1992 dollars). Doubling the area target from 20 to 40 percent could increase cost nearly four times; extending the time horizon by 25 years could reduce the cost fivefold. The estimated loss of $294 million is roughly equivalent to $17.6 million per year (constant dollars annualized at a real annual interest rate of 6 percent), or a one-time payment of $110 per adult Oregonian (at least 18 years old in 2002), or an annual payment of $6.60 per adult Oregonian (ignoring population growth and constant dollars annualized at a real annual interest rate of 6 percent). It involves a long-run reduction in timber harvest of almost 300 million board feet (1.7 million m^3) per year, on average, or almost 9 percent of our estimate of potential sustainable timber harvest on private land in western Oregon.

The model also provides a means for estimating the minimum level of compensation that would be required to induce landowners to voluntarily undertake OFS management. For example, given our assumptions about log demand elasticity, the estimated loss of $294 million would be distributed as follows: Softwood lumber and plywood producers would bear a loss of $315 million. The present value of timber harvest on land that is used to meet the regional OFS target would decrease by $221 million, and the present value of timber harvest on land that remains in intensive timber production would increase by $241 million. The landowners in the latter group would benefit from log price increases resulting from OFS management in the same way that private timber landowners benefited from log price increases in the 1990s resulting from federal timber harvest reductions for conservation of the northern spotted owl. An incentive program would cost at least as much as the reduction in timber value borne by those doing OFS management—$221 million, or an average of $427 per hectare allocated to OFS management.

IMPLEMENTING OLDER FOREST STRUCTURE MANAGEMENT

The previous studies explore how to minimize the cost of achieving particular sustainable forestry goals related to structural diversity. They describe what may be possible, but do not provide guidance on how to implement the policies. That is, by what means can landowners most effectively and economically be induced to implement OFS management consistent with a particular objective? In the proposed research, alternative strategies for implementing OFS management will be explored. Although the policies to be evaluated and compared have not been determined, the following strategies are being considered.

Regulation

Currently, the main tool for regulating forest management on private land is the Oregon Forest Practices Act of 1971, as amended in August 2003. The act contributes indirectly to old-growth forest development on private land by restricting timber harvest in streamside buffers. In 1998, Oregonians rejected ballot measure 64 that would have effected major changes in the way forests in Oregon would be managed—requiring that at least 173 trees per hectare exceeding

28 cm d.b.h. be left standing after timber harvest and that no tree exceeding 76 cm d.b.h. be harvested. There will likely be similar initiatives placed before Oregon voters in the future. For example, conservationists are promoting an Oregon Forest Restoration Initiative that bears a close resemblance to the 1998 ballot measure (Sustainable Forestry Project 2004). The proposed research will use the timber supply model to simulate the effect and cost of potential regulatory approaches to sustainable forestry, ranging from minor modifications of the Oregon Forest Practices Act, such as extending streamside buffers, to the more comprehensive approach characterized by the rejected ballot measure and the proposed initiative.

Direct Payments

There is growing recognition that further regulation of private land management activities may be counterproductive, stimulating antagonism and political backlash against conservation initiatives. As a result, conservationists are searching for alternatives to regulation that would encourage landowners to manage for old forest structure and other sustainability objectives voluntarily (e.g., Defenders of Wildlife 1993, Keystone Center 1995, Vickerman 1998). For example, a conservation incentives bill, HB 3564 (The Biodiversity Partnership, http://www.biodiversitypartners.org/, December 2003), passed nearly unanimously in Oregon in 2001. This bill created a "flexible incentives fund" and directed state agencies to report to the legislature in 2003 with recommendations for implementing or modifying incentive-based tools for conservation. The proposed research will use the timber supply model to evaluate the cost of achieving increases in OFS forest by using direct payments to landowners. Incentive programs involving direct payments will more likely be implemented if they cost taxpayers less. Several possible formulations of incentives payment programs that discriminate on the basis of a few site attributes will be designed and simulated in the model.

Certification

It may be possible to achieve some of the objectives of sustainable forestry through market mechanisms. Forest certification is a way to inform consumers about the practices used to produce the wood products they purchase. Evidence about whether price premiums for certified wood exist is inconclusive. If price premiums for certified wood do exist, then certification may provide landowners with incentives to use sustainable forest practices. We plan to simulate certification under a strict interpretation of the Forestry Stewardship Council Pacific Northwest guidelines (one of the more commonly used certification systems) and explore the question of what price premium would be required to induce different levels of participation in certification programs. We will be using certification rules developed by researchers with the Sustainable Forestry Partnership (2002) to predict the potential effects of certification on biodiversity in the Oregon Coast Range. We plan to evaluate outcomes with respect to OFS targets.

CONCLUDING REMARKS

The proposed research compares different approaches to implementing older forest structural management on private land in western Oregon on the basis of cost-effectiveness. Cost-effective conservation achieves conservation objectives with the smallest possible impact on other forest uses and the benefits they provide. Conservation strategies that minimize these impacts will be more acceptable to a society that values both wood and conservation than strategies that are perceived as ineffective and wasteful. The proposed analysis is not intended to develop a specific proposal for implementing a particular sustainable forestry objective. Rather it is intended to inform policymakers as they consider, in general, how to implement a range of sustainable forestry objectives.

ENGLISH EQUIVALENTS

When you know:	**Multiply by:**	**To find:**
Hectares (ha)	2.47	Acres
Centimeters (cm)	0.394	Inches
Meters (m)	3.28	Feet
Cubic meters (m^3)	35.3	Cubic feet

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9. A Sustainable Solution for Riparian Management

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ABSTRACT

Riparian forest management is an important element of sustainable forestry in the Pacific Northwest. Riparian harvest restrictions, such as those prescribed by Washington's Forests and Fish Rules, result in unsustainable economics for owners of many small, family forests and may lead to unintended consequences such as increased land use conversion. In some cases, these harvest restrictions may also preclude the thinning of overstocked stands, which would otherwise enhance riparian habitat for fish. Alternate plans, specifically templates that are easy to implement, were identified in the regulations as a potential solution. An integrated approach is presented that combines forest structure and economic criteria to develop a riparian management template for overstocked stands in western Washington that provides improved riparian function for fish, sustainable economics, and easy implementation. Such an approach could be expanded to address riparian management issues throughout the region.

INTRODUCTION

RIPARIAN MANAGEMENT HAS BECOME A KEY element of sustainable forestry in the Pacific Northwest as a consequence of protecting endangered salmon runs. There is growing recognition by forest and fish biologists of the importance of ecological functions provided by forested riparian areas. This fact is reflected by the current forest practices regulations in both Oregon and Washington, as each of these states has placed significant new restrictions on streamside harvesting in the past decade. In Oregon, the 1994 update to the forest practices regulations requires riparian buffers of up to 100 ft on either side of a fish-bearing stream. In Washington, the Forests and Fish Rules that were made permanent in 2001 require riparian buffers of up to 200 ft on either side of a fish-bearing stream. In both states the retention requirements in these riparian buffers are designed to produce diverse riparian forest structure, known as the desired future condition (DFC), that is similar to natural, mature, conifer-dominated riparian stands.

Current riparian harvest restrictions may result in unintended economic consequences for many family forest owners and can lead to conversion of forest land to other uses. (Photo courtesy of Kevin Zobrist and Bruce Lippke, University of Washington.)

A potential problem with a broad, regulatory approach like this is that the resulting economic impacts and management limitations may in some cases lead to unintended consequences, such as land use conversion, that act as barriers to long-term forest sustainability. In both Washington and Oregon the potential for such cases was anticipated, and the regulations in these states include provisions for landowners to pursue "alternate plans" to avoid undesirable consequences. Washington's rules further allow for templates to be established to facilitate common situations in which an alternate plan approach would be appropriate. In this paper we will demonstrate the importance of alternate plans and show how a template approach to riparian management can help achieve forest sustainability in the Pacific Northwest.

IMPORTANCE OF ALTERNATIVE PLAN TEMPLATES

In Oregon, alternate plans are intended to "identify opportunities and allow incentives for restoring or enhancing riparian management areas or streams" and to provide function while "affording a better

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opportunity to meet other objectives" (Oregon Administrative Rules 629-640-400). Similarly, the Washington rules identify alternate plans as opportunities to "meet riparian functions while requiring less costly regulatory prescriptions" and to "further meet riparian functions" (Revised Code of Washington [RCW] 76.13.110). These provisions suggest a twofold purpose of alternate plans: to provide economic relief to landowners and to provide better riparian function where there is opportunity to do so.

Economic relief by itself is an important reason to establish alternatives to the regulations, especially for smaller family-owned forests. Economic viability of forest management is a key component of long-term sustainable forestry on these ownerships given the pressures of competing, nonforest land uses. There is already concern over the rate at which family-owned forests are being converted to other uses, especially in western Washington (MacLean and Bolsinger 1997, WADNR 1998). This has significant implications for riparian habitat, as family ownerships tend to be located lower in the watersheds close to the urban fringe and often in or near riparian areas.

Recognizing the important role of family-owned forests in meeting salmon recovery goals, one of the stated intentions of Washington state's regulations is to maintain the economic viability of forestry on these ownerships and thus avoid conversion to "less desirable" uses (RCW 77.85.180). However, several studies have found significant and disproportionate economic impacts on smaller ownerships as a result of the riparian harvest restrictions (Perez-Garcia et al. 2001, Oneil 2003, Zobrist 2003, Zobrist and Lippke 2003). Two programs were implemented in Washington to mitigate the economic impacts. The first is a forest excise tax credit, but in many cases the economic losses far exceed the available credit (WADOR 2002). The second is a cost-sharing effort known as the Forestry Riparian Easement Program, but this program has not had adequate funding to compensate for losses on a statewide scale (Zobrist 2003). Without other alternatives, the economic viability of many family ownerships may be left significantly diminished at a time when economic incentives may be needed to offset a widespread trend of conversion.

At the same time, there are cases where the regulations do not enable landowners to effectively address site-specific riparian management issues, and alternatives are needed to better meet riparian functions. A classic example west of the Cascade Range is that of young, overstocked stands. There are a number of plantations that have been established at high densities to maximize early growth with the intention that thinning would be done to reduce density as the stands developed. In the case of the Washington rules, however, such thinnings may no longer be allowed or no longer be economical in riparian areas (Zobrist 2003).

In the absence of thinning in these high-density riparian stands, it is unlikely that the DFC will be achieved in the foreseeable future. Large conifers are a key characteristic of the DFC, as they are an important source of shade, large woody debris, and other biological and habitat functions. The development of large conifers is best achieved at low densities where individual tree growth is maximized. Indeed, studies have shown that natural old-growth stands developed at densities much lower than today's managed forests (Poage and Tappeiner 2002, Tappeiner et al. 1997). If high densities are maintained in these overstocked stands, they may be subject to suppressed growth and instability (Wilson and Oliver 2000). In contrast, studies have shown that thinning in young forests can accelerate the development of desirable old-growth characteristics (Acker et al. 1998, Bailey and Tappeiner 1998, Carey et al. 1999a, Garman et al. 2003, Muir et al. 2002, Tappeiner et al. 1997). This suggests that carefully designed thinning strategies in overstocked stands may better achieve the DFC.

Given the opportunities for greater economic viability and better achievement of the DFC, alternate plans can serve as an important tool for achieving sustainable riparian management. However, the widespread implementation of alternate plans is challenging. In Washington, alternate plans are subject to review by a multiagency, interdisciplinary (ID) team. The whole process can take up to a year before final approval. Given several field visits plus office time required by the ID team, the process is both costly and time-consuming for agencies that are working with limited resources. The process is also difficult for family forest landowners, as they must make a significant investment in time and consulting fees while working with limited access to the scientific resources necessary to develop and defend a successful plan. There have been no objective criteria established for assessing the adequacy of alternate plans in Washington, and given a lack of clear guidance and precedence, the goals for alternate plans are often not clearly addressed. Alternate plans are further limited in Washington by a requirement that their scope not exceed 5 years. A longer term approach is needed to achieve sustainable riparian management.

Fortunately, many of these implementation issues were anticipated. The Washington rules recommend the establishment of templates to help streamline and simplify the process (Washington Administrative Code [WAC] 222-12-0403). Established templates would have specific guidelines for "common situations," such as overstocked stands, in which an alternate plan would be appropriate. With the alternate plan parameters preestablished in the templates, qualifying landowners would not have to develop their own plan from scratch, and an ID team review would not be required, leaving agency resources free to address the less common situations in which more customized plans are needed.

The authors, working in the Rural Technology Initiative Program in Washington state, have developed an integrated approach for developing alternate plan templates that can be used to help achieve sustainable management. We used the example of overstocked stands in western Washington, to show how this approach can be used to develop templates that provide better protection, greater economic viability, and straightforward implementation when accompanied by the assurances needed to make long-term commitments. Although this example has been established with the Washington rules in mind, it demonstrates an approach that could be used to achieve sustainable riparian management throughout the Pacific Northwest.

OVERSTOCKED STAND EXAMPLE FOR WESTERN WASHINGTON

A successful template for addressing overstocked stands in western Washington must include several key elements. It must meet the requirement of the law to "provide protection for public resources at least equal in overall effectiveness" (WAC 222-12-0401). It also must be economically viable, as well as simple and flexible for both agencies and landowners. One of the first challenges will be to establish objective criteria for assessing the level of resource protection provided by a potential template. The Washington rules have established DFC targets as the criteria for assessing resource protection on the west side (Forests and Fish Report 1999). The goal of an alternate plan would thus be to develop stand attributes that fall within a DFC target.

Working within the DFC target paradigm, an assessment procedure has been established for both specifying a DFC target and determining a stand's acceptability relative to that target (Gehringer, in press). An advantage of this procedure is the ability to simultaneously consider multiple stand attributes. Three attributes—quadratic mean diameter, stand density, and average height—work well to discriminate between stand structures that are similar to or unlike the DFC. A DFC sample of data from representative mature, natural riparian stands can be plotted in three-dimensional space relative to those three attributes. A percentage acceptance level must then be chosen to determine how much of the DFC sample will qualify as the target. An acceptance level of 80 to 90 percent should usually be appropriate, since the target data were selected to represent the desired riparian forest conditions, and the acceptance level simply identifies outliers within the target data set, providing additional refinement. If the target data have a high uncertainty or are extremely variable, a lower acceptance level may be more appropriate. Figure 9.1 is an example of a three-dimensional target at a 90-percent acceptance level. The target is thus defined by the most likely 90 percent of the DFC sample observations (grey dots), with the remaining 10 percent rejected as unlikely, outlying values (black Xs). Once an appropriate target has been established, an observed stand whose attributes fall within that region is statistically indistinguishable from the DFC sample.

A way to assess the economic viability of a potential template is also needed. When using Faustmann's ([1849] 1995) approach for valuing the economic performance of forest management, two measures of performance should be considered. Forest value is the total value of a forest as an economic asset, which includes the economic value of both the currently standing timber and the land on which it stands given a target rate of return. Land expectation value (LEV), also called bare land value, is the component of forest value representing only the land. The LEV is the net present value of future forest costs and revenues exclusive of any existing timber. As LEV is most closely related to the long-term economic motivation to maintain the land as forest land rather than converting to other uses, it may be the most relevant single measure for assessing the economic viability of potential templates.

Now we have two objective criteria for assessing alternate plan templates: a multidimensional DFC target to assess riparian function and the LEV per hectare to assess economic viability. The next step is to generate a series of alternatives and simulate them on a representative stand. A good basis for these alternatives are the biodiversity pathways that were developed by the Washington Landscape

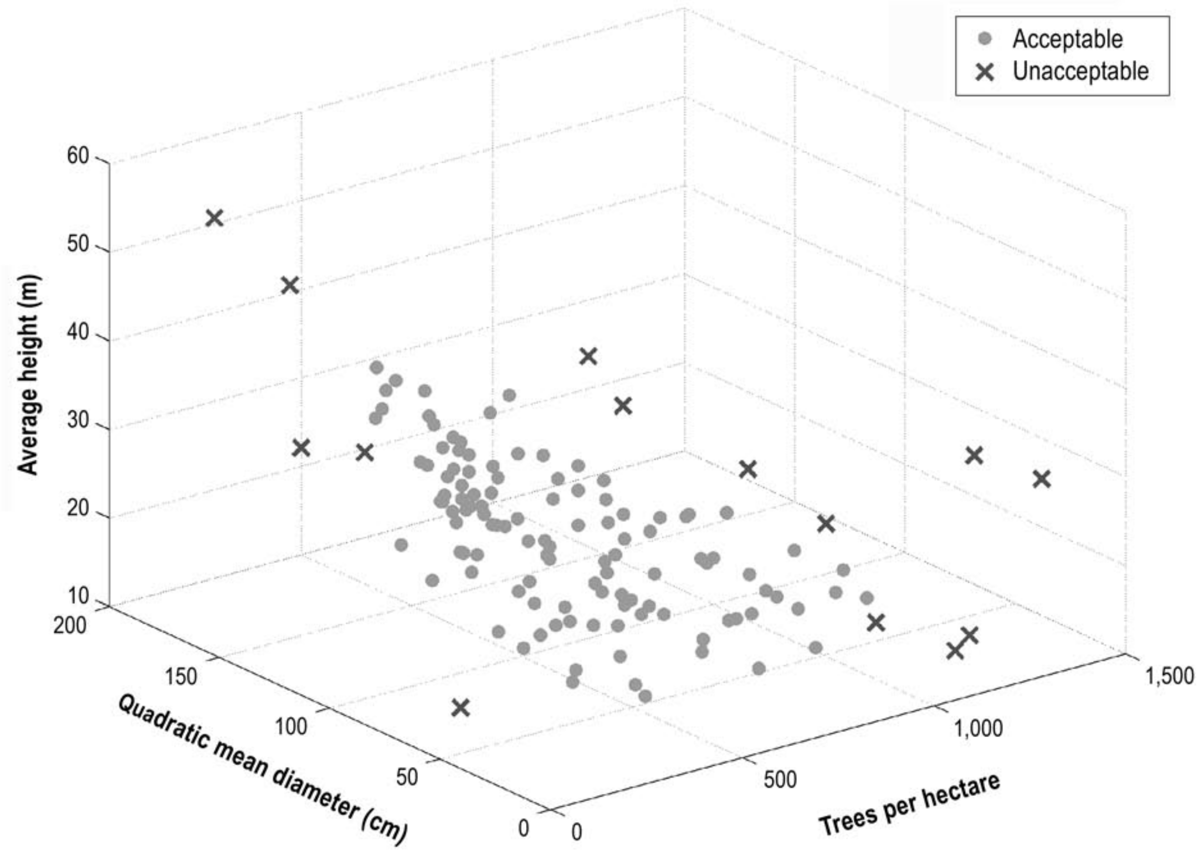

Figure 9.1—A three-dimensional desired future condition target using stand density, quadratic mean diameter, and average height at a 90-percent acceptance level.

Management Project (Carey et al. 1999b, Lippke et al. 1996). The biodiversity pathways used successive thinnings from below to accelerate the development of old-growth structure while providing a viable economic return.

Templates will need to be site specific regarding productivity to account for differing stand development trajectories. Our example template will be for Douglas-fir site class II, where dominant trees would be expected to be 115 to 135 ft tall at age 50 (King 1966). Based on the biodiversity pathway approach, we established a 100-year Douglas-fir rotation for site class II. This rotation included an early commercial thin from below to 180 trees per acre (445 per hectare) at age 20, followed by a thin from below to 60 trees per acre (148 per hectare) at age 50 and again to 25 trees per acre (62 per hectare) at age 70. A regeneration harvest would be done at age 100. The timing of each entry was intended to coordinate with upland harvesting, which we assumed for site class II would be done on a 50-year rotation with an early commercial thin around age 20. Coordination with upland harvest is necessary to keep entries into narrow riparian zones economical.

Using this 100-year rotation, we created 18 example alternatives (table 9.1) that could be used for an overstocked stand template for site class II. These alternatives included variations of the 100-year rotation, such as doing no further entries after the second commercial thin ("60-hold") or no further entries after the third commercial thin ("25-hold"). Three total buffer widths were used: 50 ft (15 m), 80 ft (24 m), and 113 ft (34 m). These widths represent riparian zone boundaries for site class II under the regulations for western Washington. Each of the 18 alternatives sets aside the first 25 ft (8 m) of the buffer as a bank stability zone for shade and streambank integrity. Prescriptions for this zone were either 60-hold, 25-hold, or no action.

All 18 alternatives were evaluated based on the DFC and LEV criteria. Figure 9.2 shows how each alternative performs relative to both criteria. For reference, the performance of no action within 170 ft (52 m) of the stream

Table 9.1—Description of 18 example alternatives for an overstocked stand template

Alternative	Bank stability zone prescription	Remaining buffer prescription	Total buffer width
1	No harvest	25-hold	113 ft (34 m)
2	No harvest	100-year	113 ft (34 m)
3	No harvest	25-hold	80 ft (24 m)
4	No harvest	100-year	80 ft (24 m)
5	No harvest	25-hold	50 ft (15 m)
6	No harvest	100-year	50 ft (15 m)
7	60-hold	25-hold	113 ft (34 m)
8	60-hold	100-year	113 ft (34 m)
9	60-hold	25-hold	80 ft (24 m)
10	60-hold	100-year	80 ft (24 m)
11	60-hold	25-hold	50 ft (15 m)
12	60-hold	100-year	50 ft (15 m)
13	25-hold	25-hold	113 ft (34 m)
14	25-hold	100-year	113 ft (34 m)
15	25-hold	25-hold	80 ft (24 m)
16	25-hold	100-year	80 ft (24 m)
17	25-hold	25-hold	50 ft (15 m)
18	25-hold	100-year	50 ft (15 m)

and "Option 2" under Washington's Forests and Fish Rules were included in figure 9.2. The hollow bars show the percentage of time over the next 140 years that the resulting stand structure under each alternative would fall within the multidimensional DFC target when using quadratic mean diameter, stand density, and average height as the target variables and a 90-percent acceptance level. The dashed line represents the performance threshold established by the regulations, in this case Option 2 under the Forests and Fish Rules. Alternatives that meet or exceed this line provide DFC structure over time at least as much as the regulations. The solid bars show LEV per hectare at a 5-percent real rate of return. To be considered economically viable, LEV must be positive at this target rate of return, with higher LEV implying greater viability. The LEV was assessed across the portion of the stand within 170 ft (52 m) of the stream, which represents the total riparian zone for site class II as defined by the Washington rules.

No action performs the worst relative to both criteria. Of the 18 example template alternatives, there is a wide range of performance, with some meeting neither of the

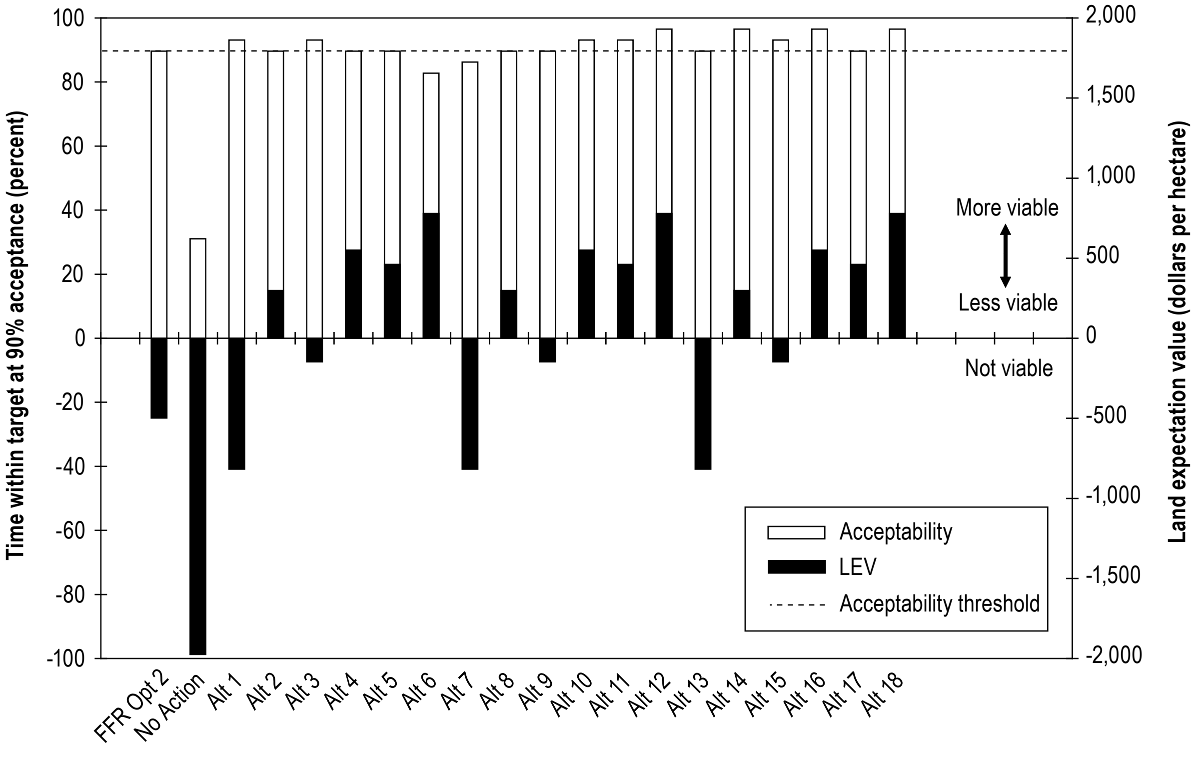

Figure 9.2—Acceptability over time relative to the desired future condition target at 90-percent acceptance level and land expectation value (LEV) per hectare.

criteria thresholds, some meeting one but not the other, and others that meet both. Those that meet both thresholds (11 of our example alternatives) would be considered viable alternatives. Each of these 11 alternatives exceeds the regulations in providing both the desired future conditions and economic viability. This set may be further simplified to a couple of specific options.

The best performing alternatives appear to be alternatives 10, 12, 16, and 18. However, it may be useful to set some additional parameters to help identify the most desirable options. Large woody debris recruitment is perhaps the most important single function parameter. The volume of potentially available functional large woody debris (PAFLWD) over time can be predicted by using a large woody debris model (Cross 2002).[2] Functional large woody debris is defined by minimum size criteria based on the size of the stream. Figure 9.3 shows the volume of PAFLWD for a small stream over time for each of the 11 viable alternatives.

Alternative 10 provides the highest volume of PAFLWD over time of the four top-performing alternatives. However, also consider alternative 11, which provides the highest level of PAFLWD over time of all 11 viable alternatives. Even though alternative 11 did not rank as high as some other alternatives in terms of economic performance and the DFC target, it still met the minimum thresholds, and because of its PAFLWD performance it may be a desirable second option.

Given the additional parameter of PAFLWD, alternatives 10 and 11 emerge as desirable alternatives. This leaves two template options, each with a tradeoff. Option A, based on alternative 10, requires a wider total buffer width of 80 ft (24 m) but allows a regeneration harvest outside of the bank stability zone at the end of the 100-year rotation. Option B, based on alternative 11, requires a narrower total buffer width of 50 ft (15 m), but calls for the 25-hold prescription outside of the bank stability zone. Both options call for the 60-hold prescription within the bank stability zone.

Because it is important to include management flexibility, the thinning age targets could be expanded to allow a

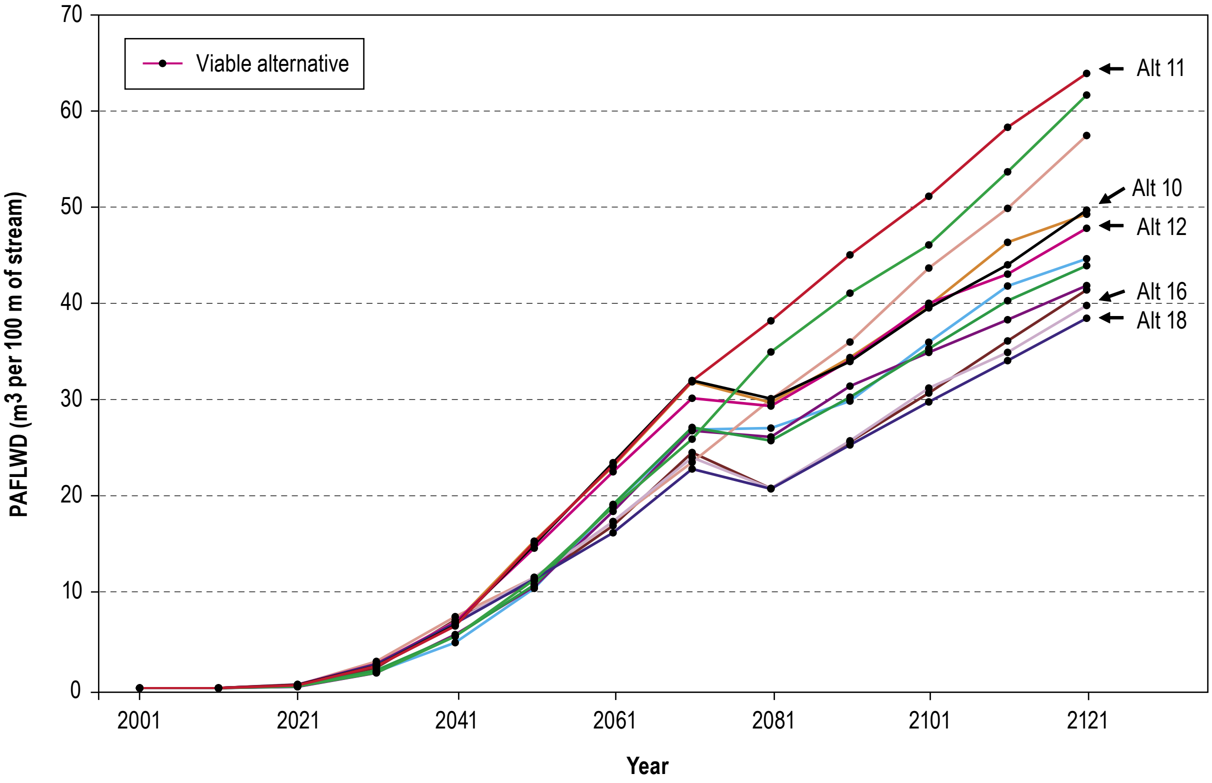

Figure 9.3—Volume of potentially available functional large woody debris (PAFLWD) over time for viable alternatives.

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[2] See also Gehringer, K.R. [N.d.]. Estimating expected values for potentially available large woody debris. Manuscript in preparation.

10-year window and thus provide some timing flexibility. A 20-percent confidence band on either side of the thinning density targets would allow further operational flexibility. The resulting template for successive entries is shown in figure 9.4. The shaded region suggests the age and density range of overstocked stands that could benefit from the template based on an estimation of imminent competition mortality (Drew and Flewelling 1979).

The final product is an easy-to-follow set of management guidelines for achieving economic viability while enhancing riparian function for fish and allowing for flexibility and straightforward implementation. Landowners can select an appropriate template by site class, each of which would include a diagram similar to figure 9.4 with a corresponding explanation of the management options available for qualifying stands. The management guidelines should include strategies for minimizing things like sedimentation and soil compaction during thinning, such that long-term benefits to streams and fish are achieved with minimal short-term costs.

CONCLUSIONS

A significant problem with the current regulatory approach is unsustainable economics for small family-owned forests that adds increasing vulnerability to land use conversion and thus acts counter to the goal of sustainable forestry in the Pacific Northwest. At the same time, there are missed opportunities for better protection of aquatic resources, such as in the case of overstocked stands. Alternate plan templates may provide a sustainable solution. The example above demonstrates how, working within the framework of the rules, an integrated approach can be used to develop successful templates that provide better protection, sustainable economics, and easy implementation. The approach is long term in nature, and thus long-term assurances will be needed to motivate intermediate treatments. Such an approach is not limited to overstocked stands in western Washington, but could be employed to address riparian management issues throughout the region.

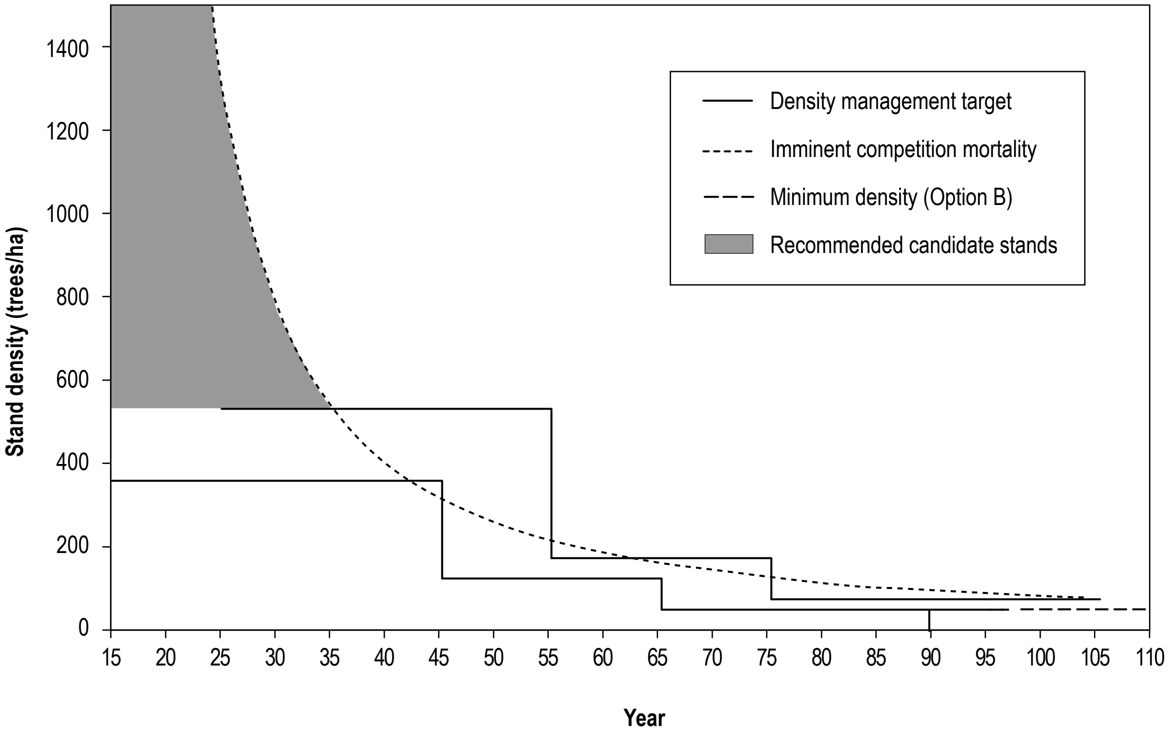

Figure 9.4—Density management guidelines for a site II overstocked-stand template.

METRIC EQUIVALENTS

When you know:	Multiply by:	To find:
Feet (ft)	0.3048	Meters
Inches (in)	2.54	Centimeters
Acres (ac)	.405	Hectares

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10. WOOD-PLASTIC COMPOSITE EXTRUSION TECHNOLOGY FOR SUSTAINABLE ECONOMIC DEVELOPMENT OF LOCAL COMMUNITIES

Vikram Yadama[1] *and Steve Shook*[2]

ABSTRACT

High volumes of small-diameter trees could potentially be available for use from national forest fire-hazard thinnings. Mean lumber recovery from these logs, however, has been reported to be very low. Extruded wood-plastic composites, for such end uses as decking, molding, siding, and other pertinent structural and nonstructural components, is an emerging technology and process where low-quality, small-diameter timber could be used to manufacture value-added products. However, to successfully penetrate the markets and replace traditionally used materials, it is critical to study and understand the markets and distribution channels of the existing products. The objectives of the following study are to compile and provide information necessary in developing business plans for starting a new wood-plastic composite industry or adding a wood-plastic composite manufacturing line to an existing operation.

INTRODUCTION

UNEMPLOYMENT HAS BEEN RELATIVELY higher than the national average in many local communities in Washington and its neighboring states. These communities are looking for innovative ways to revitalize the local industry and promote economic growth. Large volumes of small-diameter trees could potentially be available from national forest fire-hazard thinnings. There is an opportunity to create forest-related jobs in the Pacific Northwest region through promoting a more environmentally conscious forest products industry that would use small-diameter timber, wood residues from other forest products industries, and wood waste created from other applications.

Previous studies on lumber recovery by grade on a variety of tree species indicate a large variation in mean lumber recovery and very low yields of higher grades or dimension lumber for structural use (LeVan-Green and Livingston 2001, Lowell and Green 2001). The authors conclude that with new technology and emerging processes it is possible to direct this resource to a more appropriate end use. Extruded wood-plastic for decking, molding, siding, and other pertinent structural components, is one such new technology and emerging process where low-market-quality, small-diameter timber could be used to manufacture value-added products. To successfully transfer the wood-plastic composites (WPC) technology to the local communities and have profitable industries, it is necessary to develop a sound business plan and marketing strategies. The following paper provides a brief background on wood-plastic composites and discusses an ongoing project that is aimed at providing information to develop essential elements of a business plan to start a WPC industry.

RAW MATERIALS, PROCESSING, AND PERFORMANCE OF WOOD-PLASTIC COMPOSITES

The primary components of a wood-plastic composite are wood and thermoplastic resins. Wood is commonly used in a particulate form, such as wood flour, in manufacturing WPCs. An extruded WPC is composed of 50 to 70 percent wood flour by weight. Presently, maple (*Acer* spp.), oak (*Quercus* spp.), and pine (*Pinus* spp.) are the most common wood flours used in WPC extrusion. Particle size distributions of the wood flours are generally from 10 to 120 mesh. High moisture in wood can be problematic in the manufacturing process, so wood flour is generally dried to 1- or 2-percent moisture content prior to manufacturing WPCs. Thermoplastics are plastics that can be repeatedly melted upon reheating. Polyethylene (PE), polypropylene (PP), and polyvinyl chloride (PVC) are the most commonly used thermoplastics for WPC manufacturing (Clemons 2002, Optimat Ltd. and MERL Ltd. 2003, Wolcott and Englund 1999). These plastics are available in virgin or recycled forms and are preferred because they can be processed below

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200 °C, the upper temperature at which wood degrades. Besides wood and thermoplastic resins, many other additives are also used in WPC manufacturing to affect processing and performance (Clemons 2002, Optimat Ltd. and MERL Ltd. 2003, Wolcott and Englund 1999).

Wood-plastic composites are commonly manufactured by using a profile extrusion, injection molding, or compression molding processes (Clemons 2002, England and Rutherford 1999, Mapleston 2001, Optimat Ltd. and MERL Ltd. 2003, Wolcott and Englund 1999). Profile extrusion, the most common WPC manufacturing process, will be briefly discussed in this paper. It is a two-step process that involves compounding of the raw materials and then extruding the blended material through a die to achieve desired product profile. During the compounding process, the filler (wood flour) and the additives are fed and dispersed in the molten polymer to produce a homogeneous blend. This can be achieved by using a batch or a continuous process. Moisture is removed from the blend by vacuum venting during the compounding stage. The compounded material can either be immediately formed into an end product or made into pellets for processing at a later stage. A wood-plastic composite manufacturer can buy the wood composite pellets for extrusion to avoid blending their own material.

Performance of WPC depends on the inherent properties of individual components of the formulation, the type of additives, the interactions between the individual components, the processing parameters, and the end use environment. Generally speaking, however, as the percentage of wood filler is increased, there is an increase in the stiffness of the thermoplastic composite. Owing to higher percentages of plastic, WPCs absorb less moisture and the rate of absorption is much slower than that of solid wood. On the other hand, the wood filler in WPCs makes them more thermally stable. These attributes make WPCs more dimensionally stable and resistant to fungal decay.

WOOD-PLASTIC COMPOSITE MARKETS

The WPC market segment has been growing at an average of 25 percent a year since 1998 (Morton et al. 2003). The total North American and European market for natural fiber and wood-plastic composites reached 685 000 tonnes (valued at $775 million in 2002), of which WPCs accounted for 590 000 tonnes or 87 percent of the total (valued at $695 million in 2002). Demand for natural fiber and WPCs is projected to increase 290 percent by 2010 with an average annual growth rate of 14 percent over 8 years (Morton et al. 2003). Demand for natural fiber and WPCs for several end use applications has been growing significantly (fig. 10.1).

Currently, one of the primary uses for WPCs is for residential decking, which is approximately a $3 billion to $3.5 billion annual market in the United States (Smith 2001). This market share (currently about 5 percent or 4.7 billion board feet) is expected to grow at least by 15 percent within a decade (Donnell 2000, Freedonia Group 2002). Other WPC markets include a variety of interior and exterior building applications, such as molding and door and window components. Based on 2000 projections, a 50-percent growth has been predicted by year 2005 for wood plastic composites in building products. The phasing out of chromated copper arsenate (CCA)-treated wood is expected to increase demand for WPCs for residential decks, playground equipment, and fencing (Clemons 2002). Currently, most of the WPC material is used for decking, and the market is dominated by large manufacturers (Smith 2001). More marketing research is needed to understand the acceptability of WPCs and challenges they face when

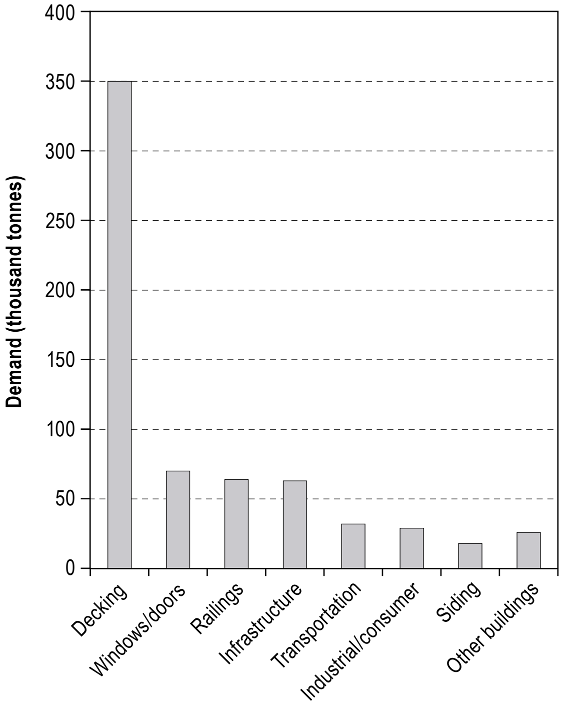

Figure 10.1—Demand for natural fiber and wood-plastic composites by end use in 2002 (revised from Morton et al. 2003).

used as a substitute for various nonstructural and structural products. These studies have to go hand in hand with development of new WPC formulations driven by the end use of a product.

PROPOSED STUDY

Wood fiber for WPC manufacturing can be milled from a variety of raw materials, such as underused species, forest debris, agriculture fibers, and waste wood. Thus, WPCs have a marketing advantage because the wood raw material could be relatively inexpensive and is environmentally friendly. Some of the advantages of manufacturing wood-plastic composites are low capital investment, the flexibility to produce various products with few adjustments, use of low-quality timber, the ability to use waste from other secondary wood product industries, and a relatively low labor requirement. Owing to these factors, the wood fiber plastic industry is ideally suited for small forest-based rural communities. However, to entice investors into such technology and process and have a successful start-up company, it is necessary to have access to the current knowledge regarding this technology, identify distribution channels for the end products, and develop feasible business plans. The objectives of this ongoing project to transfer wood-plastic composite extrusion technology to local communities for their economic development are to:

1. Facilitate the development of business plans to stimulate the creation of a wood-plastic composites industry in the Pacific Northwest.
2. Identify appropriate distribution channels to market end products.
3. Conduct workshops to disseminate information to people involved with economic development.

APPROACH

Development of a Business Plan

All businesses need a business plan to succeed. It provides a means to evaluate all aspects of the business and maps out a plan for success. Without a business plan, lenders and investors have no means of evaluating the risks and potentials of the business. However, it is a difficult and burdensome process to research and combine all the necessary information into a working business plan. We intend to gather all the necessary information and create a database that can assist in analyzing business scenarios with respect to establishing a small wood-plastic composite manufacturing facility or adding a wood-plastic product line to existing manufacturing facilities. Typically, a business plan includes a statement of purpose, the organizational plan, the marketing plan, financial documents, and supporting documents. To help develop these components of a business plan, the database will address the following issues:

- Types of end products, including identifying potential domestic and global markets
- Raw material requirements
- Equipment needs
- Drying capacity needs
- Capital investment
- Utility requirements and cost
- Preprocessing of materials (if needed)
- Technical information including species effect, plastic types, formulations, manufacturing parameters, and performance criteria and properties
- Environmental regulations and permitting

Compiling this information would assist with the development of products from raw materials to finished items. The USDA Forest Service Pacific Northwest (PNW) Research Station and the Forest Products Laboratory (FPL) will assist in developing the format and structure for the business plan.

Distribution Channels

Once the potential domestic and global markets are identified, the second objective will be to develop sales and marketing strategies and a sales plan for entering the identified markets. To successfully do this, the following research questions should be addressed:

- What are the markets for existing products similar to the wood-plastic products?
- Where do buyers of wood-plastic products prefer to shop (wholesale and retail)?
- What are the currently available channels of distribution?
- Who are the potential distributors within the Pacific Northwest market?
- What are current means of promoting wood-plastic products?
- What are the ways a company can support the distributor's distribution channel and sales program?
- How are wood-plastic products handled, inventoried, and transported within the distribution channel?

- What level of inventory of wood-plastic products is necessary within the distribution channel, and is there a seasonality effect with regard to inventory and product sales?
- What nontraditional distribution channels exist that could potentially be used to market and sell the wood-plastic products (e-commerce, trade shows, etc.)?

Answers to these questions will aid in reaching the customers for the end products and retaining these target markets. Market and customer studies, specifically targeting products such as public playground equipment and roof shingles, will be carried out to answer some of the above questions. Past marketing studies on other products, such as decking, will be tapped into to compile much of this information in the database. The results of studies could provide an understanding of the cultures within those markets and the general perception of the distributors and buyers concerning building components manufactured from wood plastic composites. We hope to answer questions regarding the buying habits of the market, preferences of buyers, distributor and buyer perceptions, product acceptance, and channels of distribution. Studies will be limited to the Western United States and more specifically to the Pacific Northwest region. The findings are intended to help a start-up company or an existing company that is interested in diversifying its product line with market identification and development of market strategies.

WORKSHOPS TO DISSEMINATE INFORMATION

After compiling the information, it is necessary to disseminate the information to people who would be influential in persuading small businesses in communities in the region to invest in WCP manufacturing. These individuals may include:

- Community economic development foundations
- Economic development consultants
- Financial institutions
- Venture capital firms and angel investors
- Local and regional politicians
- Current industrialists, such as sawmill owners and furniture manufacturers
- State-level natural resources organizations (Washington Department of Natural Resources, Oregon Department of Forestry, Idaho Department of Lands)
- Trade commissions (for global marketing)
- Architects and builders (to influence the use of products in home construction)

Two 1-day workshops will be organized to present the results of this study. USDA Forest Service PNW Research Station and FPL will assist in developing workshop format and organization.

CONCLUSION

Currently, more than 60 companies are producing natural fiber and wood-plastic composite products in North America (Morton et al. 2003). However, 70 percent of the total industry sales have been accounted for by the top 10 producers. Growth of wood-plastic composites for building products is expected to be quite high through 2010. A start-up company would be successful if it can demonstrate that a product that has already been accepted by customers can be made better with wood-plastic composites. The intent of the proposed study is to compile and provide information necessary in developing business plans for starting a new WPC industry or adding a WCP manufacturing line to an existing operation.

EQUIVALENTS

When you know:	Multiply by:	To find:
Degrees Celsius (°C)	1.8 °C + 32	Degrees Fahrenheit
Board feet (lumber)	0.0024	Cubic meters (lumber)
Tonnes	1.102	Tons

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