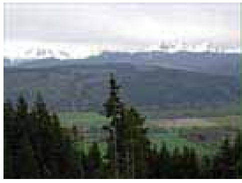

The Future of Washington's Forests and Forestry Industries

UNIVERSITY OF WASHINGTON
College of Forest Resources

THE FUTURE OF WASHINGTON'S FORESTS AND FORESTRY INDUSTRIES

Second Progress Report: July 2006

Prepared for the Washington Department of Natural Resources
By the College of Forest Resources, University of Washington

Executive Summary

Introduction

A study on the Future of Washington Forests and Forestry Industries was requested by the 2005 State Legislature. Each study area will examine the impact of different management influences and alternatives, providing a rich array of information from which the Washington Department of Natural Resources (DNR) and the University of Washington, College of Forest Resources (CFR) will collaboratively develop policy recommendations for the Legislature. The following progress report is intended to provide preliminary information that will be used in later stages of this project but may have value now for identifying issues that will be important for policy consideration.

Study areas:

<u>Timber Supply and Forest Structure Study 1:</u> *An examination of regional economic and ecological impacts across landowner types is being developed to consider sustainability challenges such as land-use conversion pressures, primarily on the Westside of the Cascades, and forest health issues, primarily effecting the Eastside forests. Contact: Bruce Lippke, 206-543-8684, blippke@u.washington.edu*

<u>Competitive Position Study 2:</u> *An analysis of Washington's competitive position with respect to other domestic and international forest products suppliers will examine the influences of changing timber harvest levels, costs, growth pressures, productivity trends, regulatory constraints, and taxes, as well as other factors. Contact: John Perez-Garcia, 206-685-2315, perjohm@u.washinton.edu*

<u>Economic Contribution Study 3:</u> *An update of revenue, employment, and tax contributions from the forest sector to the state economy will reflect industrial sensitivities to changing infrastructure and regulatory pressures. Contact: Ivan Eastin, 206-543-1918, eastin@u.washington.edu*

<u>Land Conversion and Cascade Foothills Forestry Viability Study 4:</u> *An assessment of the trends and dynamics contributing to rates of forest land conversion and the impacts of conversion of forest to non-forest land-uses, will be combined with a review of the tools and policy levers intended to retain working forests. The College of Forest Resources and Cascade Land Conservancy will work collaboratively to build consensus recommendations, developed by a work group of forestry stakeholders drawn from Northwest Environmental Forum participants, for preserving forestry as a preferred land-use and viable industry in the Cascade Foothills. Contact: Ara Erickson, 206-543-7418, arake@u.washington.edu*

<u>State Granted Lands Return on Investment Study 5:</u> *An assessment of the expected rate of return from trust-granted forestlands will be combined with a review and critique of methodologies for State forestry investment decisions. Contact: John Perez-Garcia, 206-685-2315, perjohm@u.washinton.edu*

Timber Supply Study

We begin this timber supply analysis by examining past study projections. Our conclusion that prior timber supply studies inadequately anticipated the harvest impacts of changing public policies suggests that development of alternative scenarios to reflect a range of policy changes and other assumption variables is important. This review shows that policy developments can have a significant influence on which management alternatives are adopted by different forest owner groups, with consequences to forest industries and other harvest beneficiaries. Discussion of alternatives follows the review of the past forecasts.

This review of projection errors from prior studies provides background for examining policy impacts, methods, and key assumptions. After an introduction to management treatments we characterize a range of Westside upland management alternatives starting from no management to several levels of intensive commercial management and finally a biodiversity pathway that can contribute to restoring old-forest habitat. We discuss how the different objectives of different owners lead to their likely selection among these different treatments. We then extend these alternatives to the impacts under riparian regulations considering both economic viability and desired future conditions for riparian protection.

Switching to the Eastside we characterize alarming changes in forest health conditions that require much different treatments than the Westside. We first look at changing mortality indicators some of concern also to the Westside, then describe the relationships to fire hazard and finally consider the interaction with Eastside regulatory requirements. We provide supporting appendices (A and B) on the increasing social costs of fires, and how treatments can reduce these costs and may be a sound public investment. With this background on Eastside health issues we describe forest groupings and habitat types noting the much more complex forest structure on the Eastside.

These classifications help to identify preferred management alternatives for specific forest types noting that some treatments will not be economic but may be suitable for public objectives. We analyze the impacts of several typical management strategies for dry pine forests and moist mixed conifer forests on economics, insect and fire risk. We set the stage for how these treatments have been stratified across acres and owners and the fact that recent high private harvests to offset declining federal harvests cannot be sustained.

We then introduce the role of ecosystem services using carbon as the candidate that might be closest to having a market impact, albeit very complex. We provide appendix C for assessing habitat suitability for select species as another example of non-market values. We summarize by noting some of the issues raised and set the stage for stratifying these management alternatives across owners and acres as the next stage of the study in order to develop projections for a range of different assumptions describing possible outcomes.

The timber supply study will provide potential ranges of future harvests, log supplies, and representative ecological measures including selected habitat indices. Projections will be provided for five timbersheds on the Westside and two on the Eastside, highlighting differences across owner groups and location, and further subcategorized as upland and riparian zones. Discussion of forest management changes and their impacts relative to objectives will be developed for past, present, and future conditions. Computer-generated simulations of potential future conditions will provide insight on how ecological and habitat changes are linked to harvest fluctuations and changes in forest practices.

Preliminary analysis to date has been concentrated on understanding changing management plans (forest treatment strategies) by owner type, as influenced by regulatory impacts, forest health issues, market shifts, and other factors in preparation for development of stratified management plans across ownerships by timbershed. A preliminary review of management options at the stand level has been completed. Survey data of industry and other owner groups are being collected to support the next major step in the analysis wherein representative forest plans are allocated across the forest by timbershed for a base case (i.e. current conditions) and for alternative scenarios (i.e. future possibilities). Understanding the changes in the timber supply study in concert with other information on competitiveness and land use should contribute to a better understanding of forest policy effectiveness past and prospective.

Even before we examine the latest data on the management plans for different owners, several issues relating to changing management treatments can be identified. The results of these preliminary simulations illustrate some of the economic and environmental issues, outcomes, and trade-offs associated with different management treatments. Understanding what treatments are expected to be applied to what portion of the landscape and the resulting mix of outputs is a key part of the timber supply analysis. It will also be important to identify where trade-offs can be minimized and what incentives could be used to change output mixes if desired. The decision process of deciding how much habitat or environmental protection is enough, who should provide it and who should pay is a policy debate, not a supply assessment.

1. Impact of Shorter Rotations:

Commercial management is trending toward shorter rotations with less thinning. The driving factors are several. Better understanding of the growth performance of young stands makes it possible to reach economic targets more quickly. Mill technology improvements increase smaller log values (Briggs and Mason 2006). However, general weakness in pulp and paper markets has contributed to lower values for the portion of commercial thinning yields that are not suitable for small log lumber processing.

These ongoing changes will shift the mix in forest structure on commercially managed lands with environmental impacts on habitat. While the shorter rotations may suggest increased acres in the more open conditions associated with regeneration, the more rapid young growth will also more quickly lead to canopy closure and a loss of understory complexity. If the number of acres thinned also declines, the commercially managed acres will favor only two stand structure classes, open regeneration and canopy closed stem exclusion structures, the later supporting the least habitat and diversity (Oliver et al. 1994). Will the change in stand structure significantly reduce/impair habitat availability? Might incentives for thinning be an alternative given the relatively small economic loss associated with commercial thinning?

2. Biodiversity Pathway Support for Older Forest Habitat:

If the environmental objectives are largely focused on old-forest complexity, biodiversity pathways could produce such structures, but the incentive needed has increased considerably with the decline in premiums for larger and higher quality logs. Some of this decline in premium is directly related to the decline in availability of large logs and the shutdown of large log processing facilities and it could be argued would return if owners were motivated to produce viable volumes of large logs for processing. However, the increase in engineered wood and small log processing technologies represents a more permanent shift away from the premium value for large logs. Some of the decline is related to reductions in log exports. Should more long rotations, i.e. acres devoted to old-forest complex structures, be developed? Who should provide them? Who pays? How does one motivate maintaining the infrastructure to handle the logs? DNR's Sustainable Harvest Plan moves toward providing a moving mosaic with some longer rotations. Will this program be effective and what are the implications if not?

3. Reliance on No-Action Alternatives:

While Federal management has shifted toward an emphasis on environmental protection, the operating paradigm has defaulted to the no management alternative. Forests old enough to have acquired some diversity through disturbance events and mortality provide most of the remaining old forest habitat. Overly dense stands resulting from prior commercial management and regeneration and fire suppression will remain unlikely to produce old forest habitats in the near-term unless some natural disturbance events such as fires or windstorms produce more structural heterogeneity. Open stands have nearly disappeared on Federal Forests with the absence of removals and fire suppression, producing a loss of habitat for some species. While the preservation of some older stands provides most of the old forest habitat available across all owners, there is no active Federal program to accelerate the restoration of old forest structures and the reliance on no-management comes with consequences. While there may be a diversity of structure classes across all owners, the diversity within each owner class is limited and appears to be declining. Should management practices to meet habitat and environmental objectives rely on no-action or look at a broader range of alternatives? Who makes the decision?

4. Regulatory Effectiveness

The regulations affecting stream buffers may be contributing to unintended consequences such as land conversions and overly dense stands. In the west, the overly dense buffers are not effective at reaching the Desired Future Condition of old-forest like structures and for many small owners are not economically viable. In the east, the overly dense buffers increase the hazard of fire and insect damage. While alternative plans and templates were envisioned as an alternative for adaptive management on private forestlands, they are not being effectively implemented, at least for small owners. Is there a need for effectiveness assessments or changes to the regulations or implementation process? Can regulatory objectives be met more efficiently?

5. Forest Health

There is an alarming increase in mortality from insects as well as great concern over the increase in fires and the high fire hazard levels for inland forests. The Forest Health Working Group Report (DNR 2004) provided recommendations and the committee has been re-convened to assist in communicating the issues to communities. Should more be done sooner? The Federal Forests are a large contributor to the problem. Can more cooperation accelerate a federal response?

Studies have shown that the values of avoiding the costs of fires and insect damage are much larger than the cost of treatments but these values have yet to be used in quantifying decision alternatives. How can these values be used in an institutional framework to support public investments?

6. Ecosystem Services

Forests provide much more than products for markets, jobs and habitat as they provide a broad range of other protections including clean air and water. For example, there is recognition that sequestration of carbon in forest biomass may help to reduce heightened levels of atmospheric carbon. Carbon is one of the first ecosystem services that may become internalized in the market on a large scale as efforts are increased to reduce emissions resulting from combustion of fossil fuels. Carbon trading systems and carbon registries are being created, however, until the markets and registries achieve common agreement on performance metrics and values these systems will remain relatively ineffective. How might quantification and valuation of ecosystem services better contribute to the future of forestry?

Declines in habitats and diversity may be a concern for many owners and engaged publics. Industrial forestlands are becoming increasingly homogenous as a result of shorter rotations; non-industrial lands are under pressures from land-use conversion and buffer regulations that are complicated by intergenerational ownership transfer; Federal forests have relied on no-management with continued fire suppression and, as a result, have less diversity with a heightened threat to old forests; the DNR plans increases in targeted habitats but at some cost to beneficiaries; and Tribes are challenged by issues associated with legacies of past management such as lack of heterogeneity and overly-dense forests. Who should provide habitat and other ecosystem services to whom and at what cost?

Next Steps in the Timber Supply and Forest Structure Study:
The materials covered in this preliminary progress report represent first steps toward quantifying management stratification of treatments by owner type across timbersheds. A base case will be produced consistent with initial conditions and business-as-usual policies. Alternative scenarios and an assessment of the resulting differences across alternatives are expected to sharpen the focus on problems and opportunities affecting the future. Inventory data are being collected for all owners. GIS assessments are being prepared for owner type acreages, stream buffers, upland areas, and other spatial attributes of interest. Management intentions surveys are being circulated across owner groups. Once treatment plans are stratified for timbersheds and owner types there will be an analysis of forest treatments, habitats, jobs, economic activity and tax revenues as well as multiple ecosystem services that flow from treatments and resulting stand structures.

Competitive Position Study

This study is also in early stages and only preliminary information can be provided.

Despite strong growth in the U.S. housing sector, weak international markets have moderated demand for Washington forest product exports. We have collected and begun our analysis of historical global trends in forest products markets. These trends will serve as a background in our assessment of Washington's competitive position. In addition to the broad global trends we have preliminary projections over the next decade of major wood product markets. We will finalize the projections in the coming months. We will use these projections to place Washington's competitive position within the regional, national and world wood market. We have also begun to analyze Washington's forest sector cost structure, including taxes, labor, wood and other important costs.

Among the initial observations suggested by the data are the following:

Sawmills are the dominant timber user of harvests within Washington. The export of logs has declined and correlates with the timber harvest level decline. The implication is that Washington timber producers' share of international log markets has declined. We will continue to explore this effect on international competitiveness and how it may have impacted primary and value added products.

One major trend is the step increase in the North American share of softwood production while the Asian share, principally due to the collapse of the former Soviet Union, fell sharply.

North America's share of global production of hardwood sawlogs and veneer logs has grown from less than 20 percent during the 1980's to nearly 30 percent in 2003. Washington's role in this growth will be explored. Washington's competitive position based on available hardwood resources will also be examined further.

Data suggest that North America's hardwood lumber production share has gained a nearly equal share to Asian producers of hardwood lumber, and has outpaced Latin American producers over the past two decades. We will explore the drivers behind this growth. One possible explanation is a shift from tropical to temperate hardwood use by consumers. Trends suggest market opportunities for hardwood lumber in Europe from North America. We will continue to explore this trend and its competitiveness implications in more detail for Washington hardwood lumber producers.

The newsprint component of the paper and paperboard grouping has declined drastically. We are developing these data to better understand the competitiveness of Washington's pulp and paper sector with these declining trends.

Some policy questions are suggested:

1. What are the opportunities to increase competition by Washington producers?
2. What are the risks the Washington forest sector faces (timber, sawmill, paper, etc.)
3. What policies act as disincentives for Washington producers?
4. What needs to be done to improve opportunities for processors or niche marketers in the State?

Economic Contribution Study

This study is at an early stage, and only preliminary observations can be provided.

The forestry and wood products manufacturing sectors represent important components of the economy of Washington State. In 2004, these sectors generated approximately 45,000 jobs (1.7% of total employment) and paid out over $2 billion in wages (1.9% of total wages). Perhaps more important, many of these jobs are located in rural, timber dependent communities where job opportunities are often lacking.

Gross business income in the forestry and wood products sector exceeded $14.5 billion in 2005, accounting for approximately 3% of total GBI in Washington. Growth in gross business income in the forestry and wood products sector actually exceed GBI growth for the economy as a whole, increasing by 27.4% compared to 21.1% for the economy as a whole.

Labor productivity increases for the forestry and wood products sector have been real and sustained over the period 2001-2005, suggesting that there has been substantial investment in technology and worker training.

The study will further describe the role of the industry sectors and their economic contribution on a regional basis; changes over time in key drivers; trends and economic impacts, sector by sector; and key factors that constrain investment.

Questions that should arise are:

1. What are the opportunities that could encourage investment into primary and secondary manufacturing?
2. What are the risks faced by the forest sectors?
3. What policies act as disincentives for the sector to grow?

Forest Land Conversion and Cascade Foothills Study

Of the many factors that contribute to forestland conversion, the highest and best value of forestland for development is one of the primary factors prompting non-industrial and industrial landowners to sell-off or convert their holdings. The effects of urbanization, such as an increasing population in need of buildable land, shift the value of forestland away from timber production to development. Factors relevant to the state's non-industrial forestland owners, mostly family forest owners, are those of an aging population of landowners faced with retirement investment needs, concern over high estate taxes, and an inability to absorb the costs of managing land to comply with all environmental regulations. Industrial forestland owners acknowledge fiduciary obligations to stockholders to produce investment returns and concerns related to future regulatory uncertainty as other factors they consider when deciding whether or not to retain their forest holdings.

In the absence of high timber values, private forest landowners in Washington State are motivated to sell their properties for the next highest and best value, which is rapidly becoming the real estate or residential use value. This is of concern because privately-owned timberlands and forestlands provide the public with many market benefits (such as wood products) as well as many non-market benefits (including environmental services such as clean water, air, carbon sequestration, wildlife habitat, forest beauty and aesthetics). If these forests are permanently converted into residential or other non-forested properties, then both the market and non-market benefits are lost. It is thus important to understand whether or not there are economic incentives and other policy tools that can substitute for higher timber values and thereby reduce the rate of conversion. In this study, six potential incentives for maintaining working forestlands are identified: direct payments, regulatory relief, tax relief, a social license to practice forestry, technical assistance, and market innovation and additionality.

Preliminary land use change analysis shows that amount of forest land use in western Washington has decreased from approximately 6.77 million acres in 1988 to 5.47 acres in 2004. Much of this land went either to developed lands or agricultural and mixed lands. The amount of developed land in western Washington increased from an estimated 0.56 million acres to 1.1 million acres between 1988 and 2004. Similar data is being produced for eastern Washington, but is not yet completed.

Among the policy questions that need to be explored are the following:

1. What strategies can be devised for forest landowner incentives to manage forests near urban areas ?
2. Among the potential incentives discussed, which could be enacted most quickly and be most useful?
3. To the extent that forest conversion is inevitable to some degree, can we create workable interfaces between forest use and development?

State Granted Lands Return on Investment Study

This study has not begun, so there are no preliminary findings for this report.

Acknowledgements

This progress report on the Future of Washington Forests and Forestry Industries requested by the 2005 State Legislature serves as a preliminary report identifying important issues that will be further developed in the final report. This report and the ongoing studies involve many participants and several phases of activity. Each study area is developing assessment information relating to the State of Washington's forests and forest industries and future prospects. Each study is being led by a University of Washington College of Forest Resource (CFR) faculty member and supported by a team of university experts and external consultants/advisors. Brian Boyle, consultant to the Dean and leader of the Northwest Environmental Forum, is managing the integration of the report working with Craig Partridge and Bonnie Bunning, of the Washington State Department of Natural Resources (DNR). DNR is contracting agency and is determining how best to develop recommendations for the Legislature based on the findings from the assessments.

Contact Leads are:

Administrative - PI: Robert Edmonds

Project Manager, and CFR Coordinator for Legislative Recommendations: Brian Boyle

Study 1: Timber Supply and Forest Structure - PI: Bruce Lippke

Study 2: Competitive Position - PI: John Perez-Garcia

Study 3: Economic Contribution - PI: Ivan Eastin

Study 4: Land Conversion - PI: Gordon Bradley

Study 5: State Granted Lands ROI -PI: John Perez-Garcia

Each study plan is reaching out to a number of advisors and consultants. Study 1 is benefiting from a Technical Advisory Group (TAG) of over 20 forestry and forest sector experts who are assisting in collecting information about current and prospective forest practices. Timber supply information is being provided by the USFS Forest Inventory Analysis unit (FIA), Tribes, DNR, and USFS. Study 2 and 3 are being assisted by data provided by the Departments of Revenue, Natural Resources, and Employment Security in addition to representatives of industry sectors advising Study 1. Study 4 is being supported by The Cascade Land Conservancy and a separate expert advisory group. Study 5 will depend heavily on DNR internal data and studies done for the Department and will be done in consultation with the University of Washington Department of Economics.

In addition to the many faculty, staff and graduate students listed as report authors, there are others providing critical support for the project. Clara Burnett is the professional staff assistant and along with Angel Ratliff is providing editing and layout. Matthew McLaughlin is providing web and CD production services www.ruraltech.org, www.CINTRAFOR.org, and http://www.dnr.wa.gov
The list of supporting resources for each study area will likely grow as the project nears completion.

A study of this scope is a complex undertaking depending upon many inputs from many individuals and organizations; however, any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of supporting agencies or project cooperators. The intent of the study task reports is not to make recommendations but to develop assessment information that can be used by others in support of policy considerations and recommendations to the Legislature.

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Study 1: Timber Supply and Forest Structure

Bruce Lippke, Larry Mason, Kevin Zobrist, Kevin Ceder, Elaine Oneil, Jim McCarter

Statement of Intent and Connection to Policy Issues

We begin this timber supply analysis by examining past study projections. Our conclusion that prior timber supply studies inadequately anticipated the harvest impacts of changing public policies suggests that development of alternative scenarios to reflect a range of policy changes and other assumption variables is important for policy analysis. As demonstrated by this review of prior study forecasts, policy developments can have significant influence on which management alternatives are adopted by different forest owner groups, with consequences to forest industries and other harvest beneficiaries. Discussion of such alternatives follows the review of the past forecasts.

The timber supply study will update projection information developed in prior studies (prior data for 1990 Westside; 1992 Eastside) and will provide potential ranges of future harvests, log supplies, and representative ecological measures including selected habitat indices. Projections will be provided for five timbersheds on the Westside and two on the Eastside, highlighting differences across owner groups and location. The data will be further subcategorized as upland and riparian zones. This study will provide an analysis of why timber harvest levels have dropped well below prior projections and how this has affected the forest inventory and forest sector performance. Discussion of forest management changes and their impacts relative to objectives will be developed for past, present, and future conditions. Computer-generated simulations of potential future conditions will provide insight on how ecological and habitat changes are linked to harvest fluctuations and changes in forest practices.

Preliminary analysis to date has been concentrated on understanding changing management plans (forest treatment strategies) by owner type, as influenced by regulatory impacts, forest health issues, market shifts, and other factors in preparation for development of stratified management plans across ownerships by timbershed. A preliminary review of management options at the stand level has been completed. Survey data of industry and other owner groups are being collected to support the next major step in the analysis wherein representative forest plans are allocated across the forest by timbershed for a base case (i.e. current conditions) and for alternative scenarios (i.e. future possibilities). Understanding the changes in the timber supply study in concert with other information on competitiveness and land-use should contribute to a better understanding of forest policy effectiveness past and prospective.

Roadmap for This Report

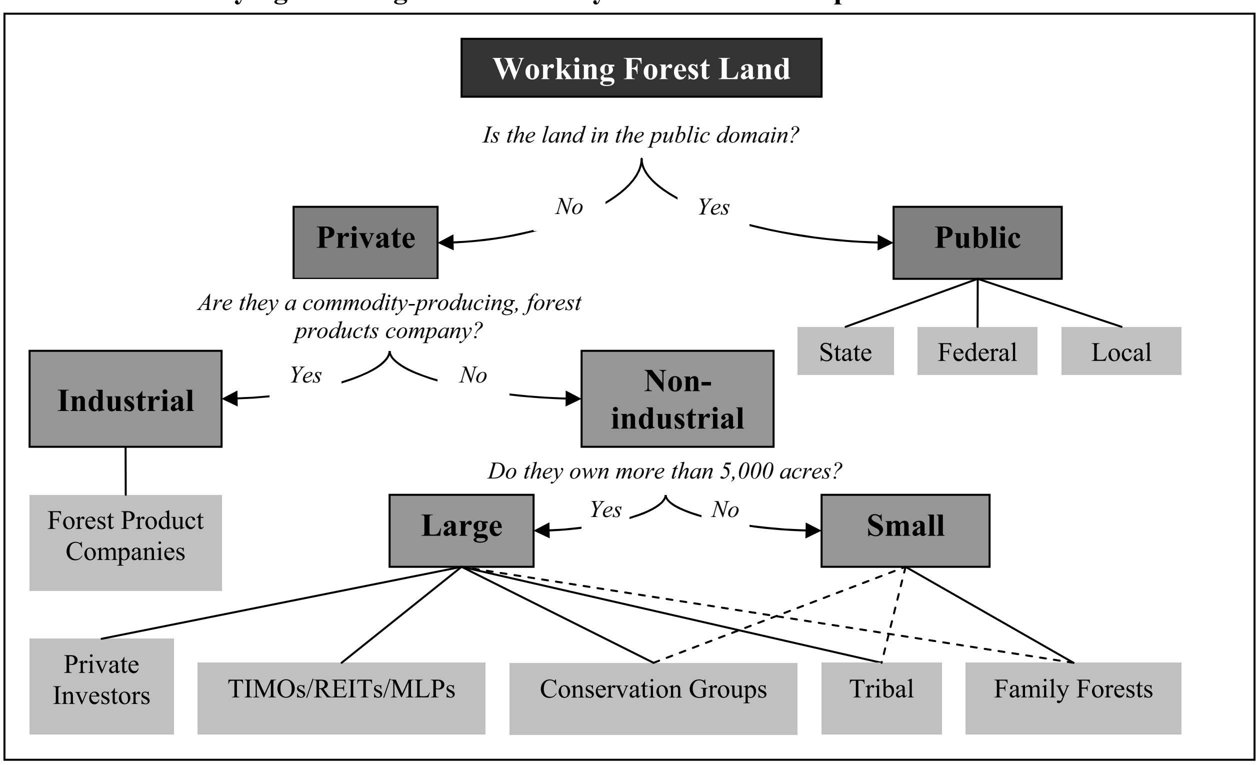
This preliminary report will first review the projection errors from prior studies as a background for the importance of policy impacts, methods, and key assumptions. Second, after an introduction to management treatments we characterize a range of Westside upland management alternatives starting from no management to several levels of intensive commercial management and finally a biodiversity pathway that can contribute to restoring old-forest habitat. We discuss how the different objectives of different owners lead to their likely selection among these different treatments. We then extend these alternatives to the impacts under riparian regulations considering both economic viability and desired future conditions for riparian protection. Switching to the Eastside we characterize alarming changes in forest health conditions that require much different treatments than the Westside. We first look at changing mortality indicators which is of some concern also to the Westside, then describe the relationships to fire hazard and finally consider the interaction with Eastside regulatory requirements. We provide supporting appendices on the increasing social costs of fires, and how treatments can reduce these costs and may be a sound public investment. With this background on Eastside health issues we describe forest groupings and habitat types noting the much more complex forest structure on the Eastside. These classifications help to identify preferred management alternatives for specific forest types noting that some treatments will not be economic but may be suitable for public objectives. We analyze the impacts of several typical management strategies for dry pine forests and moist mixed conifer forests on economics, insect and fire risk. We set the stage for how these treatments have been stratified across acres and owners and the fact that recent high private harvests to offset declining federal harvests cannot be sustained. We then introduce the role of ecosystem services using carbon as the candidate that might be closest to having a market impact. We provide appendix C for assessing habitat suitability for select species as another example of non-market values. We summarize by noting some of the issues raised and set the stage for stratifying these management alternatives across owners and acres as the next stage of the study in order to develop projections for a range of different assumptions describing possible outcomes.

Prior Timber Supply Projection Errors and Issues Raised

Acreage by Owner Issues

Prior timber supply studies have started by describing the acreage devoted to working forests on which the supply projections are based. The schematic below demonstrates the classifications of land owners of interest. The general source used for classifying acres by owner groups is the Forest Inventory Analysis (FIA) survey based on a fixed set of sample plots. Since FIA plot locations are proprietary it is difficult to cross correlate FIA data with other sources hence there always remains some uncertainty in ownership shares. Each landowner class has different management objectives and will be managed differently so it is important to develop as good a database on acreage allocations as possible. Since the FIA data updating procedure has changed to partial sampling of the plots every year instead of a complete sample of plots every ten years, it may become necessary to rely on other sources such as tax parcels and GIS locations to maintain consistency in the sample. Acreages for sub-categories of interest such as the new legal structures owning much of what was formerly industry (TIMOs/REITs/MLPs) are not available from FIA survey data and will ultimately require new survey methods. We are researching how to best stratify the forestland base to ownership categories by timbershed and expect to incorporate changing ownership trends in the final analysis.

Schematic: Classifying Working Forest Land by Landowner Groups



Of Washington State's 43 million acres of land, 21 million are forested (Bolsinger et al 1997), with 18 million classified as timberland (producing at least 20 cubic ft/acre/yr) of which 2 million are restricted by statute, leaving 18 million as unreserved timberlands i.e. potential working forests. Working forests may be further restricted to use such as stream buffers or other habitat sensitive areas and in particular all federal acres are managed for ecological values rather than timber production complicating the context of what is an unreserved forest. Of the 16 million unreserved acres almost 5 million are Federal, 2.5 million State-managed (or local), and 9 million are private.

Westside land is more productive, producing 2 to 4 times more volume per acre with 75% of the landbase in forestland of which 19% is not available as unreserved timberland. The available timberland is made up of 2.2 million Federal, 1.6 million State-managed and 5.6 million private (industry, Tribes, small private). Private lands produce the dominant share of timber products from 47% of the Westside forested landbase.

On the Eastside, 33% of the land is forested of which 28% is not available. Unreserved timberland includes 2.5 million Federal, 0.8 million state managed and 3.3 million private. Private lands are producing an increasing share of the timber products from 37% of the Eastside forested landbase.

Projection Errors and Causes

The initial conditions projections in the 1992 Westside Timber Supply Study suggested that, based upon then-available inventories, Westside annual harvest levels equivalent to the average of the 1980's could be maintained for several decades (Adams et al. 1992). However, the Federal share of timber harvest, based on expectations developed from a 1992 Forest Service environmental impact statement (EIS) for protection of the northern spotted owl (*Strix occidentalis caurina*), was projected to decline from an average of 13% to 8% while state lands were projected to maintain the average harvest level of the prior 25-year period. A sensitivity analysis to potential changes in assumptions produced a range of alternatives generally clustered within 10% of the initial condition projection. The most negative scenario was associated with a 10-year increase in harvest age resulting in a short-term harvest decrease of 17 % but a long-term increase of 7%. As will be noted in our preliminary analysis, the current practices on industrial forests appear to be shifting more to shorter rather than longer rotations. Shorter rotations were not considered within the sensitivity scenarios developed by the 1992 study.

Table 1: Westside Harvest History, 15 year Prediction & Variance

Westside mmbfs	Pre-90's 86-89	Predicted 05 +/-	Change Predicted	Last 4 yrs Act. 98-02	Actual Change	Error in Predicted
Industry	2481	2571		1447		
NIPF	1292	1089		1044		
Tribal	62	0		27		
Tot Priv	3836	3661	-5%	2518	-34%	-31%
S&L trusts	826	848	3%	487	-41%	-43%
Fed	906	238	-74%	31	-97%	-87%
All Owners	5567	4746	-15%	3036	-45%	-36%

Table 1 provides a summary of actual Westside harvests by owner group with comparisons to the earlier projections. Predicted results are the product of simulated projections developed with analytical methodologies and based upon a stated set of assumptions. Errors in prior study assumptions and projection methodologies will be important considerations as the current study proceeds. Table 1 shows that using the '86-90 harvest levels as a base period for the prior timber supply report, total Westside harvest levels in the last several years were 36% below projections and 45% below the base period harvest. This is a very substantial decline, not foreseen by the prior study, and needs to be better understood.

The Federal harvest was 87% below the 1992 projection that developed from the 1992 Owl EIS and 97% below the base period. In effect the assumptions on Federal policy were far more optimistic than the actual result. However, the Federal harvest assumptions in the 1992 study included a 74% projected volume decline so the fact that the actual decline was 97% only explains 4% of the 36% decline in total harvest for all owner types. The State-managed harvest levels were 43% below the projection and 41% below the base period as the prediction was for a 3% increase. Unlike the anticipated decline in Federal harvest the prior report did not foresee any decline in the State-managed forest harvest and consequently overestimated harvest volumes available to trust beneficiaries. The impact of protection for the spotted owl on State-managed forests and the DNR Habitat Conservation Plan (HCP) that included multi-species protections and stream buffers will likely explain much of this decline in harvest as was reported in earlier evaluations of the Plan (Bare et al 2002). Policy assumptions incorporated into prior study projections rather than simulation methodologies would appear to be the dominant explanation for the projection error.

Most surprising is the unanticipated substantial reduction in private harvest. The total private harvest is 31% below projection and 34% below the base period as the 1992 projection did include a modest decline in non-industrial and Tribal harvest volumes. While there are some ownership transfers that may have affected the within owner-class accuracy it appears that the projected harvest for non-industry lands was quite close and that the decline in actual industrial harvest levels explains most of the error. While policy changes no doubt also affected private harvest levels, the magnitude of actual decline is so much larger than other prior studies had anticipated, (Lippke and Conway 1994, Perez-Garcia et al. 2000) that other sources of error also appear to be important and will be investigated further.

Table 2 provides a summary of Eastside harvests by owner group with comparisons to earlier projections (Bare et al 1995). While this table uses the same base periods, it is important to note that the Eastside projections were developed from inventory data collected several years later than that used in the Westside study and that the Eastside study was also developed from a much smaller number and density of inventory plots. The 1990 Westside inventory sample had been doubled from prior decades to improve data accuracy. Total Eastside harvest levels in the last several years were 20% below projections and 29% below the base period harvest as the projection included an 11% decline based on an expected reduction in harvest volumes on Federal lands that would only be partially offset by projected increases in harvest on State and private lands.

Table 2: Eastside Harvest History, 15 year Prediction & Variance

Eastside mmbfs	Pre-90's 86-89	Predicted 05 +/-	Change Predicted	Last 4 yrs Act. 98-02	Actual Change	Error in Predicted
Industry	371	248		188		
NIPF	190	318		294		
Tribal	189	305		300		
Tot Priv	751	871	16%	782	4%	-10%
State	122	162	33%	81	-34%	-50%
Fed	431	133	-69%	65	-85%	-51%
All Owners	1305	1166	-11%	928	-29%	-20%

The Federal harvest was 51% below the projection and 85% below the base period harvest. However, like the Westside, much of the decline in Federal harvest was anticipated. The greater than projected decline only explains 4% of the total decline in harvest. The State-managed harvest level was 50% below the projection which had anticipated a 33% increase in harvest instead of the actual 34% decrease. The annual private harvest volume average was 10% below projections, however, prior projections forecasted a 16% increase with all of that increase attributed to non-industrial and Tribal forestlands. While there have been land transfers across these owner groups that reduce the accuracy of harvest forecasts at the individual owner level, the substantial increases in harvest projected for the non-industrial and Tribal forestlands appear to be quite close to actual with most of the unanticipated decline from private harvest attributed to industrial forestland. Since the Forest and Fish Regulations (designed to protect salmon habitats) were not anticipated at the time of the Eastside Timber Supply analysis, the 10% reduction in harvest from the projection would appear to fall within the range of what might be reasonably expected as a result of more restrictive policy changes.

The actual decline in total harvest on the Eastside is primarily explained by declines in public harvest. On the Westside, the more than 1 billion board feet of reduction in actual private harvest volume relative to projections requires further analysis. A conclusion that prior timber supply studies inadequately anticipated the harvest impacts of changing public policies suggests that development of alternative scenarios to reflect a range of policy changes and other assumption variables is important for policy analysis. As demonstrated by this review of prior study forecasts, policy developments can have significant influence on which management alternatives are adopted by different forest owner groups, with consequences to forest industries and other harvest beneficiaries. Subsequently, we begin this timber supply analysis by evaluating many different management options and strategies.

Management Specific Alternatives

Forests are managed to provide many different public and private objectives including economic returns, habitat conditions, recreational or aesthetic benefits, or to satisfy consumer demands for goods and services. Most often, forests must be managed to simultaneously achieve a mixture of value outcomes based upon determination of acceptable trade-offs among many and sometimes conflicting objectives.

Industrial forestlands are generally managed to maximize commercial returns from timber harvests while at the same time meeting the requirements of multiple political and regulatory constraints. Since timber crops require decades to mature, a long-term commitment to land stewardship has been an inherent prerequisite of successful commercial forest management. However, industrial forestland owners may develop different objectives and management strategies in response to shifting opportunities and constraints. Genetic selection of regeneration stock, brush control, fertilization and thinnings are some of the practices that have been used to increase the timber productivity. Shortened rotations can help to reduce the cost of capital and exposure to risk. When considered as a bundle of practices, selected forestry treatments are often referred to as management intensities. The more intense practices have typically involved higher initial investment to optimize growth with resulting increases to timber yields that potentially can be equivalent to twice that of natural growth (Michaelis 2000).

Small family forest owners and other non-industrial private forestland owners, of which there are many thousands in Washington State, sometimes place more emphasis on the importance of cash flow and a diverse range of environmental, aesthetic, and recreational amenities with less inclination for high capital investment towards maximizing economic return (Lippke and Bare 1998, Baumgartner et al 2003).

Native American Nations own significant timber lands in Washington. Tribal forest management includes protection of cultural resources and job creation for Tribal members along with sustainable timber harvests for income.

State granted lands management emphasizes economic returns for various public beneficiaries, and are managed with much the same commercial emphasis as industrial lands. However, State land managers also attempt to respond to a myriad of political entities that exert significant pressure for environmental protection and local values.

The forestry objectives of the Federal government have changed dramatically during the last twenty years with one result being a near elimination of timber harvest activities in favor of ecosystem protection. The result is a 97% decline in Westside removals. However, the increased frequency and intensity of forest fires on National Forests has become a cause for public concern as have epidemic infestations of forest pests and pathogens. Recent policy shifts, as evidenced by the Healthy Forest Restoration Act (The White House 2003), may result in increases in harvest activities to restore forest health through thinnings on Federal forests east of the Cascades that could be important in the future. This may raise the awareness of forest health issues on the Westside as well.

When viewed across the nearly 20 million acres of forested lands in Washington, the broad and changing range of management practices and the many different owner objectives, one sees alteration of the forest landscape over time with considerable economic and ecological implications. To anticipate how these changes might evolve, it is important to understand the potential range of management options, ownership types, and implications for economic, social and environmental outcomes. In the sections below we have developed growth projections for treatment alternatives and evaluated a range of mostly commercial treatments relative to forest economics, habitat and other ecological attributes, including carbon storage. We then consider how allocation of those treatments might change to meet other owner objectives such as those of non-industrial forest owners, Tribes, State and the Federal Forest Service.

We consider upland management first and extend typical commercial treatments to long rotations in order to develop wildlife habitat conditions found in older forests that may meet species protection objectives. We then consider riparian management alternatives that can protect and restore riparian functions that may have been compromised by population density or commercial management. Finally we look at Eastside management alternatives which present substantially different challenges given slower growth, marginal economic performance, and alarming trends in forest health decline. Collectively these management alternatives are intended to portray the range of possible future options and outcomes that could be expected for Washington's future forests.

For much of the Federal forest, the ecosystem protection default has been no-management. While no-management (often referred to as no-action) is often considered to equate to protection of "natural" forest conditions, the future forest conditions that come from no-action alternatives in previously managed forests are not likely to be the same as the future conditions that might be expected in a forest that has never been harvested (Bailey and Tappeiner 1998). In addition to previous treatment legacies, other factors such as climate change, catastrophic disturbances, and invasive species compromise achievement of desired future forest conditions through no-management. Almost all forests both public and private have been altered from their European pre-settlement conditions either by management or changes in the frequency of disturbances.

Fire incidence in both Westside and Eastside forests is an example. Indian Tribes historically used fire to enhance habitat for hunting and open areas for grasses, forbs, and other amenities. However, suppression of wildfire has since been adopted to protect forest resources and communities. A century of fire suppression in the forests east of the Cascades has produced unprecedented overstocked and drought-stressed forest conditions. Forest fires are increasing in frequency and intensity with destructive results. Restoration to less dense and more fire-safe conditions such as might have existed over a century ago should not be expected from a no-action approach to management.

In reviewing treatment alternatives some attention will be given to how current managed forests compare to older forest conditions in order to better understand issues associated with protection and restoration of desired species habitats. Multiple treatment alternatives will be developed and modeled for expected outcomes. No-action will be considered as one treatment alternative for comparison to other options. The purpose of the many sections dealing with different management treatments and intensities is to better understand the multiple consequences of any individual treatment and how it fits different objectives as well as how it might be better directed if different outcomes are desired. The cumulative effects of multiple treatments staggered through time over timbershed landscapes will be examined in the final report.

Westside Commercial Management Treatments: Options and Outcomes

Management treatments as applied on the landscape are some of the most important factors for the future of Washington's timber supply. There are a number of variables involved, including stand establishment options, rotation length, thinning options, and other stand improvement practices such as vegetation control, fertilization, and pruning. These variables can result in a wide range of economic and environmental outcomes. We simulate the treatments using the Landscape Management System (LMS), a software program developed at the University that provides tree list projections into the future based on best available growth models. An important feature is the ability to analyze a number of ecological attributes that are dependent on tree lists and stand structure, such as habitat, carbon, fire hazard, and insect hazard (McCarter el al 1998).

Key Management Variables

In terms of stand establishment options, several decades ago the choices ranged between natural regeneration, artificial seeding, and planting. Now, however, stand establishment on commercial forestlands is done almost exclusively with planting. State forest practices regulations require re-establishment of fully stocked forests. Timber managers responding to a 2000 Stand Management Cooperative (SMC) survey reported that planting occurred on 98.1% of commercial forest acres followed a regeneration harvest (Briggs and Trobaugh 2001). As seedling nursery technology has advanced, planting stock options have increased by type and species, including the maturity and degree of genetic improvement of the nursery stock. Planting density is also an important regeneration consideration. On the Westside, plantation growth response is heavily influenced by shade. Douglas-fir (*Psuedotsuga menziesii*), shade intolerant, has historically been considered the premium plantation species for Westside forests and received higher prices than hemlock. Subsequent to final harvest, regeneration follows where all trees, except those reserved by law for wildlife, are removed such that plantation seedling growth is not compromised by shade. This approach is referred to as even-aged management. Intermediate thinnings may also be employed to maximize growth and generate cash flow. Douglas-fir forests covered much of the landscape Westside of the Cascades in pre-European settlement periods as a consequence of stand replacement forest fires that occurred in several hundred-year intervals.

The economic rotation length for Westside commercial management on good (medium to high) sites has typically been around 50 years. However, changes in sawmilling technology and capacity following restrictions on Federal harvests have resulted in increased demand for smaller diameter logs generally available from private forestlands. Market premiums for high quality larger logs have disappeared in most areas. At the same time, intensive forest management techniques have increased tree growth allowing plantations to reach a merchantable harvest age much sooner.

Thinning options include both pre-commercial (removing trees that are not merchantable in order to provide more growing space to the remaining trees) and commercial thinning (removing merchantable timber to generate revenue while maximizing growth rates for leave trees). Talbert and Marshall (2005) report that pre-commercial thinning (PCT) is no longer as popular as it has been in previous decades when high establishment densities required stocking control. In addition, the increased merchantability of small logs has encouraged some landowners to forgo costly PCT treatments in favor of waiting a few more years for an early commercial thin that can generate enough revenue to at least offset some of the treatment costs. The results of the SMC survey reflect a decline in PCT treatments by commercial forest managers (Briggs and Trobaugh 2001).

However, commercial thinning is also becoming less popular. With the market shift toward smaller logs, thinning to increase diameter growth may be less advantageous (Talbert and Marshall 2005). A shift to shorter rotations brings early revenue generation with reduced costs and risks associated with establishment investments.

Economic Performance Affects Management Choices

The performance of a forestry investment is closely related to the time value of money. Money received today is worth more than money received in the future. The extent to which present incomes are preferred over future incomes is responsive to fluctuations in the interest rate, with higher interest rates resulting in a greater preference towards present incomes. When investing in a forest rotation, expected future harvest revenues must be weighed against the up-front costs of stand establishment and tending. Investment returns can be estimated by a discounted cash flow or net present value (NPV) analysis, in which costs and revenues occurring at disparate times are discounted to the present using the desired interest rate to allow for investment option comparisons. The NPV is the present value of the revenues less the present value of the costs. The best economic performance is equivalent to the highest NPV (net profit including time costs).

Forest management treatment choices have significant impacts on NPV outcomes. The magnitude of early-rotation costs is particularly important, as greater (or sooner) future harvest revenues may be needed to offset greater early-management investments. If forest managers perceive that PCT and CT treatments do not result in sufficient revenue increases, then these activities are logically foregone.

Rotation length is also of particular importance for economic outcomes. Because of the time value of money, shorter rotations will tend to be more economically advantageous than longer rotations. This is especially true at higher interest rates, which reflect a stronger preference toward present incomes. To illustrate this, Table 3 compares what $10,000 received in 40 and 80 years is worth today at 5% and 10% interest. At 5% interest, an increase in rotation length from 40 to 80 years would require a 7-fold increase in harvest revenues in order to produce equivalent return on investment. At 10% interest, the same increase in rotation length would require that harvest revenue be 45 times higher in order to produce equivalent return on investment.

Table 3: What $10,000 received in 40 or 80 years is worth at 5% or 10% interest.

Years	5%	10%
40	$1421	$221
80	$202	$5

A typical Westside harvest in recent years might generate about $10,000 revenue per acre at the optimum rotation age. Hence the investor can only afford $1421 per acre for the land and management costs, most being up front costs, in order to achieve a target rate of return of 5% from a 40-year rotation. Difficult-to-predict variables such as inflation, regulatory changes, market shifts, and natural disturbances increase the risk exposures associated with long-term forestry investments. Commercial forest managers, lacking a premium for older logs, will likely maximize NPV by shortening rotation periods.

Economic Objectives Affect Environmental Outcomes

What is advantageous economically may result in less desirable environmental outcomes. While shorter rotations have the economic advantage of faster investment recovery, they also result in more of the landscape being harvested at any given time. The landscape is further skewed toward younger stand structures, which may cause problems for species that utilize older structures (Curtis 1997). A shift away from thinning may also have undesirable environmental outcomes. Stands that are maintained in a highly dense condition have a paucity of understory vegetation and do not support high levels of biodiversity

(Oliver and Larson 1990). In contrast, thinning in managed stands has been found to promote understory development and promote development of multiple canopy layers (Bailey et al. 1998; Bailey and Tappeiner 1998, Muir et al. 2002). Thinning has been linked to increased wildlife abundance (Havari and Carey, Hayes et al. 2003, Suzuki and Hayes 2003; Wilson and Carey 2003) and it can accelerate the development of desirable old forest conditions (Busing and Garman 2002, Garman et al. 2003, McComb et al. 1993, Tappeiner et al. 1997).

Ultimately, different forest management approaches will result in trade-offs between economic and environmental outcomes with some choices having more consequences than others. It will be important to understand how management alternatives might be developed to minimize trade-off impacts in order to achieve multiple objectives on the landscape. Some countries such as New Zealand (Douglas 1993), have largely separated habitat protections from timber production by partitioning the land base into government-owned forest reserves and privately managed short-rotation commercial plantations. Studies have shown that in Washington, integrated management for multiple values may be a less costly approach (Lippke 1997).

Preliminary Management Simulations

A series of preliminary simulations have been developed to show how management outcomes compare across the range of treatment options characteristic of Westside commercial management. The simulations are not exhaustive of all possible options and for tutorial purposes are illustrated for only one land productivity class, a medium-high site (King's site index 120). Each simulation begins with a Douglas-fir plantation of 435 trees per acre (TPA), which is approximately a 10 ft by 10 ft spacing and is typical for Westside commercial management (Briggs and Trobaugh 2001, Talbert and Marshall 2005). Three commercial management pathways were evaluated: no thinning, early commercial thin (Early CT), and PCT plus Commercial thin (PCT_CT). The no thinning pathway only involved planting and final harvest. The Early CT pathway included a thinning from below to 180 TPA at age 20. The PCT_CT pathway included a PCT from below to 300 TPA at age 15 followed by a commercial thinning from below to 125 TPA at age 30. Each pathway was simulated over four rotation lengths: 40, 45, 50, and 55 years in order to illustrate comparative economic returns and forest structures.

In addition to the commercial management pathways, a "biodiversity pathway" was also simulated to provide a longer rotation multi-objective comparison. Biodiversity pathways have been designed to create complex forest structures through repeated thinnings over longer rotations. These thinnings tend to be heavier than traditional commercial thinnings in order to open the understory to more sunlight with subsequent understory development. Variable density harvest patterns can be employed to favor certain species and sizes such as understory hardwoods that enhance structural diversity. Biodiversity pathways have been proposed as a management approach for accelerating the development of older forest structures to support increased biodiversity while generating revenue from harvests (Carey and Curtis 1996, Carey et al. 1996, Carey et al. 1999, Lippke et al. 1996). While there can be many variants for biodiversity pathways, the example simulation presented here includes thinnings to 180 TPA at age 20, 75 TPA at age 50, and 35 TPA at age 70, with a final harvest at 100 years. Thinnings were done proportionally across diameter classes in order to enhance vertical structure.

Figure 1 shows the harvest volume on an annual basis for each management pathway simulation. For each management pathway, volume production per year increased with longer rotation lengths. This is to be expected, as the longer rotations approach closer to the maximum volume production per year (culmination of mean annual increment). The economic optimum rotation based only on the value of timber (exclusive of non-market environmental values) occurs earlier at the point in time when the growth in volume plus value per unit of volume falls below the targeted interest rate. Volume production per year decreased with thinning, with the no-thinning pathway producing the highest volumes and the PCT_CT pathway producing the lowest volumes. This example illustrates a common trade-off for thinning; increased individual tree growth versus total stand production (Oliver and Larson 1990). However, with improved utilization and silvicultural treatments, there may be a larger volume boost from thinning than is reflected in these simulations. Further simulations with growth models better calibrated to post-thinning performance may better reflect the economic benefits of intensively managed forests.

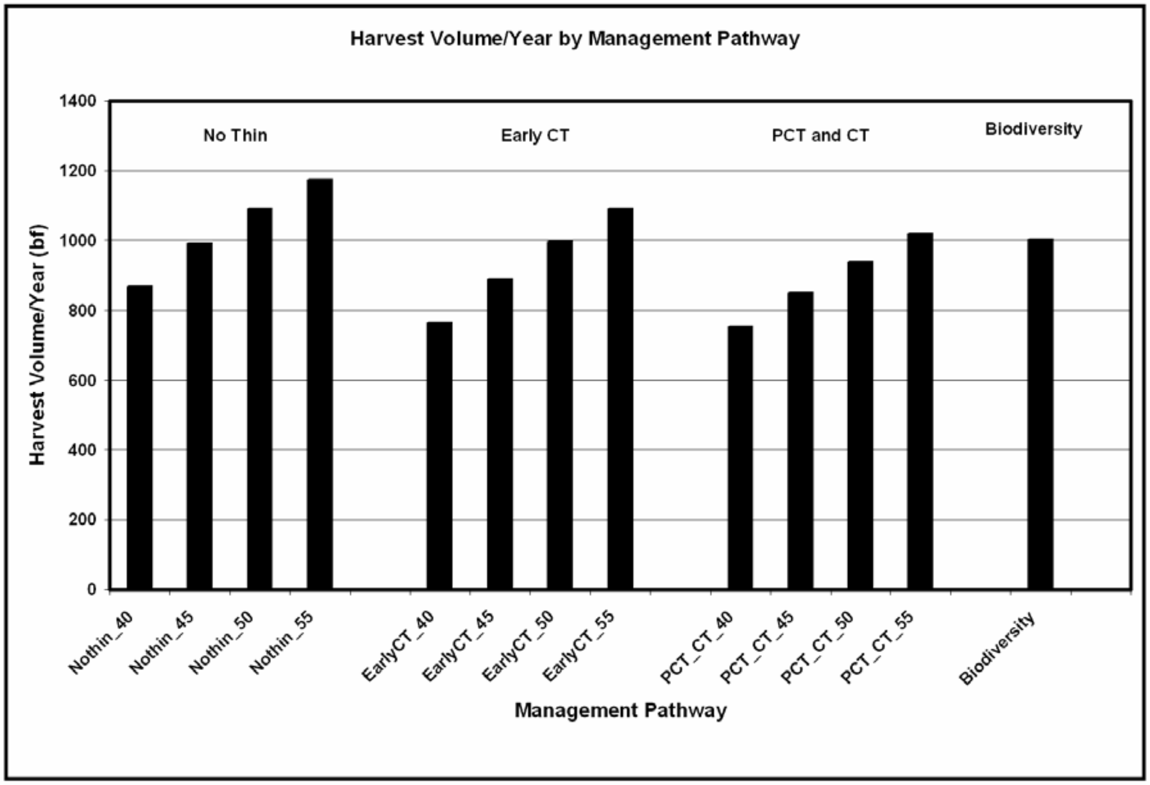


Figure 1: Board foot (bf) harvest volume per year across different management pathways. Longer rotations result in greater harvest volume. Less thinning also results in greater harvest volume.

Economic performance depends not only on how much volume is produced, but when the volume is produced, the quality of the logs, and the magnitude of management costs. These factors are all reflected in a NPV analysis. When comparing the performance of different management options, especially when looking at different rotation lengths, a special type of NPV calculation known as soil expectation value (SEV) is useful. SEV is a commonly used measure of forestry economic performance that calculates the NPV of expected costs and revenues for a complete forest rotation repeated in perpetuity. The SEV of each management pathway simulation with an assumed 5% real interest rate is presented in Figure 2. SEV calculations were done assuming a $300 per acre cost for stand establishment (planting and site preparation), a $100 per acre cost for PCT treatments, and $15 per acre annual administrative costs. Early commercial thinnings were assumed to break even. Log values are based on average year 2000 delivered prices for the Puget Sound Region (from Log Lines Report Service). Combined logging and hauling costs were applied based on the average cut diameter and typically ranged between $115 and $150 per thousand board feet (MBF) for regeneration harvests and from $200 to $250 per MBF for commercial thinnings. SEV figures were computed before taxes except for land taxes included in administrative costs.

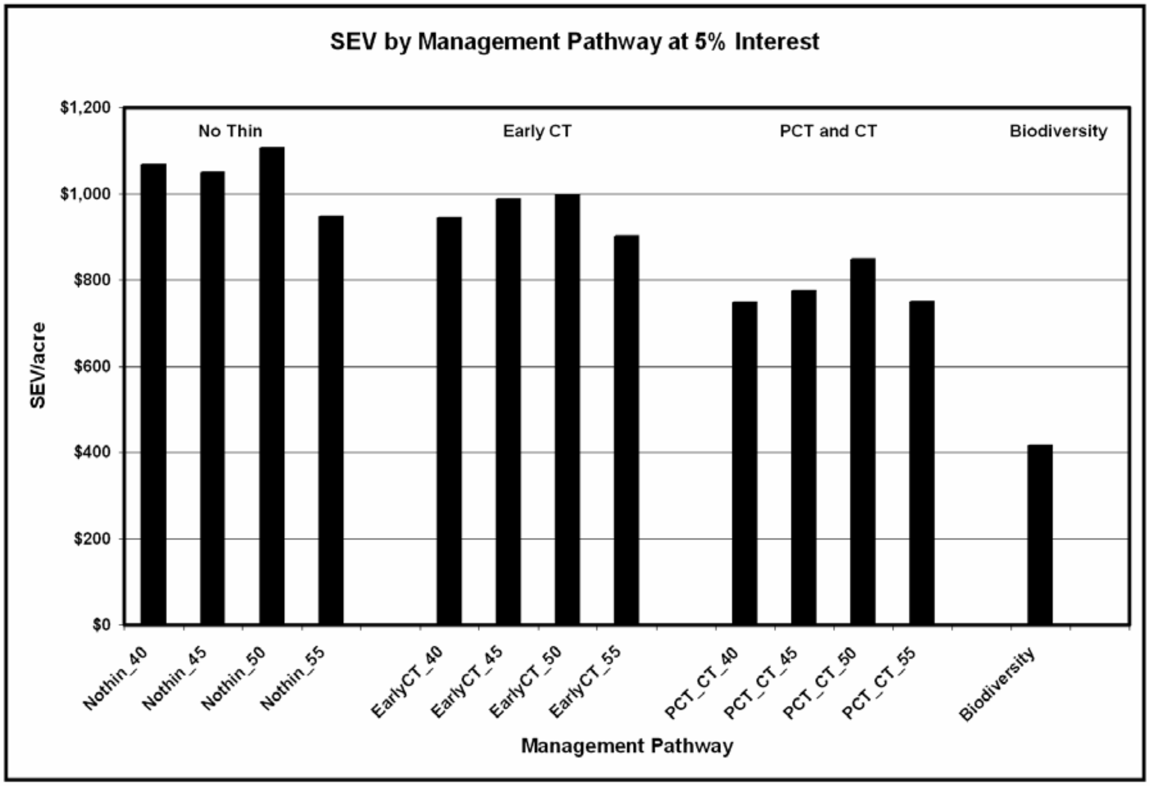


Figure 2: Soil expectation value (SEV) for different management pathways at 5% interest. The optimal rotation length at this interest rate is 50 years.

At 5% interest, a rotation length of 50 years appears to be economically optimal (i.e. has the highest SEV) for each of the management pathways. This indicates that the economic return from timber growth exceeds 5% between age 40 and 50, but that the additional growth from age 50 to 55 is less than the 5% cost of holding the asset another 5 years. Thinning appears to not be advantageous economically, as SEV is highest for the no thinning pathway and lowest for the PCT_CT pathway. As with the volume figures, however, these preliminary simulations may not fully reflect the advantages of thinning when combined with other intensive management practices. The biodiversity pathway yielded the lowest SEV at $415/acre, which is $691/acre less than the maximum SEV of $1,106/acre with a 50-year rotation and no thinning. This return difference could be considered as the least level of economic incentive that may be needed for landowners to adopt biodiversity pathways. It is noteworthy that the cost of the biodiversity pathway compared to a short rotation is much higher today than when such costs were first published (Lippke et al. 1996) largely because the quality premium for large logs has disappeared.

SEV and economically optimal choices are highly dependent on the interest rate. For firms with a higher or lower cost of money, the economically optimal choice will be different. As an example, the SEV/acre at a 6% real interest rate is shown in Figure 3. At 6% interest, no thinning still performs best, but the economically optimal rotation length shortens to 40 years. The SEV/acre of the biodiversity pathway is $1/acre, which is $523 less than the maximum SEV of $524/acre with a 40-year rotation and no thinning. At higher interest rates, the cost of managing for biodiversity decreases in absolute terms. However, it is greater in relative terms, with a 99.8% decrease relative to the maximum SEV compared to a 62.5% decrease at 5% interest.

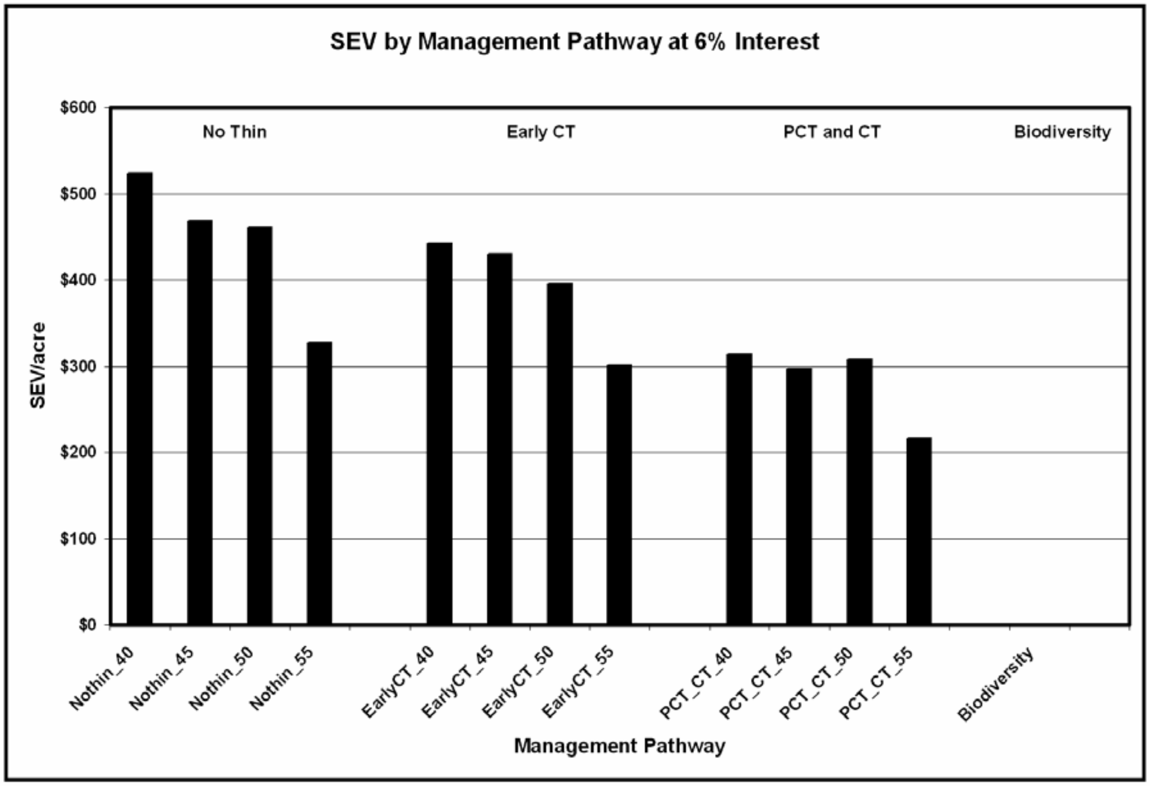


Figure 3: Soil expectation value (SEV) across different management pathways at 6% interest. The optimal rotation length shortens to 40 years.

In terms of stand structure, thinning and longer rotations can be expected to produce larger trees and greater structural complexity as compared to shorter rotations without thinning. This is especially true for the biodiversity pathway. Figure 4 shows that quadratic mean diameter (QMD) and average height at rotation age (just prior to final harvest) increase with thinning and longer rotations. The biodiversity pathway results in significantly larger trees than any of the commercial pathways.

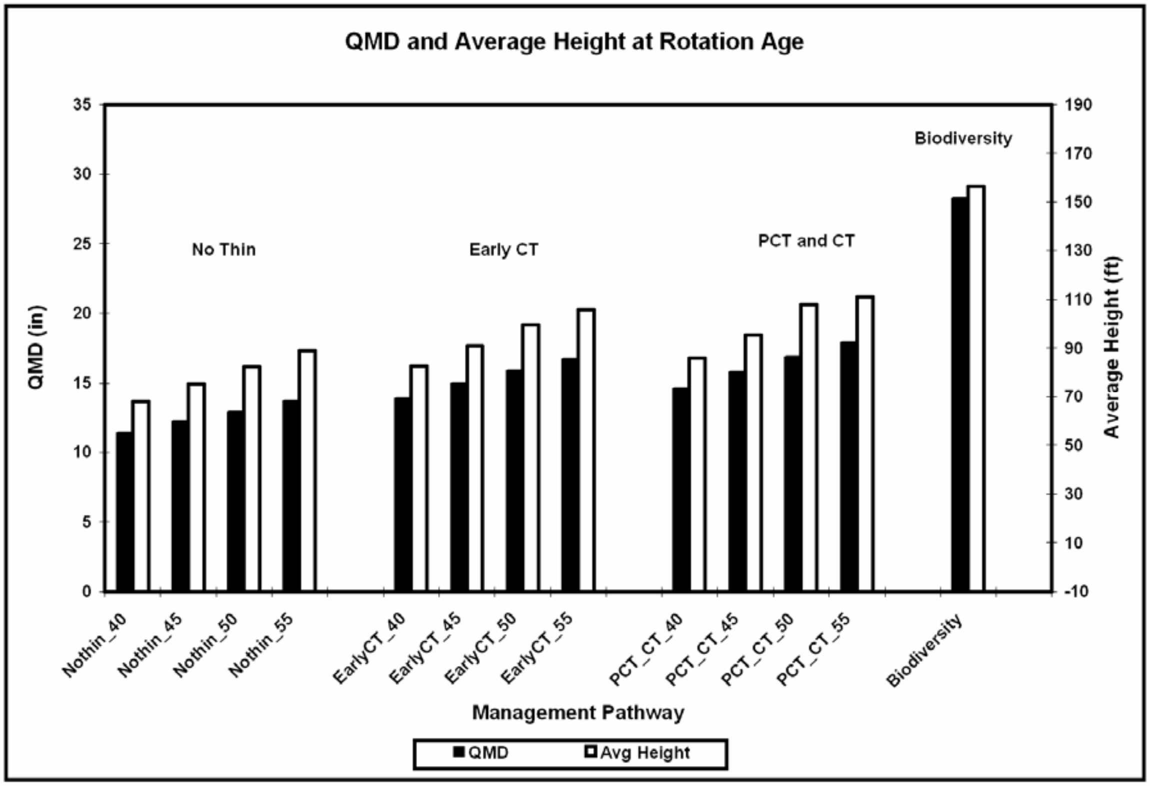


Figure 4: Quadratic mean diameter (QMD) and average height across different management pathways. Thinning and longer rotations result in greater average tree sizes. The biodiversity pathway results in significantly larger trees.

In addition to thinning treatments there are opportunities for greater diversity in managing alternative species such as cedar and alder. Both have risen in value while the premiums that once characterized Douglas-fir and hemlock have declined. The relative returns for species management are described in Appendix D. Species alternatives will be given greater attention in the final report after we review the management intension surveys by owners.

Commercial/Environmental Tradeoffs

The biodiversity pathway is not the only treatment that could be considered beneficial to habitat. Habitat Suitability Indices (HSIs) can be linked to the stand structures produced from any number of management alternatives (Ceder 2004, USDI 1980). Indices for many different bird and animal species can create a very complex analysis as any treatment that benefits some habitats will do so at the expense of others. A coarse filter approach that has been used to illustrate the benefits of different treatments was developed with the introduction of biodiversity pathways (Carey et al. 1996, Carey et al. 1999). The progression of either natural forest growth or managed stand growth tends to move through stand structure classes over time: Ecosystem Initiation (EI) for the early open stage after a stand clearing disturbance or treatment; Competitive Exclusion (CE) for the period when the canopy is closed restricting understory development; Understory Reinitiation (RI) when, through mortality, disturbances or treatments, stands are thinned sufficiently to allow understory growth; Developed Understory (DU) as this process matures; Diverse structure (D) although not necessarily old, with Niche Diverse (ND) denoting managed diversity and Botanically Diverse (BD) denoting unmanaged disturbance related processes; and finally Fully Functional (FF) when stands approach the statistical metrics associated with what have been considered to be unmanaged mature forest stands.

Without any thinning and including regeneration treatments that accelerate early stand growth, only the first 15 years would be in EI, 30% of the 50 year optimal rotation with 70% remaining in CE, the stage with the least support for habitat diversity. Including a CT at age 20 reduces the closed CE structure stage to 10% of the acres with 60% transition from RI to a more developed understory or if the thinning is too light, back to a closed structure. Including a PCT and CT replaces the 70% of closed structures with 30% UI and 40% DU and if the second CT maintained enough woody debris and snags it would be considered Diverse albeit a young diverse structure. The longer rotation Biodiversity pathway reduces the EI structure to 15% and the CE structure to 5% resulting in 30% in UI and about 50% transitioning to the more diverse Niche Diverse structure and perhaps Fully Functional near the 100 year harvest rotation age. There is a fairly clear transition to greater complexity and biodiversity supporting species that tend to be more sensitive to older forests by incorporating thinning treatments and especially successive treatments, while also maintaining snags and downed dead wood in the understory. While it is fairly straight forward to determine the management cost to produce these benefits as has been shown above (i.e. the simulated loss compared to the optimal economic treatment), and has been illustrated before for the Westside (Lippke et al 2002), cost responsibility and relative worth is a policy determination. Federal and State managers are placing more emphasis on restoring old forest attributes with significant public costs. Private managers are generally absorbing costs to meet regulatory minimums thereby increasing the pressure for land conversions to non-forest uses.

There may be benefits in analyzing the habitat for a specific species instead of a coarse filter approach. The process of developing more detailed habitat suitability measures for specific species generally involves keeping track of a greater number of forest structure types than the coarse filter approach described above. Simulating tree list models can easily break plot information into a much finer resolution of stand structures to model a large number of individual species. The problem rises at the analysis or policy level since what is good for one species will often be bad for another making the analysis of impacts much more complicated. Treatments designed to increase habitat for one species can easily leave out the impacts on other species that might be just as important. We provide several fairly simple habitat suitability case studies in Appendix C to illustrate the additional detail and complexity associated with species specific habitat suitability.

Westside Regulatory Impacts and Responses

Regulatory constraints have become important factors affecting timber harvest volumes and economic returns for forest landowners. In western Washington, regulatory constraints have increased significantly in recent years due to a major update to the forest practices regulations known as the Forests and Fish Rules (FFR). The FFR increased harvest restrictions around streams and other sensitive areas in an effort to help restore salmon populations and comply with the Endangered Species Act (ESA). The FFR are the result of 1999 legislation (WAC 222-30-021) that called for the implementation of the recommendations in the Forests and Fish Report, which represented a negotiated agreement between state and federal agencies and key stakeholder groups. Emergency rules went into effect in 1999 and were finalized in 2001. In 2006, the FFR were approved by federal agencies as a statewide Habitat Conservation Plan that satisfies the requirements of the ESA.

Forest and Fish Rules

In Western Washington, the FFR require a three-zone riparian harvest buffer along either side of a fish-bearing stream (Figure 5). The total combined buffer width is one site potential tree height (SPTH), which is 90-200 feet depending on site quality. The zone adjacent to the stream is a 50-foot no-harvest core zone. This is followed by the inner zone, in which two partial harvest options are allowed subject to minimum tree count and basal area requirements. Option 1 allows thinning from below throughout the inner zone to a minimum of 57 conifers per acre. Option 2 divides the inner zone into two portions, allowing the trees furthest from the stream to be removed (up to a minimum distance of 80' from the stream) while the trees in the portion closest to the stream are retained. The final zone is the outer zone, in which partial harvest is allowed with a minimum retention of 20 conifers per acre that are at least 12” in diameter. A 50-foot no-harvest buffer is also required around portions of non fish-bearing streams and around sensitive features such as seeps and springs.

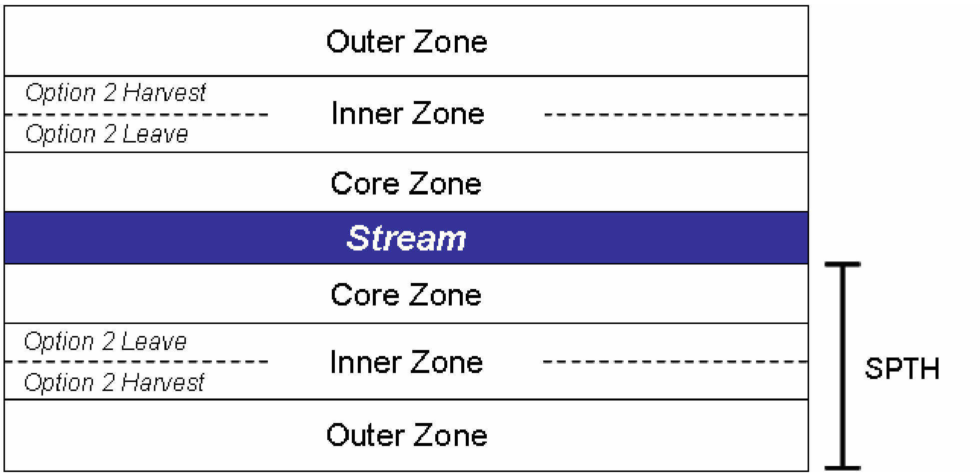


Figure 5: FFR buffers for Western WA.

Regulatory Goals and Concerns

The goal of the Westside buffer rules is to put the development of riparian stands on a trajectory toward a desired future condition (DFC) of mature forest structure intended to provide high quality riparian habitat. This DFC is defined as “the stand conditions of a mature riparian forest at 140 years of age” (WAC 222-16-010). In addition to this ecological goal, the FFR also have the concurrent economic goal of “maintaining commercial forest management as an economically viable land use” (RCW 77.85.180). There have been concerns about the economic impacts of the riparian harvest restrictions, especially for small, private forest ownerships. These concerns were expressed in the Forests and Fish legislation, which found that the riparian harvest restrictions would “further erode small landowners’ economic viability and willingness or ability to keep the lands in forestry use and, therefore, reduce the amount of habitat available for salmon recovery” (RCW 76.13.100) as an unintended impact.

The economic impacts on small forest ownerships are of particular concern, as small ownerships in western Washington tend to be located in lowland areas in close proximity to streams (Rogers 2004). This suggests that small ownerships are of particular importance for salmon recovery and are also likely to have disproportionate economic impacts compared to other ownership classes. In addition, with small ownerships, averaging the harvest impact over broader areas as generally occurs with larger landowners, does not adequately represent the impact on a small owner and does not provide useful information with respect to how he or she will make decisions. The impacts are concentrated on those ownerships where streams are present (Figure 6).

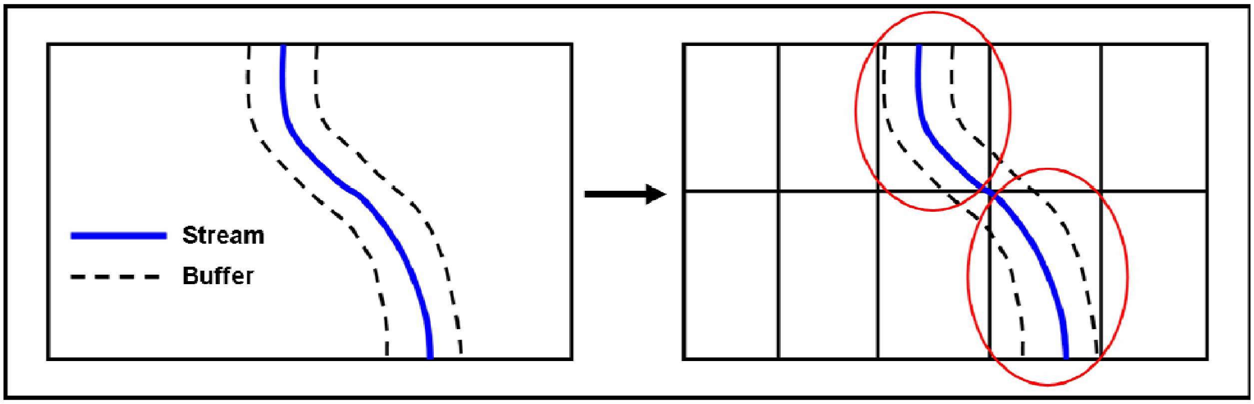


Figure 6: Unlike large landowners (left) where buffer impacts are averaged over large areas, with small ownerships (right) the impacts are concentrated on individual properties where streams are present.

An examination and comparison of the overall economic impacts of riparian harvest restrictions on large and small landowners was completed as part of a Small Business Economic Impact Statement (SBEIS) of the FFR. The SBEIS found that in western Washington, the riparian harvest restrictions cost large landowners 11.1% of their total timber asset value compared to 19.1% for small landowners (Perez-Garcia et al. 2000). These results suggest that the restrictions indeed have disproportionate impacts on small ownerships. However, these results reflect the average impact for small landowners as a whole; they do not demonstrate the high variability across small ownerships that can be expected (i.e. Figure 6). Owner decisions will be based on individual impacts, not averages.

Small Ownership Case Studies

To provide point estimates of the magnitude and variability of impacts for individual landowners, ten case studies were analyzed for small forest ownerships in western Washington that included riparian areas (Zobrist 2003). The case studies were located in Lewis County and Grays Harbor County, covering a range of coastal and inland sites. The case studies ranged in size from 33 to 310 acres, and each case study had different proportions of riparian and upland areas and had a mix of stream types, stream sizes, timber types, and timber age classes.

Most of the case study stands were medium to high site (class I or II). For Lewis County, the base management regime was assumed to be planting Douglas-fir at 435 trees per acre (10 by 10 spacing) on a 50-year rotation with an early commercial thin from below to 180 trees per acre at age 20. For the stands that had lower site quality (class III), the rotation length was extended to 55 years. The Grays Harbor County case studies assumed a different thinning regime because of the prolific natural regeneration of western hemlock (*Tsuga heterophylla*) that occurs in the coastal region. For these cases, it was assumed that a pre-commercial thin from below would be done at age 15 to 270 trees per acre (200 Douglas-fir and 70 western hemlock) followed by a commercial thin from below at age 35 to remove half of the remaining stems.

For each case study, management was simulated under several scenarios, including no riparian harvest restrictions, maximum allowable riparian harvest under the FFR (usually Option 2 when permitted), and no harvest at all within the riparian zone (full width buffer). Two measures of economic performance were used to assess the economic impacts of riparian harvest restrictions: forest value and soil expectation value (SEV). Forest value is the net present value (NPV) of the expected costs and revenues from any existing timber combined with the economic value of the land for future rotations. NPV can be used to measure the total economic cost of riparian harvest restrictions, including both land and timber.

SEV is the economic value of the land by itself (separate from any existing timber) for the purpose of perpetual forestry use given the expected costs and revenues of managing timber starting with bare ground.

Unlike forest value which largely reflects the value of existing timber for which prior establishment costs are sunk, SEV reflects the net economic return from sustainable forestry (successive rotations) starting with bare ground i.e. before planting. This is an important measure of the long-term economic sustainability of forestry as it represents the economic motivation to pursue future forest rotations rather than convert to an alternative land use once the existing timber is harvested. All economic calculations were done before taxes using a 5% real rate of return.

The range and distribution of the impacts of riparian harvest restrictions on forest value (i.e. total economic cost) for the ten case studies are presented in Figure 7. While there is a wide range of impacts, the larger impacts are associated with larger portions of ownership within a riparian area. There were also differences depending on how the riparian zone was managed. Assuming the maximum allowable riparian harvest, the economic costs ranged from 17.5% to 41.5% of the total economic asset value. However, many small landowners choose not to pursue the maximum allowable harvest. This may be due to several factors, including the complexity and additional layout costs associated with the partial harvest options for the inner and outer zones. When no harvesting in the riparian zone is assumed, the losses range from 25.1% to 57.4% of the total economic asset value.

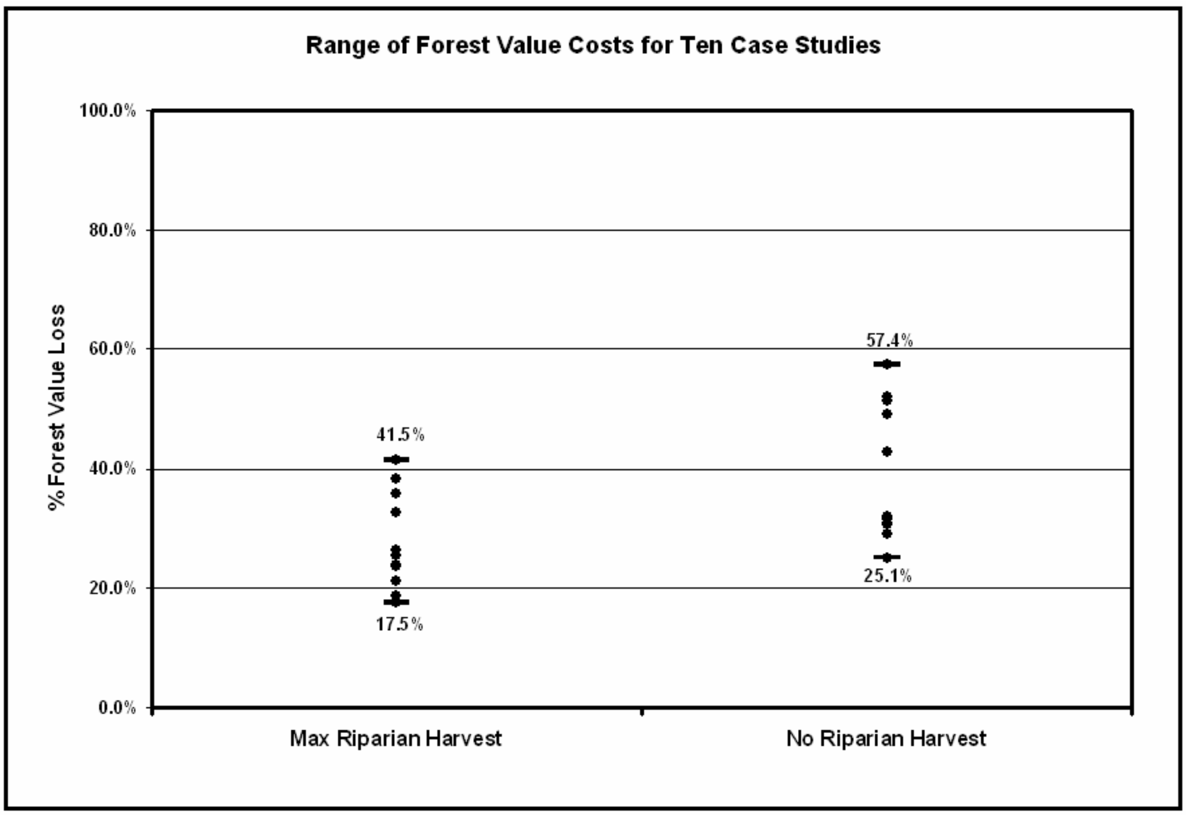


Figure 7: Riparian harvest restrictions cause a significant reduction in economic asset value.

For future rotations in which all the costs of production are considered, the economic impacts of riparian harvest restrictions are more pronounced. This is illustrated in Figure 8, which plots the range and distribution of the impacts on SEV for the ten case studies. The range and magnitude of impacts are wider, ranging from 22.9% to 144.8% of SEV assuming the maximum allowable harvest and ranging from 33.6% to 163.8% of SEV assuming no riparian harvest. Losses greater than 100% suggest that with the current riparian harvest restrictions, forestry is not economically viable (present value of expected costs exceeds present value of expected revenues) given the assumptions.

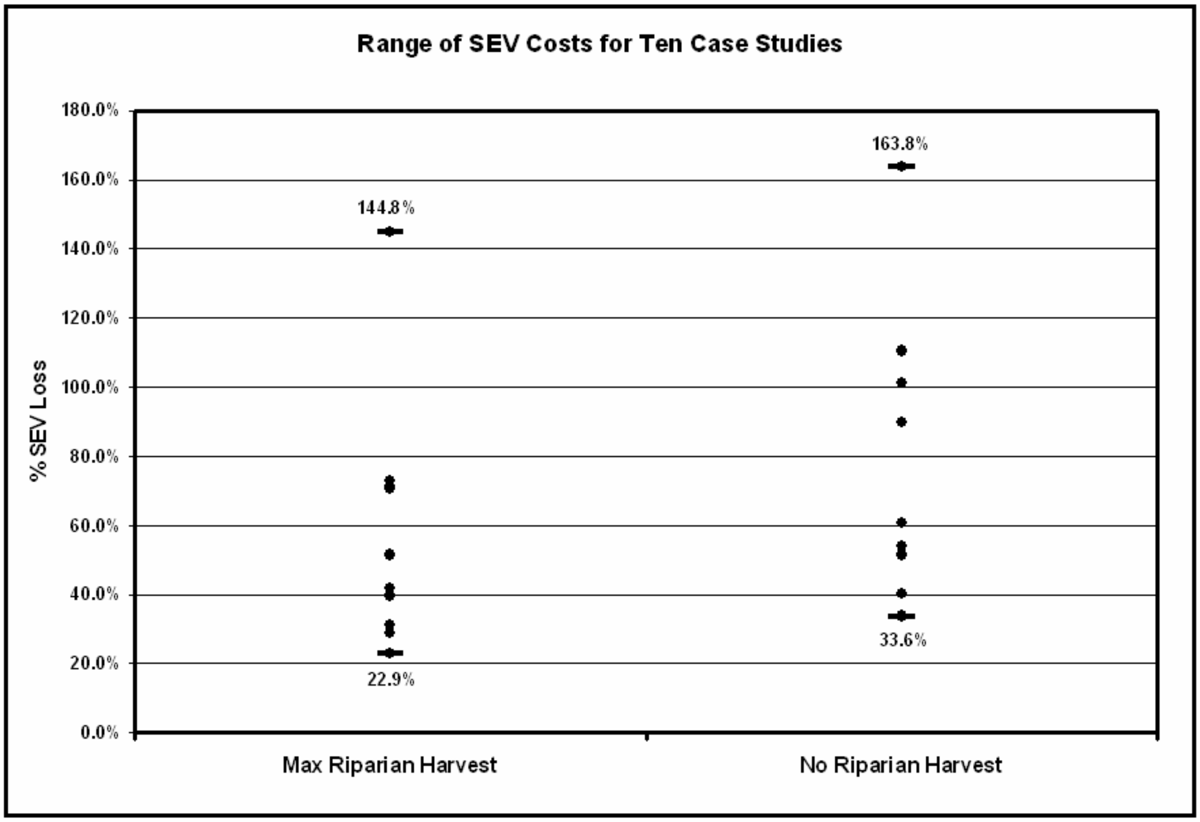


Figure 8: The impact of riparian harvest restrictions on SEV is much more pronounced, which has important implications for the long-term economic viability of forestry.

Riparian Implications for Washington's Future Timber Supply

Harvest restrictions such as the FFR have both direct and indirect impacts on Washington's future timber supply. The direct impact results from timber volume that is off-limits for harvest due to regulatory changes. For the ten case studies, the reduced volume over the next 50 years ranged from 3.4 to 5 million board feet (depending on max vs. no riparian harvest) on a total of 406 riparian acres of designated riparian management zones. This amounts to a range of 8 to 12 thousand board feet (MBF) per riparian acre over the next 50 years.

While these case studies do not represent a statistical sample of forest conditions on small ownerships, they do include a mix of Westside conditions that can be scaled up to provide preliminary, ball-park estimates of Westside impacts. Using acreage estimates of non-FFR exempt small forest ownerships and estimated proportions of riparian zone, there are approximately 238,896 acres of designated riparian zones on small ownerships in western Washington subject to the FFR. Using the case study estimate of 8-12 MBF per riparian acre, this yields an approximate total restricted volume of 2.0 to 2.9 billion board feet over the next 50 years (39 to 59 million board feet per year) depending on how intensively riparian zones are managed.

These estimates only include the direct impacts of buffer restrictions on small forest ownerships in western Washington. They ignore the impact of more difficult access to the timber caused by the buffers breaking the land into many smaller areas that may no longer be economically operational or any road or stream crossing upgrade requirements. Industrial lands are also subject to the FFR, and while they may not have as high riparian impact as a proportion of total acreage, they do have more total riparian acreage. As with the NIPF ownerships, the volume impact per riparian acre can be expected to be substantial. Industrial owners are more likely to pursue the maximum allowable harvest in the riparian zone, however, which should keep their costs at the lower end of the range.

The volume impacted by riparian buffers may be disproportionate by species. Of particular concern is red alder, which is often found in riparian areas. The commercial importance of red alder has increased in recent years. Demand for this species is strong, and alder log prices have exceeded Douglas-fir (Mason 2006). A reliable supply of this species will be needed to maintain the market infrastructure. For the ten case studies, the riparian harvest restrictions under the FFR reduced the harvestable red alder volume by 53% to 64%, compared to a 16% to 25% reduction for Douglas-fir and 17% to 26% overall (Table 4)

Table 4: Reduction in harvest volume by species over 50 years due to riparian harvest restrictions.

Species	Max riparian harvest	Full buffer
Douglas-fir	16%	25%
Red alder	53%	64%
Total	17%	26%

In addition to direct reductions in available harvest volume, the economic impacts can have long-term, indirect effects by reducing the economic competitiveness of forestry as a land use. The case studies above demonstrate that the economic costs of regulatory constraints can be high for individual landowners, especially the costs to the land value (SEV). The SEV costs are of particular concern, as they suggest a greater impact on future rotations. In some cases the loss in SEV was over 100%, indicating that, at a 5% cost of money, future timber rotations would not be economically viable. In these cases, when the existing trees are harvested at the end of the current rotation, there would be a high economic motivation for the landowner to pursue an alternative land use rather than begin a new forest rotation for which the revenues are not expected to cover the production and interest costs.

The over 100% loss cases not withstanding, any reduction in SEV is of concern because it diminishes the economic competitiveness of forestry relative to other land uses. Significant conversion of forestland to other uses has already been occurring in western Washington (McClean and Bolsinger 1997, DNR 1998) and land values for real estate development are often an order of magnitude higher than for forestry use. These pressures will be present even without regulatory constraints. However, further reductions in the economic viability of commercial forestry can be expected to exacerbate this trend, especially for landowners who are on the economic margin of conversion. Existing ownership patterns show that the forest land along streams has already been partitioned from larger upland tracts. The high cost of management within the riparian zone provides additional motivation to subdivide the land further in order to remove more of the riparian zones from timber use.

Additional forestland conversion would further diminish available timber supply, but perhaps of greater importance is the reduction in ecological services and other benefits provided by these lands remaining in forestry. The lands for which riparian harvest constraints provide the strongest economic motivation to pursue an alternative land use are the lands with the closest proximity to streams. At the same time, these are the lands that are most important for the conservation of aquatic resources. Differentially, lands being developed for non-forestry uses are not subject to the same stream buffering requirements as forestry. Depending on county-specific rules, timber can be cleared much closer to the stream for the purpose of development than for forest management purposes (Figure 9). By converting to development uses, a landowner may be able to capture additional value from the existing timber while also realizing a much higher land value. The proximity to water may even increase the property's value for development purposes.


Figure 9: A new (2006) housing development in Snohomish County, WA. Only 15 feet of forested buffer is maintained around the stream, and houses are built within 30 feet of the stream edge. Had this parcel been used for forestry, a minimum of a 50-foot no harvest buffer would have been required, with additional buffering out to a total of 90-200 feet depending on stream type and site class.

Mitigation Efforts

There have been several efforts to mitigate the economic impacts of the FFR. The Forest Excise Tax was reduced from 5% to 4.2% of the stumpage value of harvested timber for landowners (large and small) impacted by the FFR. However, the value of the timber restricted from harvest is usually many times greater than the value of the tax credit, especially for small landowners, as the value of the credit is proportional to the volume of unrestricted, harvestable timber (Reeves 2004). For the case study examples above, the economic impacts were calculated before taxes. These results suggest that even if taxes were eliminated completely, some ownerships would not be economically viable given harvest restrictions. Ultimately, while tax policies are an important factor in the economic competitiveness of forestry in Washington, tax credits alone may not carry enough leverage to offset other regulatory constraints. The regulatory impacts are several times larger than taxes and hence of greater concern for maintaining land in forestry.

Another mitigation effort is the Forestry Riparian Easement Program (FREP). The FREP is a program exclusively for small landowners which provides direct compensation for the value of timber that is restricted from harvest under the FFR. The FREP pays participating landowners 50% of the stumpage value of the restricted timber in return for a 50-year easement on that timber. In cases where the value of the restricted timber exceeds a high impact threshold of 19.1% of the total timber sale value, the value in excess of this threshold is compensated at 100%. This means that the timber value that a landowner can lose due to riparian harvest restrictions is limited to 9.55% (50% of 19.1%).

Applying projected FREP payments significantly reduced forest value costs for the case study examples (Figure 10). FREP payments coupled with maximum riparian harvest limited the costs to a range to 6.5% to 22.6% of forest value. Only the minimum trees required to be left pursuant to the FFR (i.e. the leave trees under the max riparian harvest scenario) qualify for the FREP, but even if no harvest was done in the riparian zone, the costs were reduced substantially to a range of 12.5% to 35% of forest value.

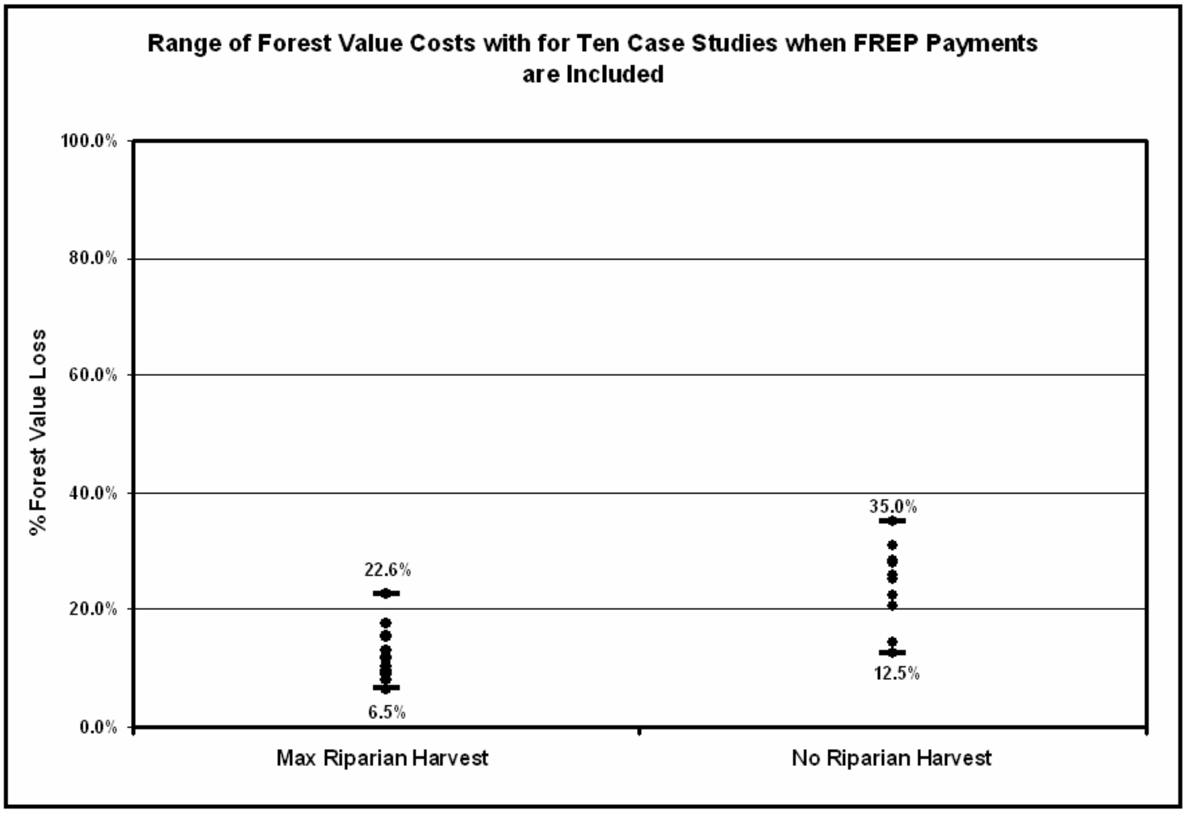


Figure 10: Forest value losses are substantially reduced by FREP payments.

While the FREP can substantially reduce economic impacts for small forest landowners, it does not fully address the impacts of riparian harvest constraints. The FREP is only applicable to small forest landowners and so it does not address the impacts of the harvest restrictions on industrial lands. The FREP also will not replace the directly restricted harvest volume. However, it does provide funds to help landowners with the additional expenses of managing within the riparian zone and thus may encourage more landowners to pursue the maximum riparian harvest which would keep harvest reductions at the lower end of the range. Furthermore, the FREP only compensates for existing timber—not for the lost economic productivity of the land that is tied up by that timber. In other words, while the FREP significantly reduces the total forest value costs, it does not change the SEV impacts and thus does not mitigate for any diminished motivation to pursue future rotations once the existing timber has been harvested and easement payments have been made.

Ultimately, the biggest limitation of the FREP may be funding. The FREP does not eliminate the costs of riparian harvest restrictions; rather it shifts those costs to the state. For the ten case studies, the present value of the total projected FREP payments was $1,914 per riparian acre. Using the same scale-up factor as before, the present value of the cost to cover all qualifying landowners would be in excess of $457 million, just for the Westside. This is equivalent to a cost of over $25 million per year, which far exceeds current funding for the entire state.

Opportunities for Management Alternatives to Achieve Desired Future Conditions

The significant economic costs of riparian harvest restrictions and the challenges of long-term mitigation of those costs suggest that lower cost management alternatives are needed. This is especially true for circumstances in which the prescribed harvest restrictions may not effectively achieve the desired future conditions. Private ownerships in western Washington are often characterized by young, dense Douglas-fir plantations. These stands would typically be thinned to maintain growth and vigor. However, commercial thinning is generally not permitted in the no-harvest portions of riparian buffers, and pre-commercial thinning is not economically attractive since the costs would not be recovered by subsequent commercial harvests in these areas. The absence of thinning would leave these areas closest to the stream that are particularly important for riparian function in a dense, overstocked condition that may inhibit the development of the DFC (Carey et al. 1996, Carey et al. 1999, Chan et al. 2004).

In anticipation of these issues, the FFR allow landowners to deviate from the default buffer prescriptions using approved alternate plans. The rules recognize alternate plans as a means of reducing compliance costs for landowners, stating that alternate plans can be used to "meet riparian functions while requiring less costly regulatory prescriptions"(RCW 76.13.110). The rules further suggest that templates be used to facilitate alternate plan preparation and approval for common situations such as young, overstocked stands (WAC 222-12-0403). Templates would outline specific strategies to serve as management models for achieving ecological and economic goals in riparian areas.

Alternate plan templates are a potential riparian management solution for achieving the DFC sooner in managed stands and for providing for greater economic sustainability, especially for small landowners. In the common case of young, overstocked stands, alternate plans can utilize thinnings throughout the riparian zone, which can accelerate the development of mature forest structure (Garman et al. 2003; Tappeiner et al. 1997). In particular, "biodiversity pathways" that utilize repeated, heavy thinnings over long rotations show promise as a management approach for quickly developing the DFC while reducing economic costs (Carey et al. 1996, Carey et al. 1999, Lippke et al. 1996).

Two example alternate plan templates for young, overstocked stands were developed based on the biodiversity pathway approach (Zobrist et al. 2004, 2005a). Both example templates utilize repeated thinnings throughout the riparian zone. Each template includes a 25-foot bank stability zone in which the overstory is not thinned below 60 trees per acre (TPA) in order to provide for continuous shade and bank stability. Beyond the bank stability zone, one template (Alt A) calls for additional buffering out to 80 feet that will receive additional thinning treatments and a regeneration harvest at age 100. The other template (Alt B) calls for additional buffering out to 50 feet but does not allow thinning below 25 TPA.

To measure the performance of template options relative to the DFC, a targeting and assessment procedure was developed (Gehringer, 2006). This procedure uses a reference dataset of actual stands that are representative of the DFC. The key stand attributes are then identified that best describe the structure represented by the reference dataset. The distributions of these attributes, when considered simultaneously, provide a quantitative management target. A stand whose attributes overlap with this target is statistically similar to the DFC as quantified by the reference dataset. In this case the reference dataset was comprised of Forest Inventory and Analysis (FIA) data that had been selected based on age, management history, and proximity to a stream. Stand density, quadratic mean diameter, and average height were identified as attributes that described the structure of the reference stands well and provided good discrimination between stands that were or were not representative of the DFC.

To compare the performance of the two example template options with the two FFR scenarios (max harvest and full buffer), each scenario was projected over time with the Landscape Management System (LMS) for a 20-year-old Douglas-fir plantation that was representative of a typical young, overstocked stand in western Washington. This test stand was site class II, and a small stream was assumed for the regulatory scenarios. The DFC targeting and assessment procedure was used to assess what percentage of time each option achieved the DFC management target over a 140-year projection. The forest value and SEV cost per acre were computed for each scenario to compare economic performance. Unlike the earlier case study results that looked at costs across the combined riparian and upland areas for each ownership, for this comparison the economic costs were computed exclusively within the riparian zone (defined as the area within 170 feet from the stream, which is the full width of the buffer for site class II) to provide cost measures that are independent of upland ownership.

The results of the template and regulatory scenario comparisons are summarized in Table 5. The two FFR scenarios had the lowest percentage of time in the DFC target because of the wide no-harvest areas which resulted in the longest delays for achieving the DFC. These scenarios also had the highest economic costs. Accordingly, the DFC/cost ratios, measures of efficient production of the DFC, were very low. The two template options achieved the DFC target a significantly greater percentage of the time, as the template options were able to achieve the DFC quickly and remain within the target over a long rotation. The economic costs of the template options were also lower. Furthermore, the SEV costs for the template options were less than 100% such that the templates did not reduce the economic return below the 5% target rate of return within the riparian buffer, which is an important criterion for maintaining a long-term incentive to keep the land invested in forestry. The combination of a high percentage of time in the DFC target and relatively low costs for the template options resulted in DFC/cost ratios that were among the highest. The template options thus appear to work well for achieving environmental goals in riparian areas while also maintaining sustainable economic returns.

Table 5: A comparison of the percent time the DFC target is achieved over a 140-year projection and the economic costs for the two FFR scenarios and two alternate plan template examples.

Scenario	Time in DFC Target (%)	Forest Value Cost (%)	SEV Cost (%)	DFC/Forest Value Cost	DFC/SEV Cost
FFR Max Harvest	32	70	134	0.46	0.24
FFR Full Buffer	31	130	228	0.24	0.14
Alt A	70	29	67	2.44	1.05
Alt B	65	22	67	2.89	0.87

For further comparison between the regulatory and template scenarios, Figure 11 shows the visual results of the FFR max harvest scenario and the two template examples after a 110-year landscape simulation. Different stand age classes were randomly assigned at 200-foot intervals along the stream. Stand units in reality would usually be much wider than 200 feet, but for demonstration purposes this simulates in a compressed space the staggered timing of treatments that would occur at the landscape level. Heavy cover is demonstrated for all scenarios both inside and outside the buffer, with the exception of the area outside the buffer between 200 and 400 feet along the stream that demonstrates a stand in an open condition for this particular time interval (110 years). In effect, at the landscape scale approximately 80% of the upland area (assuming a 50-year rotation) and 100% of the area closest to the stream is always covered.

As for the stand structure within the riparian buffer, the FFR max harvest simulation (Figure 11a) shows a wide buffer with slender, uniform trees with short crowns. The alternate plan template simulations (Figures 11b and 11c) show medium-width buffers that have greater structural diversity including larger trees, deeper crowns, and height differentiation.

(a)

(b) (c)

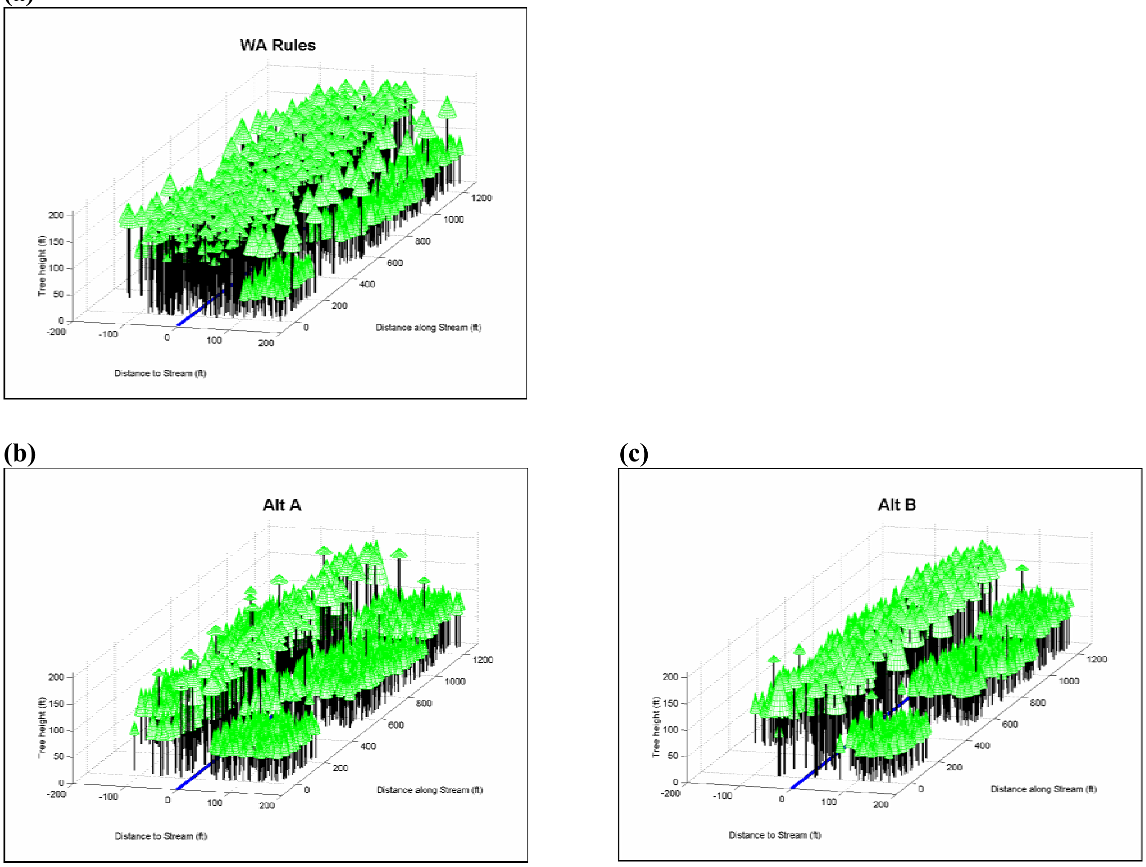


Figure 11: Visual results after 110-year landscape simulations of the default regulatory buffers for FFR Max Harvest (a) and two example alternate plan templates (b and c).

The templates framework above appears to be a promising approach for balancing economic and environmental objectives and providing higher levels of both than might otherwise be achieved without this regulatory flexibility. The simple explanation for the effectiveness of these alternative plans for riparian protection relates directly to the fact that currently, the stands along streams are much more dense than unmanaged old forests and are not on a management trajectory to reach the desired condition. By thinning the stands the value of the removed thinnings greatly improves the economic returns and the thinned stands are placed on a trajectory that reaches the desired conditions much more rapidly, and both conditions are sustainable.

The alternative plan template framework is not limited to overstocked riparian zones, but can be applied to other situations where objective measures are needed for achieving multiple objectives. For instance, the template framework has been applied to southern loblolly pine (*Pinus taeda*) plantations to help forest managers support greater biodiversity while still maintaining favorable economic returns (Zobrist et al. 2005b). The template framework may be useful for meeting other regulatory goals in Washington. This approach is currently being evaluated for the Olympic Experimental State Forest (OESF) to examine management pathways for accelerating the development of both young and old forest northern spotted owl habitat while generating revenue for the trust beneficiaries. The results of this study will be useful for looking at ways to increase older forest habitat across the state.

Eastside Forest Health Trends and Implications for Management

Eastside forests present very different problems and opportunities than the Westside. Eastside investments in forestry are very marginal hence forest management plans are more about how to sustain a revenue stream from treatments than the pay out from investing in intensive regeneration. While on the Westside the focus is on obtaining the best economics and controlling density to reach a desired future condition, on the Eastside the focus is on finding a treatment path with sustainable economics while avoiding the much more critical problems associated with excess density contributing to elevated fire and insect risk. To reduce the investment cost in the face of generally lower growth rates and sometimes problematic regeneration, management has historically relied on selective harvesting, uneven-aged management, natural regeneration and limited planting and thinning treatments. Declines in forest health associated with overstocking, past management practices, insect infestations, drought, wildfire, and other factors have become widespread making treatments that restore health of prime importance (Western Governors Association 2001 and 2002). We will first characterize changes in forest health and regulatory impacts before tackling commercial management practices and potential alternatives. Projections must take into account mortality from forest health problems and wildfire as well as removals and growth.

Mortality from Damage Agents – Defoliators, Diseases, Blights and Bears

For the most part, mortality is built into growth models based on historical average loss figures. This baseline mortality in the growth models is inherently a site specific variable as it reflects differences in habitat type*, species, various tree size metrics, stand location, maximum stand density index (SDI)* estimates, and maximum basal area (BA)* estimates (*see definitions section). Baseline mortality does not account for episodic impacts of species specific insects and diseases; neither does it reflect the differential size class changes that occur when dominant trees are removed by insect vectors such as the mountain pine bark beetle *(Dendroctonus ponderosae*), fir engraver beetle (*Scolytus ventralis*) and others, nor the loss of the best growing trees from vectors such as bear damage in western Washington. As these 3 damage agents are ranked 1, 2 and 3 at the current time (Ripley, 2006) our focus is on classifying and quantifying the impact that they have on the productivity of forests, their long term yield potential and treatments that reduce risk. Diseases, including foliar, stem, and root pathogens, are becoming increasingly important sources of forest mortality as well, but are not explicitly modeled in this analysis (http://www.dnr.wa.gov/htdocs/rp/forhealth).

Recent overview flights to assess insect and disease damage suggest that upwards of 13% of annual growth is lost to damaging agents (http://www.dnr.wa.gov/htdocs/rp/forhealth). In 2005 alone, 11.9% of the total forested area of Washington State showed elevated insect and disease damage, with most of that damage located in eastern Washington. This loss is sometimes captured in inventory data, but the timing of re-measurement, sampling changes and lack of a complete re-sample may obscure important trends. In addition, five-year trends in insect and disease outbreaks suggest a recent and significant shift in mortality patterns that have not been captured by data collected prior to 2001. Of the inventory data currently available, only 23% of the National Forest Continuous Vegetation Survey (CVS) plots have been resurveyed since 2001. The Forest Inventory Analysis (FIA) data on state and private lands pose even more challenges with respect to insect and disease correlations as plot locations are obscured to protect proprietary ownership data which makes confirming damage extent and trends problematic. Forest health overview flights can, however, be cross-correlated between re-measurements and historical aerial survey data to provide estimates of the current degree of damage and impact by owner group and forest type over time. Estimated extent and degree of damage can then be used to calibrate growth models to more effectively capture any current forest health trends.

For example the time series data provided in Figure 12 identifies the mortality and mortality per acre in eastern Washington from a single insect; the mountain pine beetle (MBP), on only two of its hosts: lodgepole (LPP) (*Pinus contorta*) and ponderosa pine (PP) (*Pinus ponderosa*). Across all ownerships, the average mortality rate for 1980-2000 is 2.2 trees per acre while for 2001-2005 the average is 8.4 trees per acre. In 2005 alone, MPB affected over 415,000 acres resulting in over 4 million dead pine trees in eastern Washington out of a total of 7.3 million trees killed by all insects, disease, animals, and weather damage across the entire state. This and other data suggest that there has been an alarming change in the character of MPB attacks. The ubiquitous nature of the MPB attacks means that impacts are no longer largely confined to LPP in National Forests, but have now become a major element in more valuable timber producing forests as well. An analysis of the aerial overview flight data indicates that in 2005, the area affected on non-federal lands was approximately three times that in 2004 while National Forests had 1.5 times the number of acres affected in 2004.

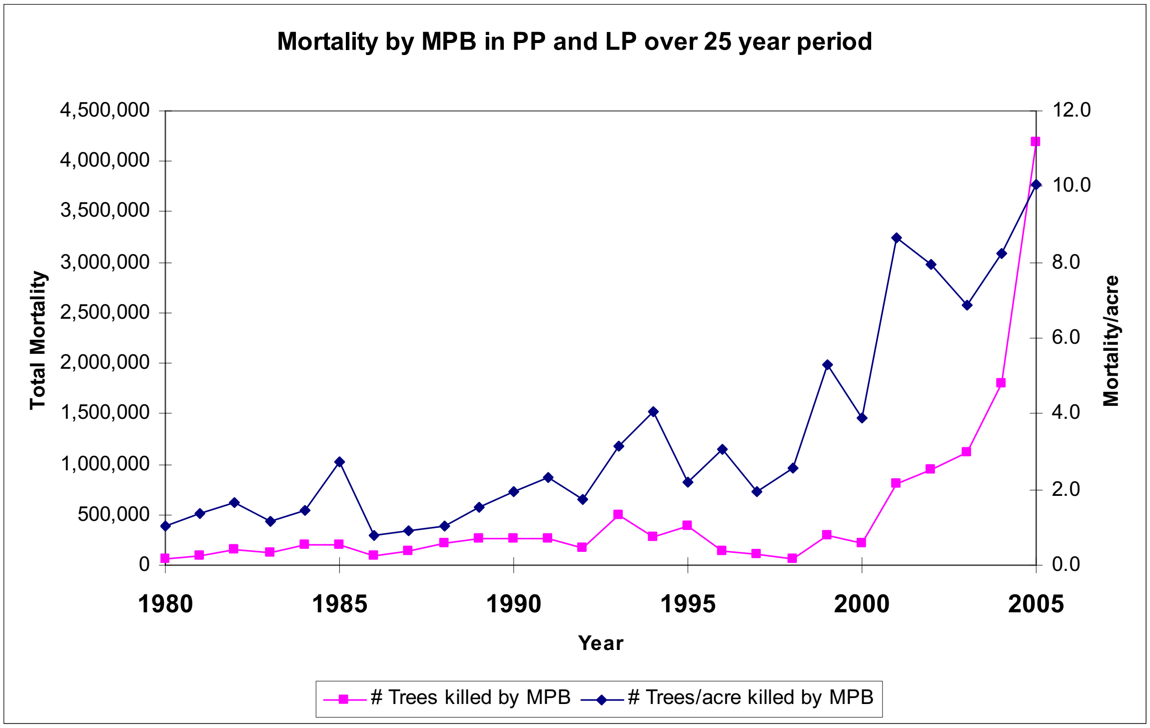


Figure 12: Time series of mortality from MPB in Eastern Washington.

In Figures 13 and 14 MPB attack data is segregated by species (PP and LPP) and location (National Forest and non-federal forests) to illustrate the substantial differences by species (about 3 TPA for PP and 11 TPA for LPP in 2005 for example) and by location (about 11 TPA affected in both species in 2005 on National Forests as compared to 8 TPA on non-federal forests).

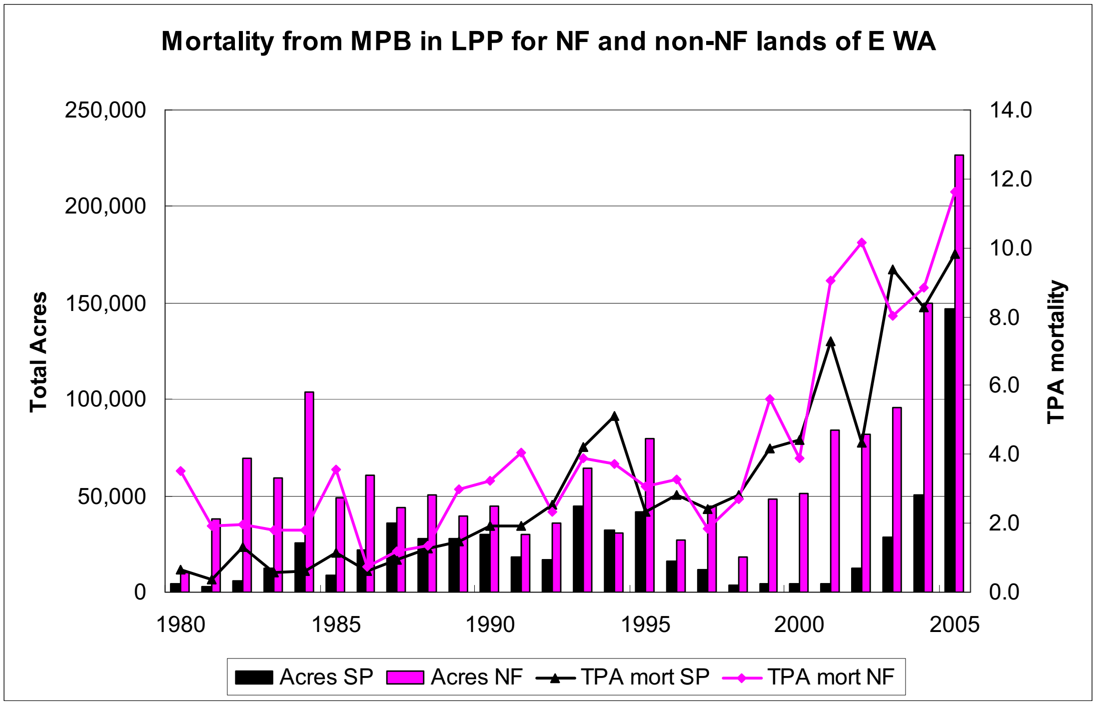


Figure 13: Mountain pine beetle mortality in lodgepole pine for State, private, and Tribal forest ownerships (SP) and National Forests (NF) 1980-2005

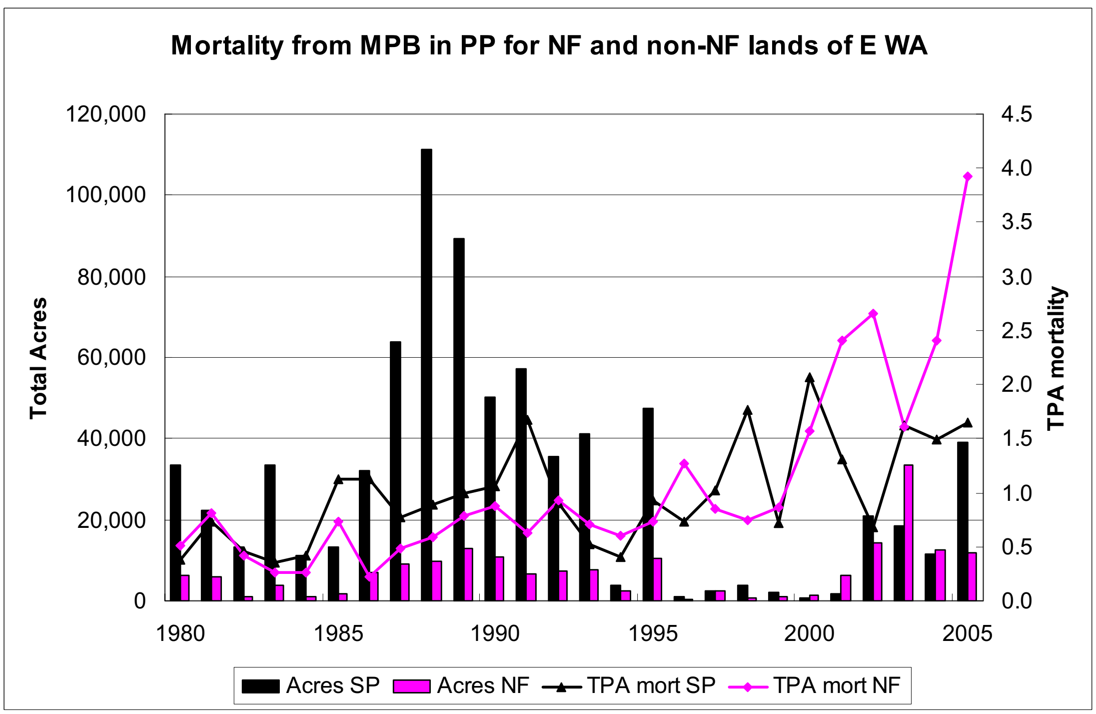


Figure 14: Mountain pine beetle mortality in ponderosa pine for State, private, and Tribal forest ownerships (SP) and National Forests (NF) 1980-2005

Figure 13 illustrates similar trends in MPB activity in lodgepole pine on both National Forest and non-federal forests which include State, private and Tribal lands. State lands refer to forests managed by the Washington Department of Natural Resources (DNR) for the benefit of trust beneficiaries. In contrast,

Figure 14 indicates a poor correlation between MPB activity on National Forests and other ownerships. The differences may be attributable to differences in management activities, age and size classes of the PP resource, or some other variable that has yet to be determined.

Just as baseline mortality equations in growth models vary by habitat type and species, so too does the expected mortality rate from insect attack. There has been extensive research documenting insect risk as being dependent upon stand density and stress (Sartwell 1971, Sartwell and Stevens 1975, Schenk et al. 1980, Schmid and Mata 1992, Shore and Safranyik 1992, and others). Hazard or risk rating systems developed from this research fail in predictive capacity when expanded outside the region where they were derived (Shore et al 1989 and 2000) and individual predictor variables commonly used in risk rating systems varied widely in their predictive power across the region (Amman and Anhold 1989). In addition the non-linear trends in recent insect outbreak conditions suggest that estimating likelihood of attack and predicting long term outcomes based on recent insect trend data requires a high resolution model that incorporates differences between habitat types and stand characteristics as well as incorporating stresses associated with extreme weather and predicted climate change. The approach taken for this analysis uses historical weather, stand density, site carrying capacity and insect outbreak variables as predictors for future trends in insect attack. This approach allows for the testing of impacts of various density thresholds in order to predict outcomes and provide management options that reduce insect outbreaks and risk across a wide range of disparate stand conditions.

In addition to Eastside forest declines associated with MPB attacks, increasing mortality trends have been observed over the past 5 years from damage in other forest types. For example, bear damage in western Washington has increased over the last decade as shown in Figure 15. This damage often affects the largest and most vigorous trees in commercial plantations rather than the slower growing stressed trees that would be the first to die in a normal growth simulation.

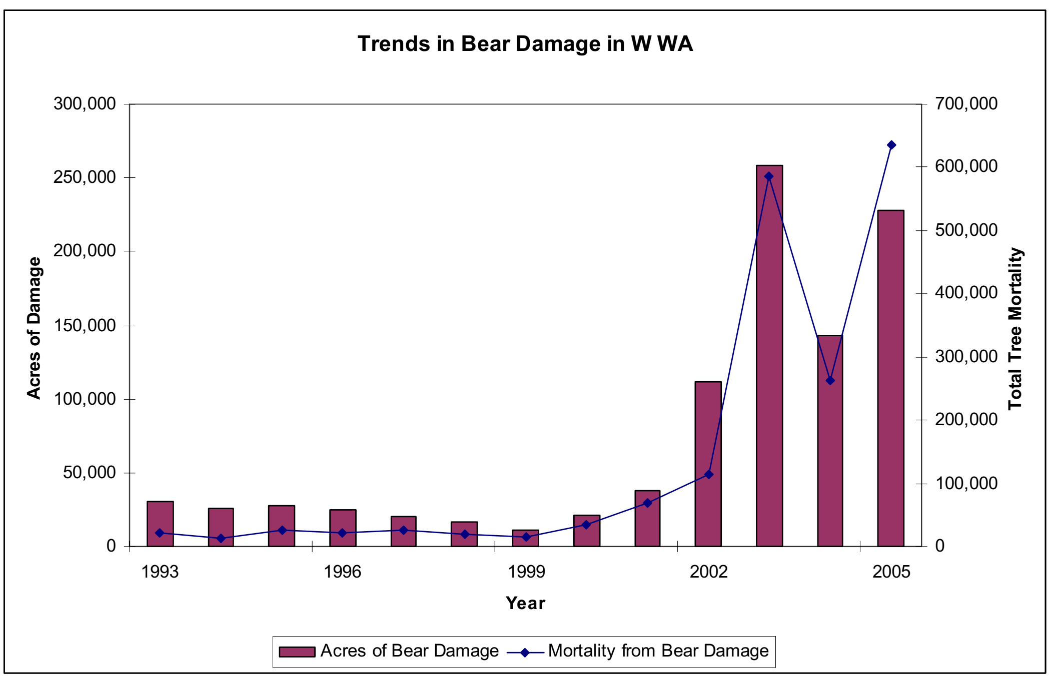


Figure 15: Bear damage trends in western Washington

Trends in the number of acres affected and tree mortality associated with forest damage agents will need to be incorporated into projection analysis in order to characterize developing forest health challenges for the decades ahead. Prior timber supply studies have not included potential mortality trends from damage agents relative to simulated management alternatives into long term growth and yield analyses.

For the current study, ARCGIS 9.0©, a geographical information system, will be used to overlay forest health polygons determined from aerial overview flights onto the CVS/FIA forest inventory plot locations for a given year. From the overlays we can obtain an estimate of the number of plots affected by a given damage vector by major timber species and owner type. In order to produce summary values for trees per acre (TPA) affected by year by species and ownership, a weighted average will be developed to estimate net mortality factors for volume reductions linked to growth and yield simulations. The impacts are reported in TPA affected for bark beetles and bear damage and low/moderate/high rankings on the defoliators, diseases, and blights.

Figure 16 displays a change in the character of MPB attacks – that is, prior to 2000 when there was an increase in MPB mortality it was concentrated in a few large patches so average polygon size was high when outbreaks occurred (as in 1984, 1993, 1994) but in the more recent years, though mortality is up, the average polygon size is low or even stable. This trend suggests a more widespread ecological footprint which will influence long term trends in forest stand dynamics. A confounding factor is that improved technology has become available starting in 2003 which improves the accuracy at capturing small polygons which tends to reduce the overall average polygon size. However, information from the data survey crew (Moore, 2006) concurs with this assumption of a broader ecological footprint for this insect in particular.

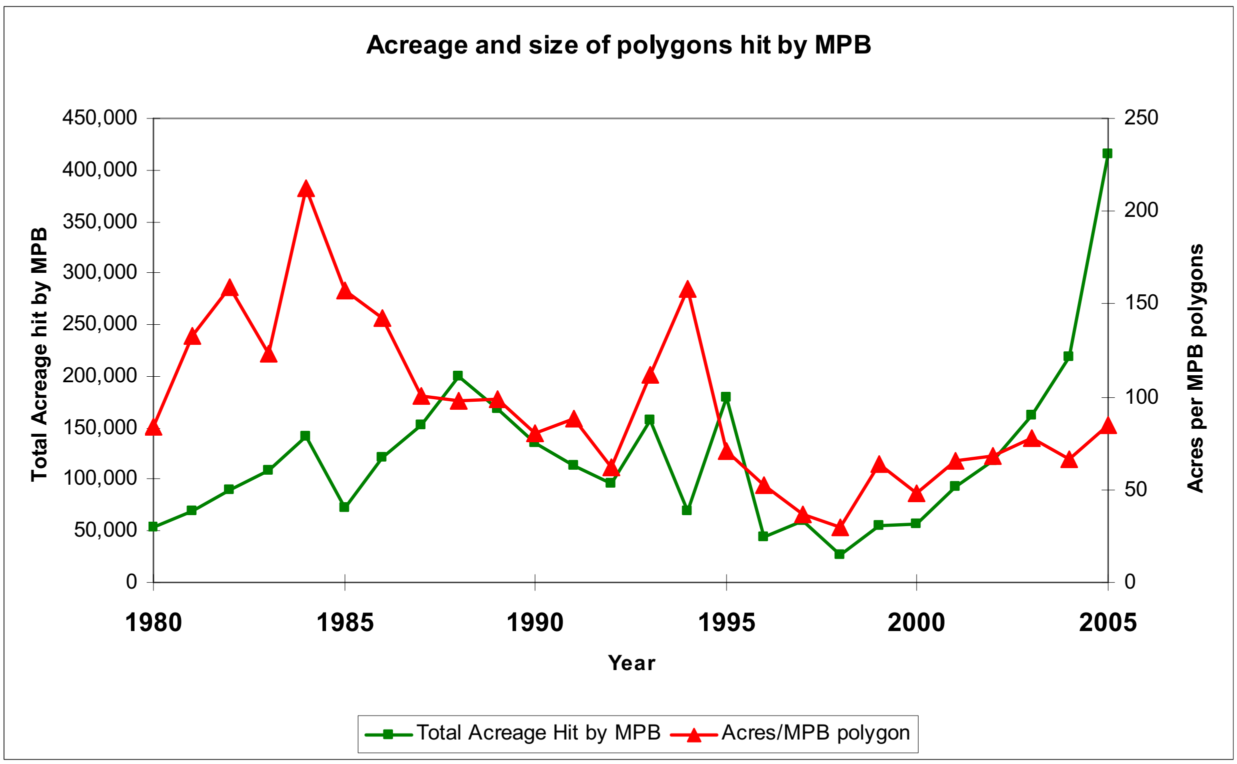


Figure 16: Acreage and size of MPB outbreaks from aerial surveys of eastern Washington 1980-2005

While the mortality increases can be built into projections and treatments can be designed to reduce the consequences of insect attacks, there remains a large uncertainty as to whether insect losses will continue to accelerate or perhaps respond to natural events such as population collapse once suitable host species have been eliminated. An alarming scenario can be drawn by comparison to the problems being experienced in British Columbia where uncontrolled forest health conditions have destroyed millions of acres (Eng et al. 2006).

Forest Fire Risks and Impacts

There is general agreement that many overstocked and drought-stressed forests in the Inland West are decades out of historical fire return intervals and are uncharacteristically at risk from catastrophic crown fires (Graham et al. 2004, Arno 2000, Pyne 1997). As a consequence of large intense forest fires in the inland west over recent years, considerable public attention is being directed at the question of how to reduce hazardous fuel loads from the overly dense forests that characterize the region (DNR 2004, Western Governors Association 2001 and 2002, The White House 2003). Fire hazards relate to infestations in reciprocal ways as burned stands become a suitable host for infestations and the overly dense stressed stand conditions resulting largely from fire suppression increase both fire hazards and the risk of infestations (Agee 1993). However, forests thinned to remove excessive fuel loads can be restored to more open conditions and have been found to be unlikely to experience destructive crown fires (Omi et al. 2002).

A recent study of the Okanogan National Forest in Washington found that greater than 70% of these federal forestlands could be classified, based upon potential crowning fire indices, as having a medium to high risk of a stand-replacing crown fire (Mason et al. 2003). Mason et al. also conducted analysis to examine a spectrum of fuels removal treatment intensities to reduce fire hazards. In particular it was shown that neither a light thinning from below such as removal of all trees 9 inches diameter at breast height (DBH) and smaller or removal of only the largest merchantable trees, 12 inches DBH and larger were effective in reducing fire hazard. The most effective treatment for reducing fire hazard was to thin from below to a target of 45 square feet of basal area while leaving the largest trees. Since a portion of the trees removed have merchantable value, some stands can be treated with positive net revenue while others will be costly. However, even though fuels removal treatments may result in operational costs over and above log revenues, this study suggests that there are many non-market benefits or avoided costs (such as the value of habitats and the costs of fighting fire) that are important. A first attempt at estimating these costs and benefits was provided by Mason et al (2003 and 2006) and appears to show that the benefits will likely exceed the costs of aggressive treatments to reduce fire hazard.

Private harvest treatments have a greater operational focus on providing economic returns than restoring a fire resistant overstory for ecosystem values. Consequently, many Eastside private forestland owners have adopted management strategies for successive selective harvests of merchantable logs generally occurring every 20-30 years. These treatments can be costly, however, if pulp markets are low and all the non-merchantable ladder fuels are removed. Avoiding the costs of fire and the potential impact to private property can be an important motivation for fuels removals on private as well public forests (DNR 2004).

A brief summary on market and non-market values associated with fire hazard reduction (Mason et al. 2003, 2006) has been included in Appendix A to provide more complete accounting on the multiple public benefits of investments to reduce forest fire hazard. Appendix B provides information on the accelerating costs of fighting forest fires. Appendix E provides information on biomass use for renewable energy as one of the promising opportunities to provide financial incentive to undertake fire risk reduction treatments.

Eastside Forest Practice Regulations: Response and Impacts

Since the last Eastern Washington timber supply study was released in 1995 (Bare et al.), the harvest impacts associated with federal and state protection of threatened and endangered species such as the northern spotted owl (*Strix occidentalis*), the bull trout (*Salvelinus confluentus*), the Canadian lynx (*Lynx canadensis*), several species of salmon (*Oncorhynchus ssp.*) and others have been significant. Emergency forest practice rules to address threatened and endangered species listings came into effect in 1997 and were followed by the Forest and Fish Rule (FFR) package in 2001. Regulatory changes have varied in impact and intensity by landowner owner type resulting in shifts in the amount and location of harvest, the type of harvest, and the condition of the remaining forests. To understand differing regulatory responses and outcomes it is important to understand the impact on specific owner situations as well as broad scale harvest trends across timbersheds and owner types.

Broad scale regulatory impacts

As anticipated in the 1995 timber supply study, harvest volumes have declined dramatically from National Forests in response to ESA listings and planning requirements as illustrated in Figure 6. The 1995 report used publicly available Forest Service planning documents to estimate probable harvest volumes by national forest and timbershed for the entire one hundred year planning horizon. The extent of the harvest decline appears to be approximately 82 million board feet (MMBF) per year for the federal forests located in eastern Washington. Currently the Colville, Okanogan, and Wenatchee National Forests are developing new forest plans that may alter this harvest level. Forest plan drafts are still in the public comment period and, subsequently, no information regarding potential changes in harvest levels is currently available.

Declines in harvest on public lands were offset to some degree by an increase in harvest volume from private owner groups as indicated in Figure 17. Some of the harvest volume increase was the result of aggressive forest health treatments on Tribal forestlands. Small private forestlands and, to a lesser extent, large private non-industrial forestlands showed harvest volume increases during the last decade, as indicated in Figure 18. It is not known if the decline in industrial harvest volumes during the 1993-2002 time period has any connection to the emerging trend toward sale of industrial timber lands to timberland investment management organizations (TIMO's), real estate investment trusts (REIT's), or other investment groups. Timber volumes harvested from State trust lands managed by the DNR did not appear to vary in response to increased protection of threatened and endangered species in spite of the creation of a habitat conservation plan (HCP) to protect spotted owl habitat across much of the East Cascades region.

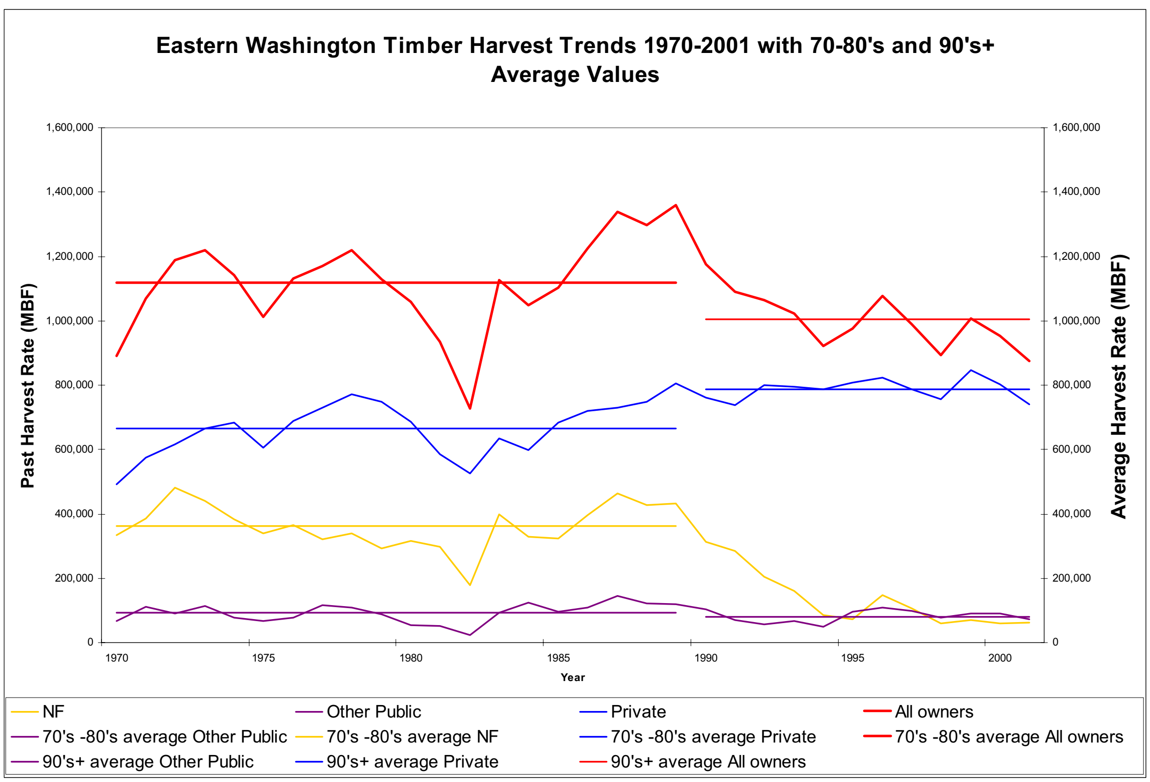


Figure 17: 30 year timber harvest trends in Eastern Washington by owner group

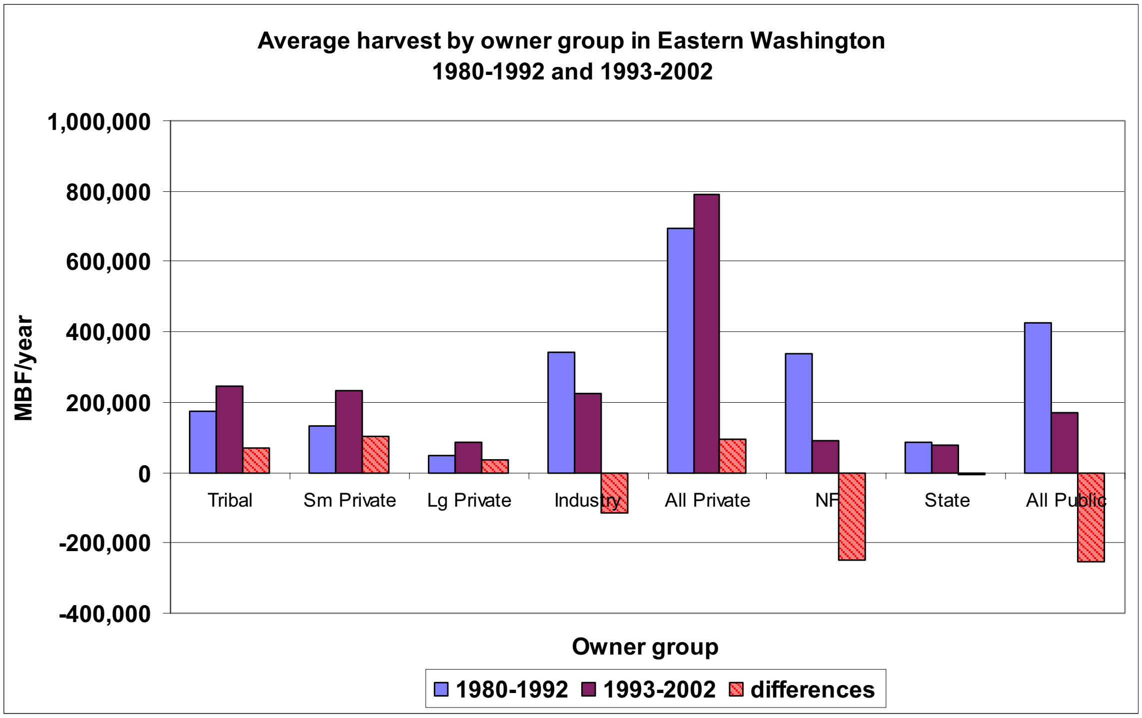


Figure 18: Harvest trends from 1980 to 2002 for eastern Washington owner groups.
(Data summarized from WA DNR harvest summary 1965-2002 at http://www.dnr.wa.gov/htdocs/obe/obehome4.htm)

Preliminary analysis of FIA data using median inventory values for each habitat type suggests that private harvests cannot be sustained at the 1993-2002 rates. The fall down in available volume is most pronounced in the East Cascades timbershed, but reduced availability also appears likely in northeastern Washington. If expected declines in private harvest are to be offset to sustain the current milling capacity an increase in public harvest volumes will be needed. Changes in the type of milling capacity in order to utilize even smaller diameter wood may alter fall down estimates and serve multiple benefits such as providing economically viable opportunities to remove excess biomass to address forest health needs, supplying emerging biofuel markets, and reducing fire suppression costs. Analysis of the wood supply needed to support these opportunities for renewal of both forests and rural economies are integrated into the alternative treatment regime options discussion for Eastside forests.

Merchantability specifications have altered since 1995 resulting in more wood volume being merchandized to a smaller top diameter. Since 2001 merchandizing trends include selling larger logs and a greater percentage of the harvest as tonnage wood. The small diameter market has provided an opportunity for private landowners to economically remove 6-10 inch dbh material as tonnage wood but the market for pulp logs was poor. Loss of a pulp market eliminates opportunities for private landowners to remove very small trees in order to meet habitat and forest health objectives. Concurrently the strong hewsaw market results in the removal of mid sized trees that would be potentially recruitable into the overstory as large diameter trees. This shift to tonnage wood may result in changes in local and state revenue streams via the excise tax as well as adjustments in milling capacity with the elimination of price premiums for larger diameter logs. These shifts in merchandizing and operability will also affect how landowners respond to changes in regulations to address short and long term habitat values, water and forest health issues. Predicting the boundaries of potential outcomes of the complex interaction between regulatory change, market forces, landowner choice, forest health, and biological carrying capacity using alternative scenario testing will be completed in the later stages of the project.

Eastside Impacts of the Forest and Fish Rules on Small Landowners

The adoption of emergency rules covering bull trout in 1997 and the FFR in 2001 has meant that eastern Washington private forestland owners must operate within regulatory constraints that were not anticipated in earlier timber supply analyses. Case study analysis covering a diversity of sites in Okanogan, Pend Oreille, Stevens, and Whitman counties have been conducted to examine the impacts of the FFR on eastern Washington small forest landowners. Computer simulations of forest stand development and economic outcomes were developed to estimate landowner losses as a result of changes in regulations across the region (Oneil 2005). Simulations suggest that because of the cost of compliance with new forest practice regulations, there is no economic return from the affected acres unless they participate in the State-funded forest riparian easement program (FREP) at the time of harvest.

Despite the gains that can accrue under the FREP, a review of Forest Practices Applications to the DNR indicates that the vast majority of small forest landowners are choosing to forego both riparian harvests and participation in FREP. Anecdotal evidence suggests that the complexity and cost of rule implementation results in most of the riparian areas becoming de facto reserves. Riparian reserves are effectively removed from the working forest land base with subsequent reductions of harvest yields and revenues. As there are far fewer stream miles in eastern Washington than in western Washington, the impact of these riparian reserves on timber supply is smaller, but not inconsequential.

The impact of riparian reserves on forest health may be much more significant (WADNR 2004) than the harvest volume constraint on available timber supply as options for continued entry to reduce insect and disease risk are not feasible under the FFR. The stated intent of the forest practice rules in eastern Washington is to provide for restoration of riparian function while reducing risks associated with fire, disease, and insects. However, with little economic justification to enter the riparian zone, there is a loss of willingness and ability to mitigate the impacts of insects, disease and wildfire in these areas. Presentations to the 2004 Forest Health Working Group suggests that the role that unmanaged densely stocked riparian zones play in exacerbating the spread of fire in particular is much greater than the percentage of the land base that they occupy (Berndt, 2004).

In cases where the biological intent of the FFR cannot be met with the current rule package, the adoption of alternative strategies that integrate forest health, habitat and economic values may provide a solution. Work to develop alternative strategies which are identified as Alternate Plans (AP) in the adaptive management component of the State forest practice rules is ongoing, but as yet streamlined approaches have not been developed for widespread implementation. An examination of potential forest health treatments is included in the section on ‘Eastside Commercial Forest Harvest Alternatives’.

Treatment Regimes for Eastside Forests

Forest Groups

Eastern Washington forests are a complex mosaic of species mixes, habitat types, productivity classes, and ownerships. In order to condense the complexity and diversity of the Eastside region into a relatively small number of groups to demonstrate treatment regimes, forest types are grouped according to an elevation gradient and moisture regime that captures many of the productivity and species composition differences. These broad groupings are identified as **dry forests**, including ponderosa pine, dry Douglas-fir (*Psuedotsuga menzeisii*) and dry grand fir (*Abies grandis*) habitat types, **moist forests**, with most of the mixed conifer forest types including moist Douglas-fir, grand fir, spruce (*Picea englemanii x glauca*), western larch (*Larix occidentalis*), and western red cedar (*Thuja plicata*) – western hemlock (*Tsuga heterophylla*) habitat types at mid elevations, and **cold forests**, which include subalpine fir (*Abies lasiocarpa*), spruce, and lodgepole pine forests at high elevations. These groupings are commonly used for wide-scale fire hazard assessments as well as for differentiating treatment regimes. These groupings are also useful as variability in ownership pattern and resulting management intensities are generally correlated with elevation and eco-type.

Heterogeneity Within Forest Types

Within the dry, moist, and cold forest categories there are a large number of habitat types that reflect unique moisture and species composition gradients. Additionally there is significant heterogeneity in stand structure and condition within each habitat type. For example, Figure 19 shows the range of quadratic mean diameters (QMD) for the habitat types of National Forest lands in the East Cascades. The broad range of stand structures within a given habitat type drives the approach used to estimate growth and yield across the landscape. That approach relies on simulating growth, yield, a range of potential management actions, mortality, and recruitment for individual plots prior to aggregating into the appropriate strata. The plot level predictions are scaled and aggregated to strata based on broad forest group (dry, cold, moist), timbershed, and ownership type.

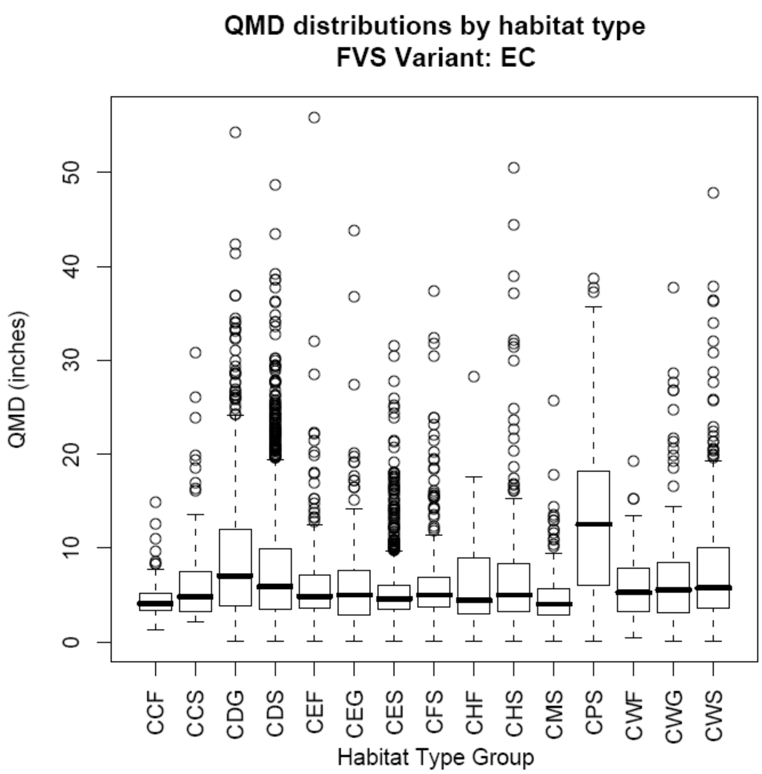


Figure 19: Range of QMD for plots in the habitat types found on National Forests along the East Cascades

To estimate growth and yield we use the three regional variants of the Forest Vegetation Simulator (FVS), a Forest Service growth and yield model, which cover the geographic extent of eastern Washington forests. These variants are the Inland Empire (IE) variant for northeastern Washington, the East Cascades (EC) variant for the East Cascades, and the Blue Mountains (BM) variant for southeastern Washington.

Within each FVS variant there are a range of habitat types that generate substantially different yields for a given species reflecting the inherent variability in growth potential. Figure 20 provides an estimate of the range of growth expected for ponderosa pine in all the habitat types where it is found in the FVS EC variant. In this example the ponderosa pine was 'planted' at 400 TPA and grown for 100 years without further treatment. Yield as measured by basal area varies from a low of 83 square feet per acre on the driest sites to a high of 290 square feet on the wettest and most productive sites.

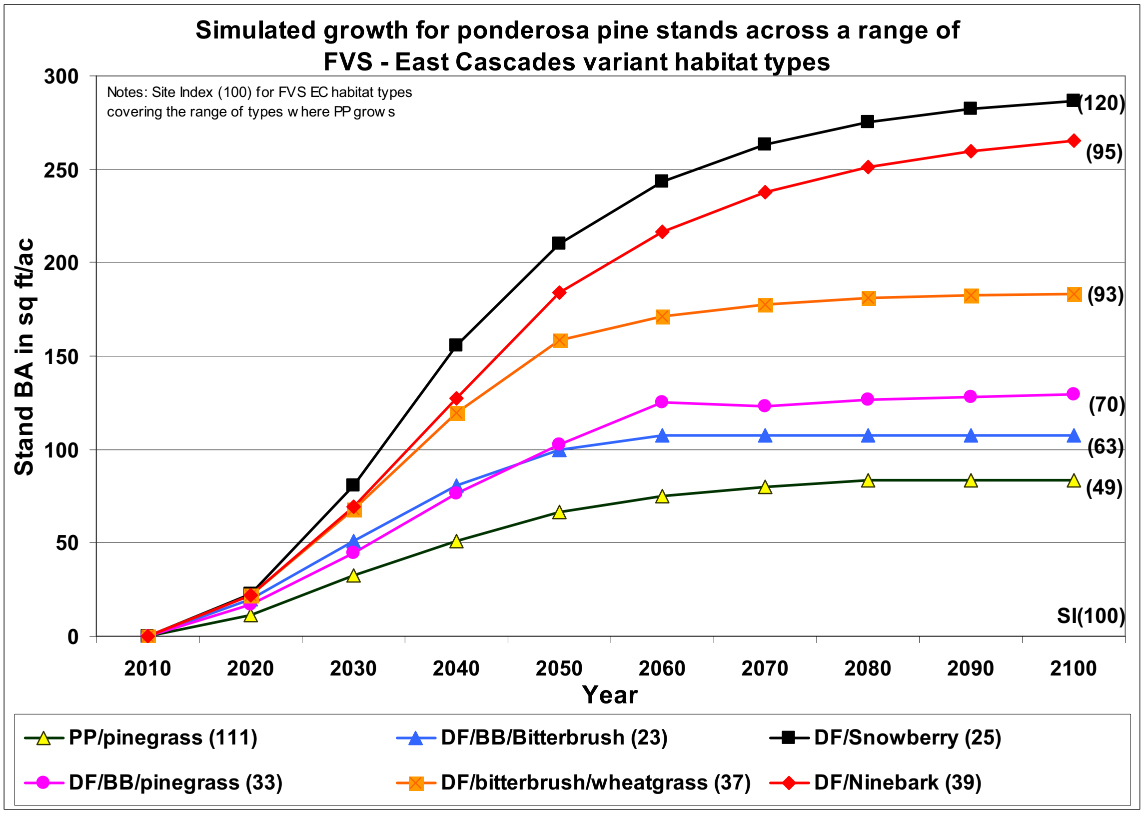


Figure 20: Simulated ponderosa pine yield for a range of habitat types in the FVS East Cascades variant

To capture this range in growth potential, individual plots will be grown in the habitat type indicated by their respective data sources (FIA or CVS). For FIA data where habitat type is identified only to the level of tree species, plots will be mapped to the closest habitat type based on a comparison of plot site quality variables to FVS habitat type site quality estimates used for modeling. In the absence of plot site quality estimates, the individual plots will be assigned a habitat type of average site quality and the same dominant tree species.

Management Intensities

The timber supply analysis will include one management treatment scenario developed to reflect current practices for each owner group (the base case) and a series of management scenarios developed to investigate potential alternative management intensities and forest health treatments dependent upon owner type. The primary management objective for many private forestland owners is sustainable economic returns from harvest activities. Private forest managers periodically remove merchantable trees while retaining those trees, often in the understory, with the potential of growth towards future merchantability. This management approach is called uneven-aged management. In situations where the understory growth potential becomes inadequate to support the next re-entry, a regeneration harvest using clearcut, shelterwood or seed tree methods along with planting of seral species is initiated. Variation on these treatment options have been customized for each owner type based upon merchantability of the standing inventory and the need for density control to improve forest health. A general threshold for merchantability is met with a standing volume of 6000 BF per acre with some limits on minimum diameter and height. Statutory green tree retention of a minimum of 4 TPA >10" DBH after harvest is required. Once merchantability criteria are met, threshold assessments test understory and pole sapling layers to determine if they are sufficient for an overstory removal with some culturing of residual understory. Specific assumptions associated with treatment regimes by ownership classes within the three forest types are highlighted below.

Large Private and Industrial Treatment Regime

Dry Forests

The treatment regime is a shelterwood thin from below to re-establish the next crop retaining 25-40 TPA first entry, but with no required retention of the dominant cohort except for statutory requirements for green tree retention.

Moist Forests

The treatment regime is a periodic entry to remove merchantable volume, with only minimal stand improvements and promotion of non-seral understory. Alternative strategies in moist forests also depend on regular stand entries with aggressive focus on re-establishment and stand improvement with more fill planting and stand tending.

High Elevation Forests and Wet forests (includes LPP)

The treatment regime is a No Retention even-aged strategy that leaves a minimum of 4 TPA>10"DBH following regeneration harvest to meet statutory requirements for green tree retention.

Small Private Treatment Regime

Dry Forests

The treatment regime is a shelterwood thin from below to re-establish the next crop, with some retention of the dominant cohort for non-timber values.

Moist Forests

The treatment regime is a periodic entry to remove merchantable volume, with only minimal stand improvements and promotion of non-seral understory.

High Elevation Forests and Wet forests (includes LPP)

The treatment regime is a No Retention even-aged strategy that leaves a minimum of 4 TPA>10"DBH following regeneration harvest to meet statutory requirements for green tree retention.

State Lands Treatment Regime

Harvests on state forests assume similar treatment regimes as those for private forests with the following exceptions. In retaining dominant and codominant leave trees as part of a statutory requirement, a seedtree system, or as a shelterwood, the largest trees in the stand are retained rather than leaving the smaller trees of the required size class. Additionally, more trees are left in dominant and co-dominant size classes for a given treatment regime.

State and Private Planting

Treated forests are fill planted with seral species in the range of 250-350 TPA with some natural regeneration from overstory trees. The seral species mix contains ponderosa pine and often contains western larch, western white pine (*Pinus monticola*), and sometimes Douglas-fir depending on habitat type. As well as 'fill planting' with these species in cases where the understory is removed, the simulations also include the addition of a 'natural regeneration' component to the stand depending on the level and intensity of treatments applied. This natural regeneration component varies by habitat type as well as reflecting the overstory component of the stand.

National Forests Treatment Regime

National forests base case management intensity applies restoration strategies to reduce fire and insect risk with a target volume removal based on current (1995-2003) harvest trends as indicated in Figure 17. These national forest harvest strategies are applied to plots located in dry and moist forests that roughly correspond to areas within the Wildland Urban Interface (WUI). The management intensity assumes that only the current harvest volume will be removed, regardless of the number of potentially treatable sites that are available on National Forest land.

Treatment regimes for National Forests assume that thinning from below is standard with trees removed up to a diameter limit of 12" dbh. After that limit is reached, on pine stands at risk for mountain pine beetle outbreak, a further removal to a basal area of 60 square feet/acre is also applied. No planting is assumed, but natural regeneration is included in the simulations with species compositions based on forest type, overstory species composition, and habitat type.

Treatment Alternatives

Eastern Washington forests are facing extreme pressure from stand-replacing fire and insect and disease outbreaks as indicated in the section on forest health. The historic management approach over the last 100 years has favored continuous forest cover and 'uneven-aged' management strategies combined with fire suppression. In all but the driest forests, this management strategy has produced multi-layered stands of shade-tolerant species on sites previously dominated by single-storied seral species. Fire suppression has homogenized stand structure and species distributions as well as increased the overall stocking and biomass levels in the forest. These past practices have created conditions suitable for extensive insect and disease epidemics and high fire risk. Against this backdrop of legacies from past management, it is necessary to overlay a complex pattern of land ownership, a wide array of management goals, and challenges in meeting those goals because of the lack of infrastructure for removing excess fuel accumulations and small diameter wood from the forest.

Because of the tight complementarities of economic, social, and biological systems in eastern Washington, effective alternative strategies must address all criteria simultaneously. Thus treating forests to increase their resilience to insects and disease requires an approach that addresses economic and social criteria as well. The diversity of ownerships and situations suggests that approaches will vary across ownerships. For example, private forest land owners have the option to aggressively salvage affected trees and reduce the rate of insect spread by preferentially harvesting at-risk stands and those with active beetle populations. They also have much greater latitude in determining which trees to take and which to leave. Public land owners have a much more challenging task in addressing the risks and impacts from insects and disease because of the work necessary to perform required impact analysis and to obtain agreement among many stakeholders. Using different types of alternative strategies for different situations and owner types results in a wide range of biological solutions that may be economically justified.

Alternative strategies to maximize private landowner economic goals by increasing management intensity are possible, but this requires substantial increases in intensity in areas that have not historically been high timber producing regions. Maximizing volume through increased management intensities may not necessarily produce a greater net present value (NPV) as the higher volume and value tends to be generated later in the simulation period and the investment in planting and stand tending occurs early on in the simulation period. While long-term forest productivity, forest health restoration, and community stability in the historically poorer regions of the state could benefit from increased management intensity on private lands, economic criteria suggests that increased investment in forestry for small private landowners are not likely without greater incentives.

From a timber supply perspective, the potential for increased management intensity on state lands would seem to be more likely than it is on private lands given the historic low level of management intensity and the acreage that is overstocked relative to its historic carrying capacity. Alternative strategies focus on integrating forest health concerns with habitat objectives. According to a presentation to the Forest Health Working Group in August 2004, the DNR's Southeast Region is poised to take on the dual issues of habitat conservation and forest health using an approach that moves forest condition to a more historic cover type via active management to remove grand fir and Douglas-fir understories from ponderosa pine and dry Douglas-fir forest types. This approach is estimated to increase available timber volumes from the DNR Southeast Region in the near term, while meeting forest health and habitat concerns (Shelton, 2004).

Management alternatives for the National Forests center on managing fire hazard on all dry forests and moist Douglas-fir and grand fir forests, as well as managing insect risk on lodgepole pine forests. Treating all National Forest acres within the first three habitat types roughly corresponds to thinning in low and mixed severity fire regime locations with a concentration on the WUI in the first decades. With the inclusion of treating lodgepole pine types the alternative would also manage the escalating impact of mountain pine beetle in lodgepole pine forests. In order to maintain the benefit of thinning treatments with respect to fire safety, additional treatments are required on a 30-40 year return interval. Depending on the growth of regeneration and the overstory, the second and subsequent entries typically do not yield much merchantable volume and thus are categorized as fire safe treatments. These treatments do not contribute merchantable volume toward timber supply, or generate net carbon benefits with respect to the products stream, but will ameliorate fire risk and its resulting carbon release. The alternative regime assumes that continued management to reduce fire and insect risks would occur despite lack of financial incentive after the first treatment. These treatments, while not justified by market values, have been demonstrated to produce many benefits above and beyond their cost including avoided fire fighting costs, reduced acres burned, increased carbon stored, biomass removed and other non-market values. A brief summary of the magnitude of potential avoided costs and non-market values is included in Appendix A.

Single Acre Simulation Examples of Alternative Strategies to Address Forest Health

Treatment alternatives were simulated on two of the more prevalent forest types: a ponderosa pine type in the Okanogan area and a mixed conifer type in northeastern Washington. The analysis identifies break points between economic return and reducing stand susceptibility to insects, disease, and fire. For each alternative, we report on the likelihood of risk reduction, economic outcomes, and the subsequent level of additional cost or incentive that might be needed to encourage landowners to adopt a specific treatment. Given the array of management goals across the ownerships of eastern Washington, there is no best single management alternative. Analyzing alternatives provides a useful comparison of trade-offs, costs, and expected outcomes for meeting forest health goals.

In the ponderosa pine forest type, the stand used for analysis was a fully stocked merchantable ponderosa pine stand that is currently experiencing mountain pine beetle (MPB) mortality because of excessive density and basal area relative to site carrying capacity. On this very dry site, the ponderosa pine is regenerating (albeit poorly) under its own shade, which allows for treatment approaches that would not be as successful on wetter sites. Periodic stand entries were simulated using four different treatment regimes: (1) **Max NPV**—maximizes net present value of cash flows through removal of merchantable volume to the limits permitted by state forest practices laws; (2) **Partial Retention—**partial cutting from below to a target basal area; (3) **Overstory Maintenance**—treatments to move the stand toward 'old growth' conditions with a few large trees/acre including understory removal; and (4) **No Action**—assuming no disturbance (note that with high fire hazard the stand would likely burn early in the period).

Figure 21 demonstrates the diversity of stand conditions present after the first entry and 40 years forward in the simulation for the three treatment types that have active management undertaken. While the short term results look very similar, in the long term Figure 21 demonstrates the variability across the landscape that might occur with the application of these three treatment types, the most notable being the elimination of understory recruitment in a true overstory maintenance treatment. Both Max NPV and Partial Retention emphasize initial overstory retention to facilitate regeneration and result in very similar residual stand conditions depending on leave tree characteristics. Both treatment regimes can immediately move stands away from high hazard thresholds for fire, insects, and disease, regardless of differences in the long-term management goal. These two alternatives would likely be acceptable choices for an array of private landowners that had various degrees of interest in maintaining large diameter trees for their long-term habitat attributes.

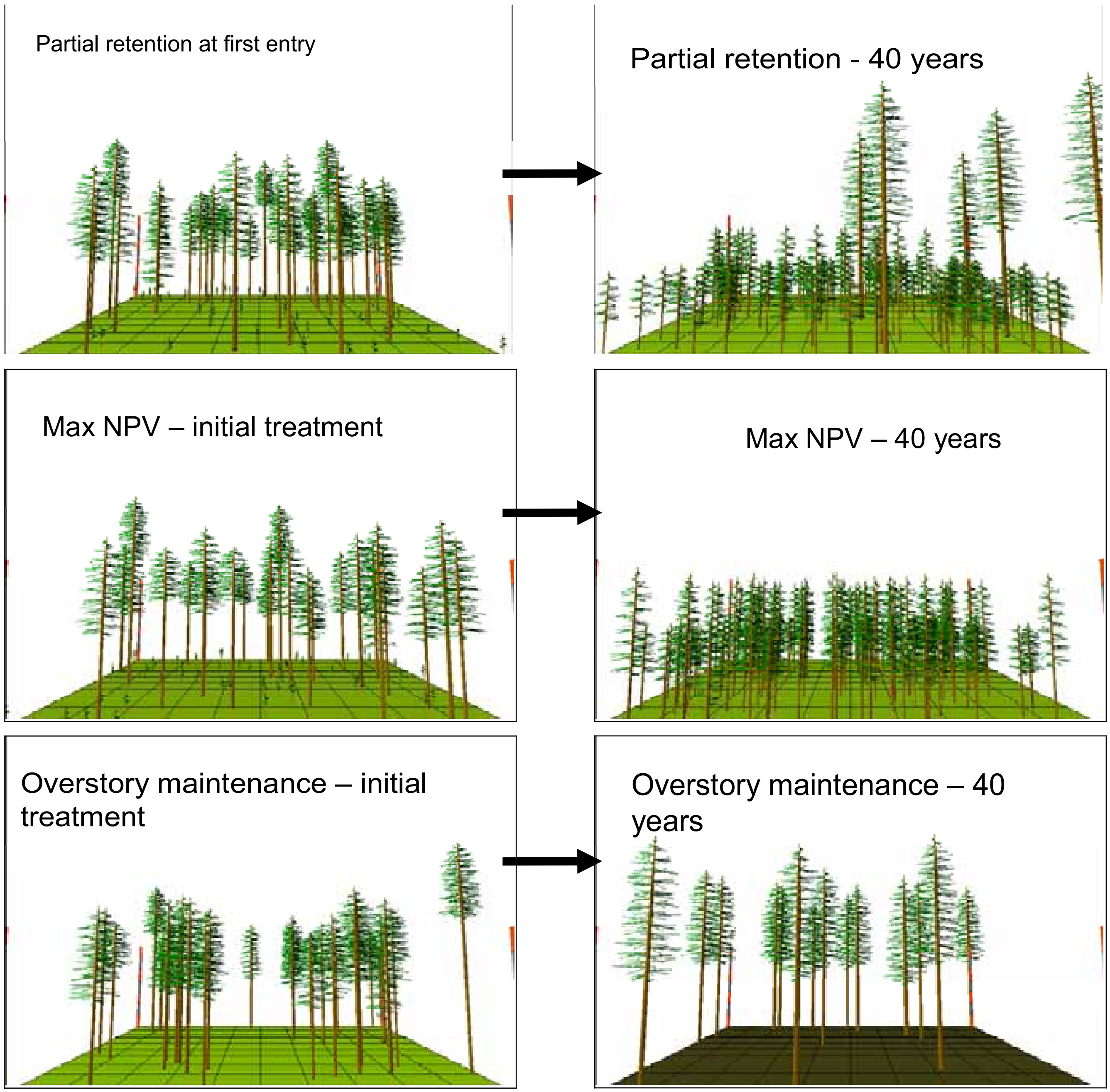


Figure 21: Three management options for dry forests showing initial stand conditions and 40 years forward in the simulation

Table 6 gives the range of basal area, density, hazard ratings for fire and MPB, and economic values over a 90-year simulation period for all simulations including the No Action alternative. For the Max NPV and Partial Retention Scenario the residual basal area (BA) after treatment is capped at 60 while overstory maintenance continues to increase over time even as the understory is removed to keep the fire risk down. Tree density values assume regeneration in managed scenarios, but assume negligible regeneration in the No Action scenario because the overstory does and would continue to eliminate the potential for natural regeneration in the absence of mortality from bark beetles or fire. The bark beetle risk increases when BA exceeds carrying capacity, as it does in the Overstory Maintenance scenario in latter years and the No Action alternative throughout the simulation. Crowning index is the predicted wind speed at which a ground fire would move into the crown resulting in tree mortality (>50mph low risk, 25 to 50mph moderate risk, <25mph high risk). Thus low crowning indices indicate that low wind speeds are all that is required to cause tree mortality and the risk of crown fire becomes higher. All treatments reduce the risk of crown fires, but even without treatment the lack of viable understory and high live crowns in this particular stand preclude high fire risk under normal fire conditions in the No Action scenario. Only in cases of running crown fire would the high crown density in the No Action alternative produce significant changes in fire risk relative to the managed scenarios assuming that canopy base height is low enough to initiate a crown fire (Graham et al, 1999).

Table 6: Predicted mortality rates and economic returns for a ponderosa pine stand under four treatment scenarios

Ponderosa Pine Scenarios	Max NPV	Partial Retention	Overstory Maintenance	No Action
BA range (across decades)	9 to 53	20 to 60	60 to 78	111 to 183
BA ave. (sq.ft.)	32	28	68	161
Crowning index range (across decades)	40 to 106	41 to 88	60 to 134	41 to 63
Crowning index average (mph)	63	61	98	48
TPA range (across decades)	25 to 475	83 to 335	15 to 281	61 to 147
TPA ave.	164	157	96	105
NPV $@5%	$3,586	$2,652	$1,109	(-)
Cash Flow (decades entered)	5 times	5 times	2 times	none
Beetle risk	Low	Low	Marginal	High
Fire risk	Low	Low	Very low	Moderate
Sustainable econ	Yes	Yes	No	No

Table 6 indicates that the discounted financial returns per acre for the three treatments in ponderosa pine are positive, primarily because the stand has a significant merchantable component. Reduced returns from the Partial Retention treatments are a result of retaining some large diameter overstory trees that would otherwise have been removed in the Max NPV alternative. In contrast to the first two alternatives, Overstory Maintenance treatments are designed to produce a widely spaced dominant pine overstory. Reduced returns from these treatments are a function of lost revenue beyond the second entry coupled with continuing financial obligations for understory removal, either mechanically or by burning, to ensure that the stand does not become overstocked and multi-layered and thus susceptible to MPB attack and increasing fire risk. The overstory maintenance approach is not considered viable for private landowners, but may meet the non-market goals of public and Tribal landowners.

The mixed conifer stand case study examines the potential treatment outcomes from a commonly occurring situation where a stand has been repeatedly harvested over the past century using selective overstory removal techniques. In the case study, the stand is composed of grand fir, western red cedar and Douglas-fir that are growing slowly on a dry Douglas-fir habitat type that does not support rapid growth of these species. The stand is currently not merchantable, but within 30-40 years, a large component of the intermediate cohort would become merchantable.

Periodic stand entries were simulated using four different treatment regimes: (1) **Max NPV**—removal of merchantable volume at regular cutting cycles; (2) **OS with Retention**—overstory conversion to a seral species mix with retention of dominant Douglas-fir to provide structural diversity; (3) **OS without Retention**—no retention of dominants (required wildlife trees in adjacent riparian zones are retained); and (4) **No Action**—assumes no disturbances. Figure 22 demonstrates the diversity of stand conditions present after the first entry for the three treatment scenarios with active management. While the 'No Action' alternative stand is identical prior to these treatments and reflects the assumption of no stand altering disturbance for the rest of the period. The risk of loss from root rot, budworm and fire are all high suggesting that stand conditions will likely be altered by a disturbance.

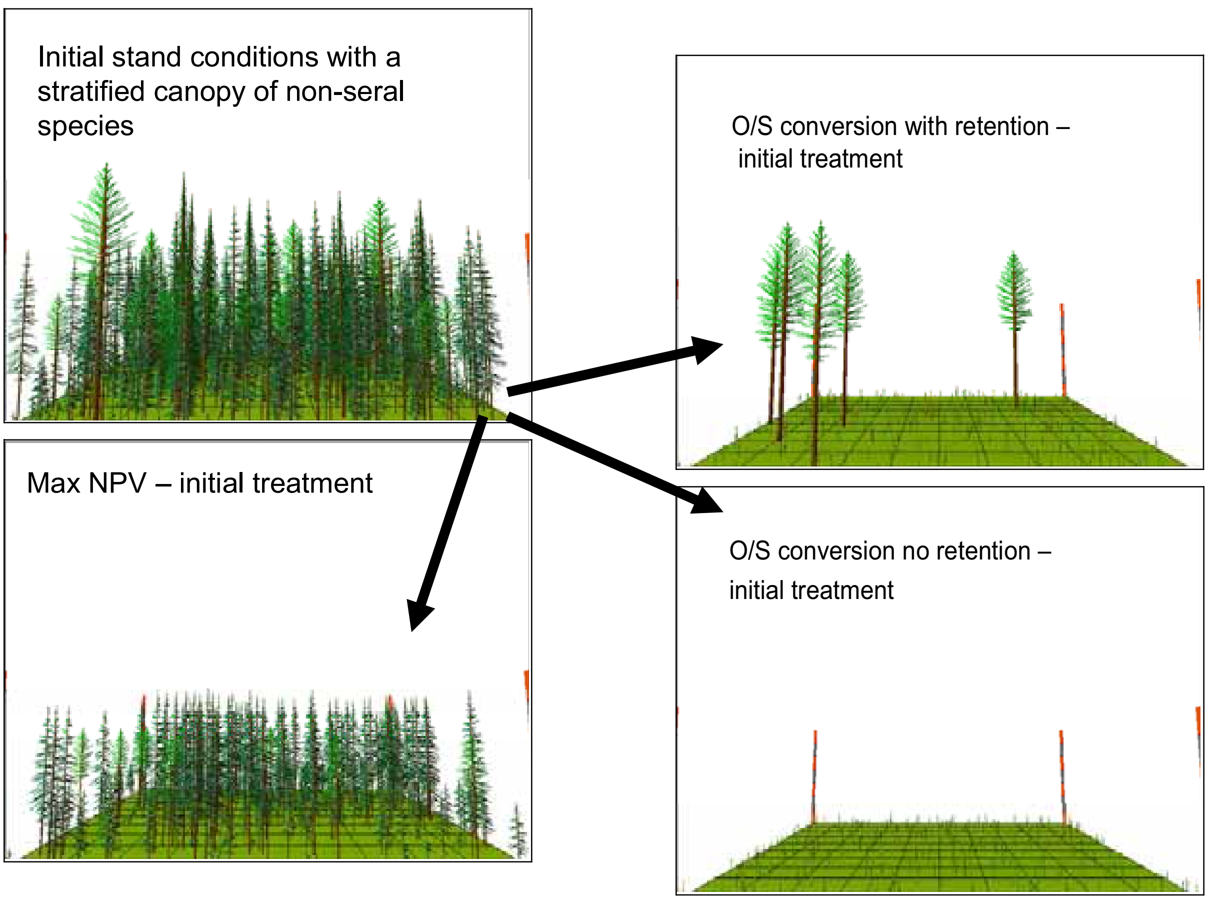


Figure 22: Three management options for moist forests showing treatment outcomes

Table 7 gives the stand metrics, hazard ratings for fire, insects and disease, and economic values over a 90-year simulation period. This simulation demonstrates that the timing of treatments to address forest health is critical. In this case the simulation indicates that the investment required for overstory conversion to forests with reduced fire and root rot risk must be amortized over a minimum of 40 years prior to any returns. A status quo treatment regime of continuing overstory removal maximizes economic gain while doing little to alleviate risks associated with fire, insects, and disease.

While return per acre in the species conversion scenarios continues to improve through the simulation period, discounting at 5% negates the gains in later years as compared to the Max NPV case. Thus the economic trade-offs may dissuade conversion to species and stand structures that can avert forest health problems unless small diameter timber becomes more valuable, resulting in earlier merchantability of the current inventory. However, the incentive required to motivate overstory conversion is not great in cases where forest health risks are of utmost importance.

Simulation results reported in Table 7 suggest that retaining even a few large trees into the next forest stand in the 'with Retention' case impacts both immediate timber value and subsequent growth of understory trees resulting in a 44% loss in economic return over the 90 year period relative to the 'without Retention' case. This loss in value is consistent with the fact that the few large diameter trees in the stand would be left at the first entry which is an immediate loss of revenue, coupled with the fact that overstory trees substantially reduce the growth and yield of subsequent seral regeneration in the simulation.

Table 7: Predicted mortality risks and economic returns for a mixed conifer stand under four treatment scenarios

Mixed Conifer Scenarios	Max NPV	OS convert with Retention	OS convert without Retention	No Action
BA range (across decades)	2 to 39	15 to 53	0 to 48	111 to 357
BA ave. (sq.ft.)	23	37	29	264
Crowning index range (across decades)	18 to 125	38 to 160	0 to 110	10 to 18
Crowning index average (mph)	54	76	51	13
TPA range (across decades)	72 to 515	5 to 400	0 to 388	137 to 539
TPA ave.	250	197	198	315
NPV $@5%	$2,814	$1,213	$2,164	(-)
Cash Flow (decades entered)	5 times	4 times	4 times	none
Root rot risk	Marginal	Better	OK	High
Budworm risk	3 bad decades	OK	OK	High
Fire risk	Low	Very low (just)	Low (just)	High
Sustainable cash flow	Yes	Yes	Yes	No

Reducing forest health risks is accomplished in all three mixed conifer scenarios where active management is pursued. Delaying the transition from a multi-layered stand to an even aged stand composed of seral species is responsible for the reduced forest health benefits of the Max NPV case with respect to root rot and budworm risk. Fire risk varies substantially through time as managed stands transition from regeneration through sapling, pole, and mature phases, whereas it remains high throughout the simulation for the No Action scenario. Table 7 indicates that all stands have periods when they are at high risk of crown fire, but that the managed stands do not stay in the high risk category as indicated by the average crowning index over the 100 year simulation period. Likewise, all stands have periods of higher and lower density and basal area as indicated by the ranges and average values given in Table 2. The simulation did not invoke reduced growth and mortality from root rot or initiate a fire under any scenario, thus the No Action alternative does not reflect the impacts or probabilities associated with maintaining a stand in a high risk condition for an extended period of time.

Developing a Base Case Consistent with Initial Assumptions

The determination of how many acres are under more intensive management and what constitutes intensive management has been developed from both expert opinion and the historical harvest data. Low intensity treatment regimes are those that are likely to be used by non-industrial private owners or government entities that are focused on establishing habitat conditions. Data on private ownership classes suggests that roughly 53% of private forests are in ownerships less than 100 acres (WADNR 2002) and that these smaller acreages are located closer to urban centers and at lower elevations. These lower elevation forests are typically dry forests therefore we have assumed that they are in the low management intensity class for the base case analysis. Medium intensity treatment regimes are used as the base case for private industrial and large private owners on moist and cold forests where the emphasis is most likely on timber revenue maximization.

Plots are segregated by owner type to facilitate estimation of target baseline harvest rates and fire probability estimates as well as to provide a separation into management intensity classes. Historical harvest rates by ownership and region are developed in Table 8. There is an implicit assumption that treatments are applied across the inventory profile and that owners are ‘harvesting the profile’ of habitat types. Some areas are harvested more intensely than others in any given time period in order to meet harvest volumes that had been historically removed from a given timbershed. Cross validating the 30 year average harvest rates with treatment regimes applied to median stands within the inventory suggests that current management on private forests is moderate to high intensity with very little merchantable volume remaining in any cutting cycle.

As identified in Figure 18 there has been a shift toward increased harvests on private forests in the past decade. The accelerated harvest is incorporated into initial conditions by allocating harvests between forest types and ownerships to mimic the increase in the past decade and then maintain a relatively even flow harvest volume by decade. Given the accelerated private harvest rate of the past decade, there are difficulties in maintaining an even flow of timber volume through time. Volume shortfalls are particularly apparent in the East Cascades variant 20 to 30 years forward in the simulation once stand inventories are corrected to the current time period. Accounting for the escalating mortality present in all forests as a result of the past 5 years of mountain pine beetle activity will also result in further decreases in the initially available starting volume.

Table 8: Average harvest rates and management intensity allocation by owner group in Eastern Washington

			Management Intensity Allocation				Management Intensity Allocation			
30 year average harvest rate	State average volume	State average %	Low (MBF)	Medium (MBF)	Private average volume	Private average %	Low (MBF)	Medium (MBF)	NF 1995-2003 harvest rate	% by FVS variant
East Cascades variant	58,875 MBF/yr	73.10%	17,663	41,212	365,317 MBF/yr	53.60%	271,024	94,293	27,208 MBF/yr	35.30%
North Idaho/Inland Empire variant	18,041 MBF/yr	22.40%	5,412	12,629	299,887 MBF/yr	44.00%	163,728	136,158	42,778 MBF/yr	55.50%
Blue Mountains variant	3624 MBF/yr	4.50%	not allocated -only 1 FIA plot		16,357 MBF/yr	2.40%	7,858	8,499	7,091 MBF/yr	9.20%
Totals	80,541 MBF/yr	100%	----	----	681,562 MBF/yr	100%	----	----	77,078 MBF/yr	100%

Preliminary comparisons of stand projections and historical harvests suggest that non-Federal harvest rates have increased to fill the void of the declining Federal harvest. As a consequence the initial harvest rates in some owner groups will ultimately decline as the inventory is reduced. As a preliminary analysis we have used the harvest rate of the last 30 years as a target to determine the degree to which it can be supported.

Future analysis that incorporates inventory declines from forest health vectors will determine the degree to which harvest levels may change in the base case as well as alternative scenarios.

Assessment of long-term timber harvest trends suggests that harvests from state lands are relatively stable, do not seem to respond to market trends and could increase. An analysis of potential incremental yield and carbon impacts will be completed as part of an alternate case using data from the DNR's southeast region.

National Forests base case management intensity includes only recent and near term planning levels of restoration activities to reduce fire and insect risk based on current harvest trends targeted at the Wildland Urban Interface (WUI). The opportunity to increase activity in fire restoration thinnings on sites located in areas with mixed and low severity fire regimes results in an estimated four-fold increase in treatable area in eastern Washington.

Carbon as an Emerging Ecosystem Service with a Market Value

Forests produce many services benefiting many groups but for which the values are not internalized into market prices. The value of products, the value of real estate and the cost of meeting regulations including the risk of lawsuits are all internalized into market prices. The value of clean air and water and habitat are not, and in fact each may be a cost required to meet regulations rather than compensation for the value produced. Markets are developing for the carbon stored in forests, although not yet in products. Therefore carbon may be one of the more promising ecosystem services to return value to forest management. The link between forest management and carbon will be developed in this section recognizing that the markets and policies affecting carbon exchanges are embryonic but could explode if the demand for carbon trading moves from voluntary to required.

Carbon Tracking and Life Cycle Studies

Several years ago a consortium of 15 research institutions across the US (mostly universities) launched a research project to characterize the environmental performance of wood as a renewable resource by developing a life cycle inventory (LCI) data base of all forest products inputs and outputs from forest regeneration, harvest, processing, construction, building use and final disposal. The Consortium for Research on Renewable Industrial Materials (CORRIM), published their findings in several journals (Lippke et al 2004, Wilson et al 2005) with carbon tracking one of the more important performance measures. These reports provide the source for this analysis of the potential for carbon to provide value as an ecosystem service.

Carbon in Forest Pools

A simple example often cited is that carbon storage is maximized in the forest by lengthening rotations and/or foregoing harvests. It is true that extending the rotation age from 50 to 100 years in the PNW will more than double the volumes of wood biomass and carbon stored in the forest. Depending upon forest type and conditions, deferring forest harvest longer than 100 years may continue to increase the stored carbon but eventually, mortality due to natural disturbances such as windstorms, fire, and disease accompanied by combustion and decay will result in carbon release.

However, the carbon stored in forest biomass is only part of forest carbon storage accounting. Many different types of forest products can continue to store carbon long after trees have been harvested. While short-lived products such as paper may enter the waste stream quickly and decompose, long-lived products such as panels and lumber used in housing construction will store carbon for decades, even centuries. As housing stocks increase, the cumulative carbon storage of forest and products increases as well. The carbon stored in forest pools (stem, root, crown, litter, and dead or dying carbon pools) for rotation intervals of 45, 80 (with two thinnings), and 120 (with three thinnings) years, as well as no harvest or disturbance are shown in Figure 23. While the growth model simulation shows carbon storage continuing to increase with time, empirical plot data shows no increase in stands over 120 years of age for PNW forests.

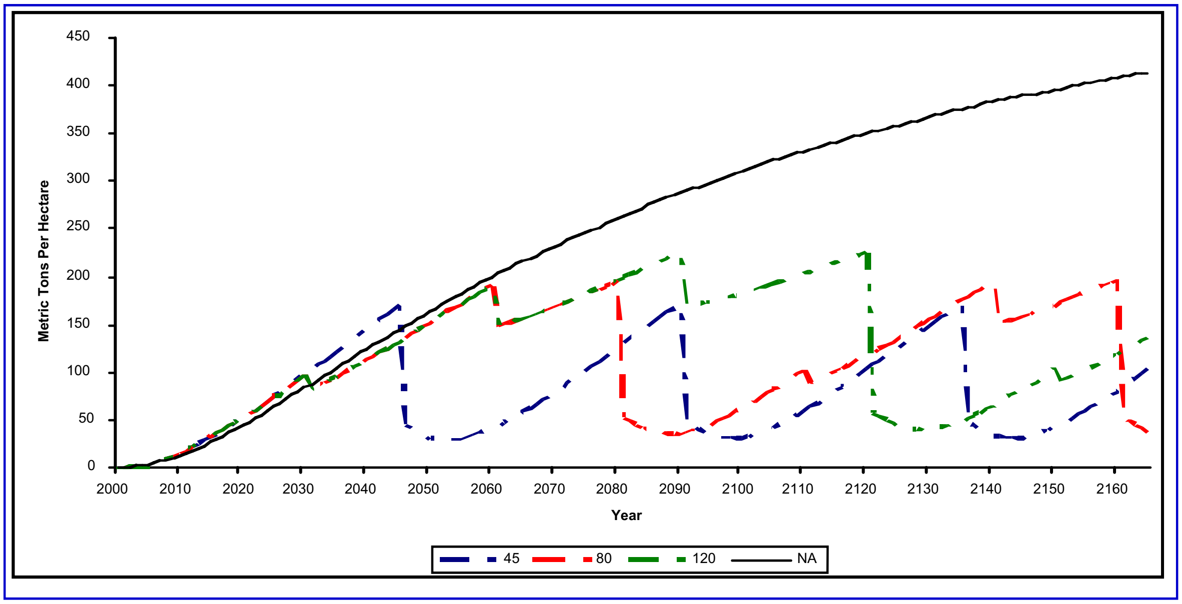


Figure 23. Carbon in forest pools for different rotations

Carbon in Product Pools

Short-lived forest products decompose rapidly resulting in carbon emissions while long-lived products decompose slowly resulting in an accumulation of carbon from rotation to rotation. The carbon stored in products is illustrated in Figure 24 for an 80-year rotation showing successively more product carbon storage in the first two thinnings followed by a larger increase at the harvest rotation. Figure 24 also displays the emissions from the logging and manufacturing as negative pools, the rapid decomposition for short lived products such as chips, and the accumulation of carbon storage in long lived lumber products. Lumber products are assumed to last 80 years, the expected life of a house (Winistorfer et al 2005).

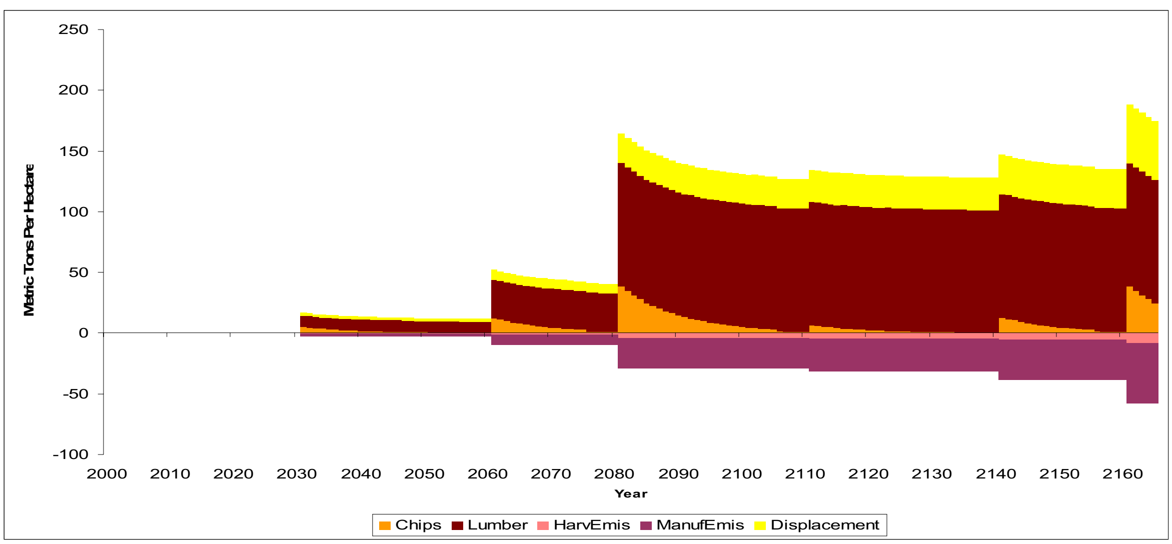


Figure 24. Carbon in products, energy displacement and processing emissions

When short-lived products such as wood chips are used as a biomass source for energy production, energy otherwise generated from fossil fuels is displaced with a consequent offset to the carbon emissions from the energy used in wood product processing. While energy generation is currently a low-valued use of wood, when biomass substitutes for fossil fuels carbon storage is effectively increased over time without the decomposition associated with short-lived products. Figure 2 illustrates the displacement of fossil fuels as carbon stored, a partial offset to the carbon emissions shown for harvesting and processing.

Forest Carbon, Products Carbon and Substitution

Figure 25 shows the carbon stored in the forest and both short- and long-lived product pools along with the displacement of fossil fuels as a positive pool and the energy for processing as a negative pool for a 45-year forest rotation. Note the positive trend increase in the carbon pool that develops when the long-lived products are available as substitutes for other product alternatives that are energy intensive in manufacture, such as steel or concrete. Note that the carbon in the forest is stable across rotations and, when the carbon in products is added, there is a modest increase in carbon stored. When the estimated reduction of carbon emissions associated with the use of wood as a product substitute for more energy intensive products, such as wood instead of concrete frame in this example, there is a substantial increasing trend in stored carbon.

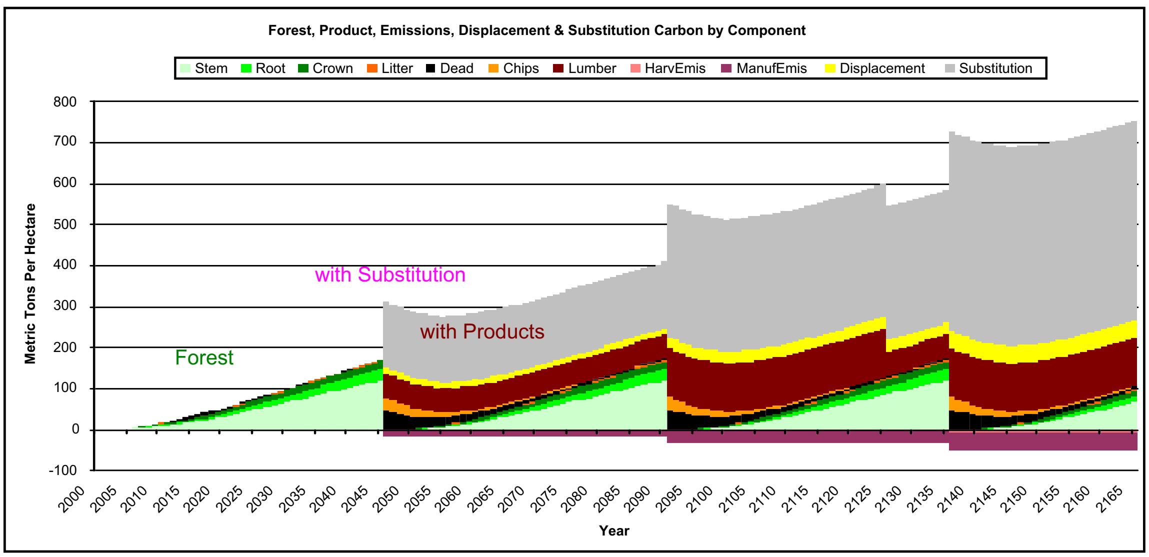


Figure 25. Carbon in the forest and product pools with concrete substitution for the 45 year rotation

Impact of Rotation Length

Figure 26 summarizes the carbon account averages for intervals of 0-45, 0-80, 0-120 and 0-165 for each example rotation scenario and for the no action (no harvest or disturbance) scenario. In the first 45 years, since there is no harvest, there is little difference between the alternative scenarios. For the 0-80 year interval the 45-year rotation harvest produces product substitution that results in more carbon stored and offset than the other scenarios. For the 120-year interval, a harvest has also occurred on the 80-year rotation and a heavy thin on the 120-year rotation. Finally by 165 years all scenarios have included a harvest except for no action. The cumulative carbon storage and offset comparisons illustrate that shorter rotations followed by products manufacture and regeneration are likely to result in greater reductions to atmospheric carbon releases than longer rotations and no harvest scenarios.

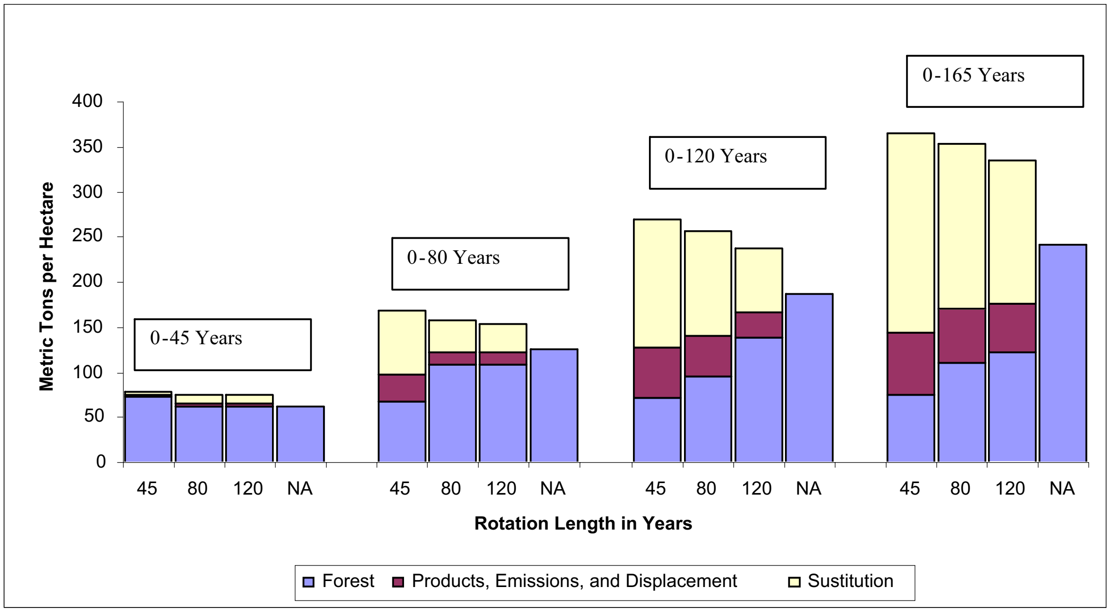


Figure 26. Average annual carbon in forest, product and concrete substitution pools for different rotations.

Figure 27 shows the carbon stored in the base case with a 45-year rotation and a more intensive management example to illustrate the potential results of fertilization and a commercial thinning on the same rotation. As a second case, the rotation was extended by 10 years to see if the response time after the thinning would produce increased storage. There is a significant increase in carbon stored from the intensive management but very little gain from increasing the rotation age by ten years.

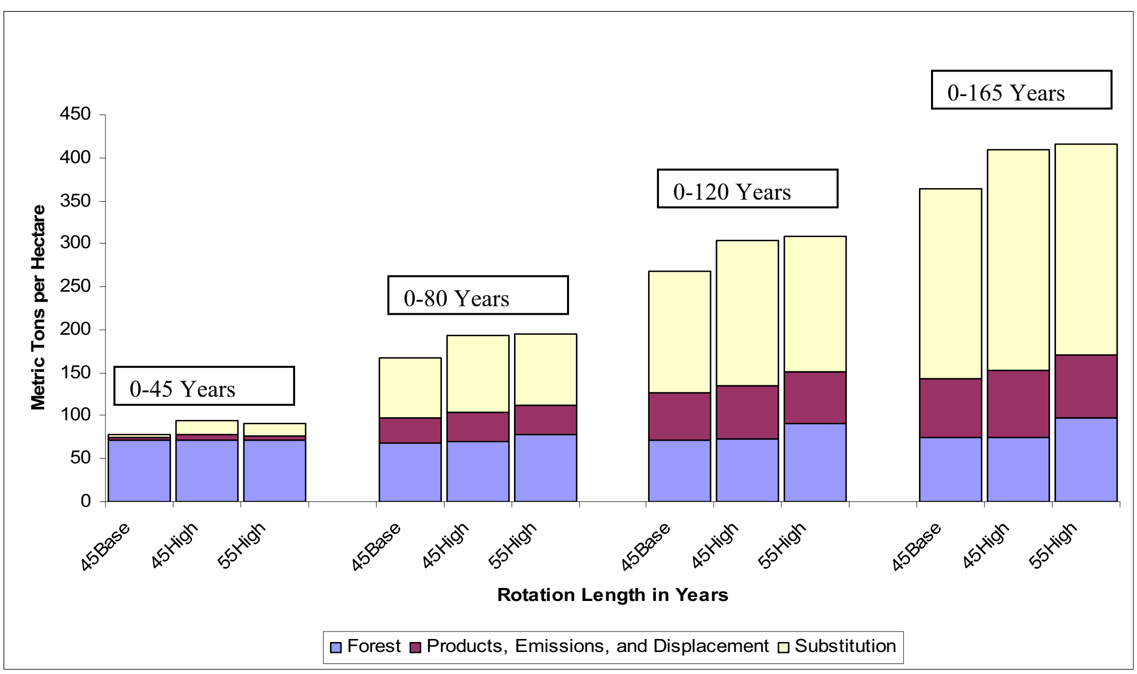


Figure 27. Average carbon in forest, product and concrete substitution for different management intensities.

Drawing the boundary conditions for carbon analysis around a forest is only correct if there is no harvest, in which case, over the long term, the forest stores an amount of carbon that is neither increasing nor decreasing when disturbance cycles are considered. Forest management approaches that maximize production of long-lived forest products have the greatest potential to contribute to reduction of atmospheric carbon.

Valuing Carbon as an Ecosystem Service

Figure 27 shows carbon increasing about 3.5 tons per hectare per year (1.4 tons per acre) in the first 45 years rising to 4.5 tons per hectare (1.8 tons per acre) in 165 years. This ecosystem service could add $500 to $700 of net present value (NPV) per acre if carbon is valued at $20 per ton. However, the value of carbon will be dependent upon supply and demand. Emerging voluntary markets have produced transaction prices that have ranged from less than $1 per ton to $20 per ton.

Moreover, if carbon markets only recognize the carbon storage benefits in the forest pool since it is stationary over the long term, there is at best only a first rotation payment with no further increase in carbon stored. In addition, if the principle of additionality is required so only new carbon is credited, there would be no new carbon in the forest except by demonstrating that the forest land is newly converted from other uses or being managed more intensively producing additional carbon over a base level.

The question then becomes over what baseline can credits for additionality be obtained. The increase over natural regeneration may be as much as 100% more carbon. The increase in carbon for increased management shown in Figure 5 is about 10% and if limited to forest carbon it is only a first rotation payment. But it could contribute $60 or more NPV which could be enough to motivate more intensive management since the rate of return to investments for the next increment of intensive production was shown to be almost unchanged under the commercial management options. A small incentive could therefore increase investments in more intensive management resulting in increased carbon production.

The real problems with capturing value for carbon as an ecosystem service will be in the policy relative to accounting. Using the California Climate Action Registry example (2005) credits are only accrued through three activities, (1) afforestation, (2) avoiding what would be near certain deforestation and (3) conservation. The first two don't really apply to a fixed commercial land base. The registry cites as conservation such things as harvesting less basal area, longer rotations, or leaving increased volumes in buffers. As shown by Figure 25 and 26 these would likely be counterproductive because it would lower the carbon flowing into products and substituting for steel and concrete which provides the highest leverage for storing carbon, assuming the landowner harvests periodically. In effect, accounting metrics will need to be recognized in order to avoid unintended consequences.

Eastside Carbon Issues

The above Westside examples assume no disturbances such as fire. The higher frequency of fires in the inland region will have two additional impacts on carbon storage. First, the risk of fire is high and with that the risk of carbon emissions from fire and the rapid decomposition of dead wood after a fire. Fire risk reduction treatments can save the carbon that is emitted by fire and post-fire decomposition of dead material when removals are converted to long-lived products or biofuels, both providing substitutes for fossil intensive products and fuels. While the removal of small diameter material may be costly, the avoided cost analysis (Appendix A) would suggest it is a good public investment. If incentives are used to remove the excess fuel some of the material may be best used as a biofuel, displacing fossil energy sources as another way to extend the carbon benefits long after the carbon leaves the forest. In addition, the destructive fires associated with excess density can cause substantial problems for regeneration and hence forest productivity, lowering post fire growing capacity for a lengthy period of time.

Summary of Landowner Group Differences

Many management options are available to any forest manager but will receive different levels of attention based on individual owner objectives.

Industrial owners will generally manage to maximize economic returns and should be expected to select the optimal economic treatment compatible with long-term stewardship and asset management objectives while meeting regulatory requirements.

Many surveys have shown that small owners retain forests for multiple reasons. For example, many place high value on conservation and wildlife habitats, holding the land for future generations, and/or using the asset to finance important life events like retirement and education. Small owners are also generally cash-poor and asset-rich as the value accumulates in the standing timber with infrequent harvests. Unlike industrial forest managers, small forest owners lack the ability to generate annual harvest revenues and a small scale of operations tends to increase administrative management costs per acre and harvest costs per unit of volume. Small forestland owners may be disproportionately impacted by harvest restrictions such as riparian regulations, yet since many small forests are located near areas of development, land conversion opportunities may be available to sell the land for more profitable non-timber uses. While small owners may not manage forests to maximize economic returns like industrial counterparts, the vast majority still consider economics as critical to their ownership decisions (Baumgartner et al 2003, Lippke and Bare 1998). While they have the opportunity to select the same management plans as industry they are less likely to place as much investment into making plans and hence will generally select simpler management options. Some will gravitate to shorter rotations as the simplest of all treatments, others to thinning and longer rotations.

Tribal forests are managed for multiple values that include timber yields, wildlife habitats, and cultural values. Tribal forestry programs are assisted by technical support from the USDI Bureau of Indian Affairs under arrangements that are unique to each Tribal organization. Annual allowable cut calculations are developed in accordance with forest planning and subsequently the Tribes manage their forestlands based upon sustained yields with relatively little harvest volume deviation over time. Two Tribal organizations (Confederated Tribes of the Colville Reservation and the Yakama Nation) have developed successful forest enterprises that rely upon Reservation harvest volumes as raw material for forest products manufacturing operations that provide needed jobs for Tribal members. Both Eastside Tribes have been very active in management to reduce fire hazards and insect risk. As sovereign nations, tribes can more easily make tradeoffs in their own best interest and more readily incorporate environmental services such as the value of habitat and the costs of reducing disturbance hazards in their treatment decisions (Mason 2006).

In the spirit of integrated management for the production of environmental and economic objectives, the DNR, in 1997, negotiated with federal agencies to establish a Habitat Conservation Plan (HCP) on 1.6 million acres of western Washington State forestlands. Eight years later this approach to forest landscape management led to the selection of a Preferred Alternative for the sustainable forestry calculation that will guide DNR management objectives on western forestlands into the future. The DNR will increase its use of innovative silvicultural approaches to alter forest conditions to produce habitats needed for sensitive wildlife species. A variety of thinning strategies will be employed. The goal will be to maintain distributions of forest structural classes across broad landscapes on a rotational basis so that adequate habitat is sustained into the future while providing financial returns to trust beneficiaries (DNR 2004).

The Federal Forests are undergoing revisions to their long-term forest plans. The current conditions assumptions result in almost no harvest as evidenced by the 97% reduction in the Westside Federal harvest from the base period. While the stated objective is ecosystem management (Huff et al. 2006), the default practices are essentially no-management. The opportunity for more restoration management i.e. to accelerate some stands taking on old forest functions more quickly to reduce the risk of disturbance and to provide a broader range of structures to support more species does exist but has not become operational. There is little pressure to reduce fire risk on the Westside but with increased densities, the risk is increasing. No management without disturbances, a consequence of fire suppression, reduces the diversity in stand structures. There may be a growing pressure to provide greater diversity in forest structures than the no action strategy is achieving as the impacts on some species become better known. On the Eastside there is great pressure to reduce fire risk and growth in the acceptability of stewardship contracting could support large increases in federal removals without increased costs as the value in merchantable timber can often offset the cost of other removals.

Management Treatment Issues Summary

Even before we examine the latest data on the management plans for different owners, several issues relating to changing management treatments can be identified. The results of these preliminary simulations illustrate some of the economic and environmental issues, outcomes, and trade-offs associated with different management treatments. Understanding what treatments are expected to be applied to what portion of the landscape and the resulting mix of outputs is a key part of the timber supply analysis. It will also be important to identify where trade-offs can be minimized and what incentives could be used to change output mixes if desired. The decision process of deciding how much habitat or environmental protection is enough, who should provide it and who should pay is a policy debate, not a supply assessment.

1. The impact of shorter rotations:

Commercial management is trending toward shorter rotations with less thinning. There are several driving factors. Better understanding of the growth performance of young stands from the evaluation of test plots that have now been monitored for 10-20 years suggests that early brush control boosts young tree growth making it possible to reach economic targets more quickly. Recently released growth models such as Organon 8 developed to fit the Stand Management test plot data reflect this impact. The increase in value for smaller logs responding to mill technology improvements is also contributing to shorter rotations (Briggs and Mason 2006). However, general weakness in pulp and paper markets has contributed to lower values for the portion of commercial thinning yields that are not suitable for small log lumber processing.

These ongoing changes will shift the mix in forest structure on commercially managed lands with environmental impacts on habitat. While the shorter rotations may suggest increased acres in the more open conditions associated with regeneration, the more rapid young growth will also more quickly lead to canopy closure and a loss of under story complexity. If the number of acres thinned also declines, the commercially managed acres will favor only two stand structure classes, open regeneration and canopy closed stem exclusion structures, the later supporting the least habitat and diversity (Oliver et al. 1994). Will the change in stand structure significantly reduce/impair habitat availability? Might incentives for thinning be an alternative given the relatively small economic loss associated with commercial thinning?

2. Biodiversity Pathway Support for Older Forest Habitat:

If the environmental objectives are largely focused on old-forest complexity, biodiversity pathways could produce such structures but the incentive needed has increased considerably with the decline in premiums for larger and higher quality logs. Some of this decline in premium is directly related to the decline in availability of large logs and the shutdown of large log processing facilities and it could be argued would return if owners were motivated to produce viable volumes of large logs for processing. However, the increase in engineered wood and small log processing technologies represents a more permanent shift away from the premium value for large logs. Some of the decline is related to reduced log exports as foreign markets have historically paid higher prices for larger logs. This decline will also likely be more permanent as the foreign demand has changed with much greater emphasis on precut engineered wood applications. Should more long rotations (i.e. acres devoted to old-forest complex structures) be developed? Who should provide them? Who pays? How does one motivate maintaining the infrastructure to handle the logs? DNR's Sustainable Harvest Plan moves toward providing a moving mosaic with some longer rotations. Will this program be effective, and what are the implications if not?

3. Reliance on No-Action Alternatives:

While Federal management has shifted toward an emphasis on ecosystem management and protection, the operating paradigm has defaulted to the no management alternative. Forests old enough to have acquired some diversity through disturbance events and mortality provide most of the remaining old forest habitat. Overly dense stands resulting from prior commercial management and regeneration and fire suppression will remain unlikely to produce old forest habitats in the near-term unless some natural disturbance events such as fires or windstorms produce more structural heterogeneity. Open stands have nearly disappeared on Federal Forests with the absence of removals and fire suppression, producing a loss of habitat for some species. While the preservation of some older stands provides most of the old forest habitat available across all owners, there is no active Federal program to accelerate the restoration of old forest structures and the reliance on no-management comes with consequences. While there may be a diversity of structure classes across all owners, the diversity within each owner class is limited and appears to be declining. Should management practices to meet habitat and environmental objectives rely on no-action or look at a broader range of alternatives? Who makes the decision?

4. Regulatory Effectiveness

The regulations affecting stream buffers appear to be contributing to unintended consequences such as land conversions and overly dense stands. In the west, the overly dense buffers are not effective at reaching the Desired Future Condition of old-forest like structures and for many small owners are not economically viable. In the east, the overly dense buffers increase the hazard of fire and insect damage. While alternative plans and templates were envisioned as an alternative for adaptive management on private forestlands, they are not being effectively implemented at least for small owners. Is there a need for effectiveness assessments or changes to the regulations or implementation process? Can regulatory objectives be met more efficiently?

5. Forest Health

There is an alarming increase in mortality from insects as well as great concern over the increase in fires and the high fire hazard levels for inland forests. The Forest Health Working Group Report (DNR 2004) provided recommendations and the committee has been re-convened to assist in communicating the issues to communities. Should more be done sooner? The Federal Forests are a large contributor to the problem. Can more cooperation accelerate a federal response?

Studies have shown that the values of avoiding the costs of fires and insect damage are much larger than the cost of treatments but these values have yet to be used in quantifying decision alternatives. Should these values be used in an institutional framework to support public investments and how might that be done?

6. Declining Private Harvest

There will likely be a decline in private harvest on the Eastside in the near future given the high harvest rates that appear to have offset much of the Federal decline. Yet there is also a possibility of a substantial increase in volume removed to reduce fire hazards with some being merchantable as potential offset to declining harvest and some most suitable for biofuel use. Are there steps that may contribute to solving both the declining harvest problem and the high fire hazard problem?

7. Ecosystem Services

Forests provide much more than products for markets, jobs and habitat as they provide a broad range of other protections including clean air and water. For example, there is recognition that sequestration of carbon in forest biomass may help to reduce heightened levels of atmospheric carbon. Carbon is one the first ecosystem services that may become internalized in the market on a large scale as efforts are increased to reduce emissions resulting from combustion of fossil fuels. Carbon trading systems and carbon registries are being created, however, until the markets and registries achieve agreement on performance metrics with system level accounting these systems will remain relatively ineffective and cold be counterproductive. Carbon is only one example of an ecosystem service with public value. How might quantification and valuation of ecosystem services better contribute to the future of forestry?

Declines in habitats and diversity may be a concern for many owners and engaged publics. Industrial forestlands are becoming increasingly homogenous as a result of shorter rotations; non-industrial lands are under pressures from land-use conversion and buffer regulations that are complicated by intergenerational ownership transfer; Federal Forests have relied on no-management with continued fire suppression and, as a result, have less diversity with a heightened threat to old forests; the DNR plans increases in targeted habitats but at some cost to beneficiaries; and Tribes are challenged by issues associated with legacies of past management such as lack of heterogeneity and overly-dense forests. Who should provide habitat and other ecosystem services to whom and at what cost?

Next Steps in the Timber Supply and Forest Structure Study

The materials covered in this preliminary progress report represent first steps toward quantifying management stratification of treatments by owner type across timbersheds. A base case will be produced consistent with initial conditions and business-as-usual policies. Alternative scenarios and an assessment of the resulting differences across alternatives are expected to sharpen the focus on problems and opportunities affecting the future. Inventory data is being collected for all owners. GIS assessments are being prepared for owner type acreages, stream buffers, upland areas, and other spatial attributes of interest. Management intentions surveys are being circulated across owner groups. Once treatment plans are stratified for timbersheds and owner types there will be an analysis of forest treatments, habitats, jobs, economic activity and tax revenues as well as multiple ecosystem services that flow from treatments and resulting stand structures. This will provide the assessment information for a closer look at the impact of alternatives and support for the consideration of policy alternatives that is planned to follow this assessment.

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Study 2: Competitive Position

John Perez-Garcia, Hideaki Kubota, Adam Lewis

We have collected and begun our analysis of historical global trends in forest products markets. These trends will serve as a background in our assessment of Washington's competitive position. In addition to the broad global trends we have preliminary projections over the next decade of major wood product markets. We will finalize the projections in the coming months. We will use these projections to place Washington's competitive position within the regional, national and world wood market. We have also begun to analyze Washington's forest sector cost structure, including taxes, labor, wood and other important costs.

We provide a preliminary summary of global tends in what follows. We utilize graphs extensively and produce summary points. We will reduce the number of charts in our formal report to those charts that are most relevant.

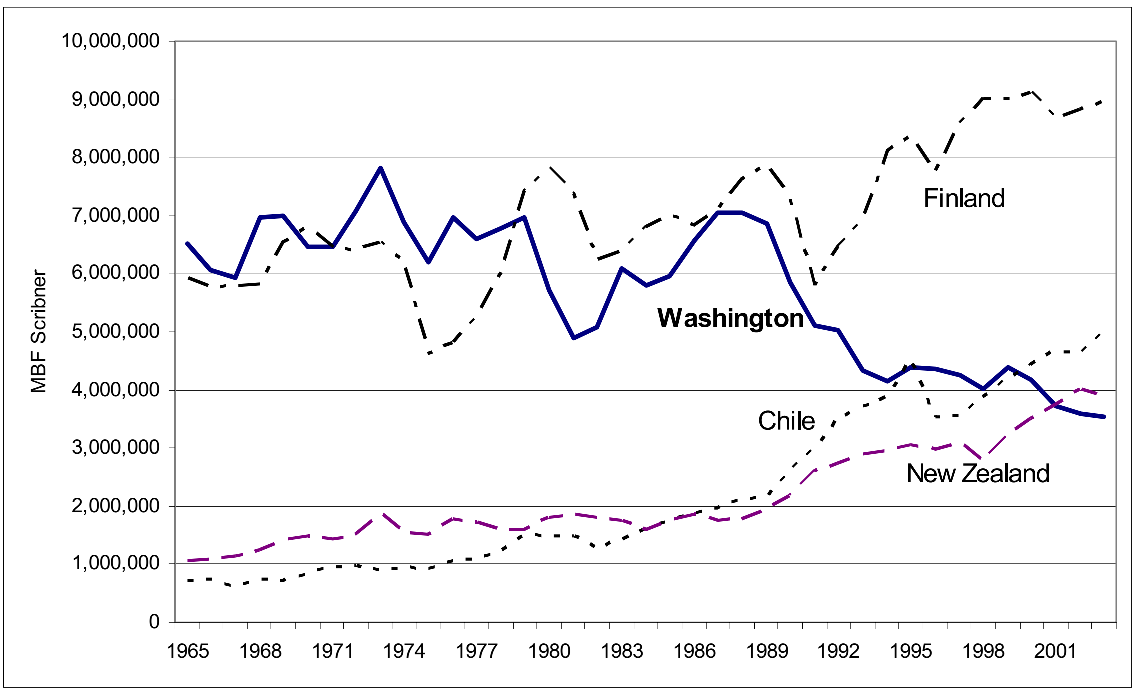


Figure 1. Timber harvest levels in Washington, Chile, New Zealand, and Finland: 1965-2003.

Sources: Washington harvest level taken from WA DNR Timber Harvest Reports (various years); Chile, New Zealand, and Finland harvest levels taken from FAOSTAT industrial roundwood production converted to mbf using 5.5 cubic meters per mbf.

Figure 1 illustrates harvest levels and how they have declined in Washington while emerging plantation regions in Chile and New Zealand have expanded their harvest levels. These two nations compete with Washington timber producers in Asian and other wood product markets. Finland has also increased its harvest levels and competes with Washington producers in Asian and other markets. We will expand the harvest level data to include other U.S. states and key Canadian provinces. We are exploring the potential impact the mountain pine beetle might have on Canadian harvest levels.

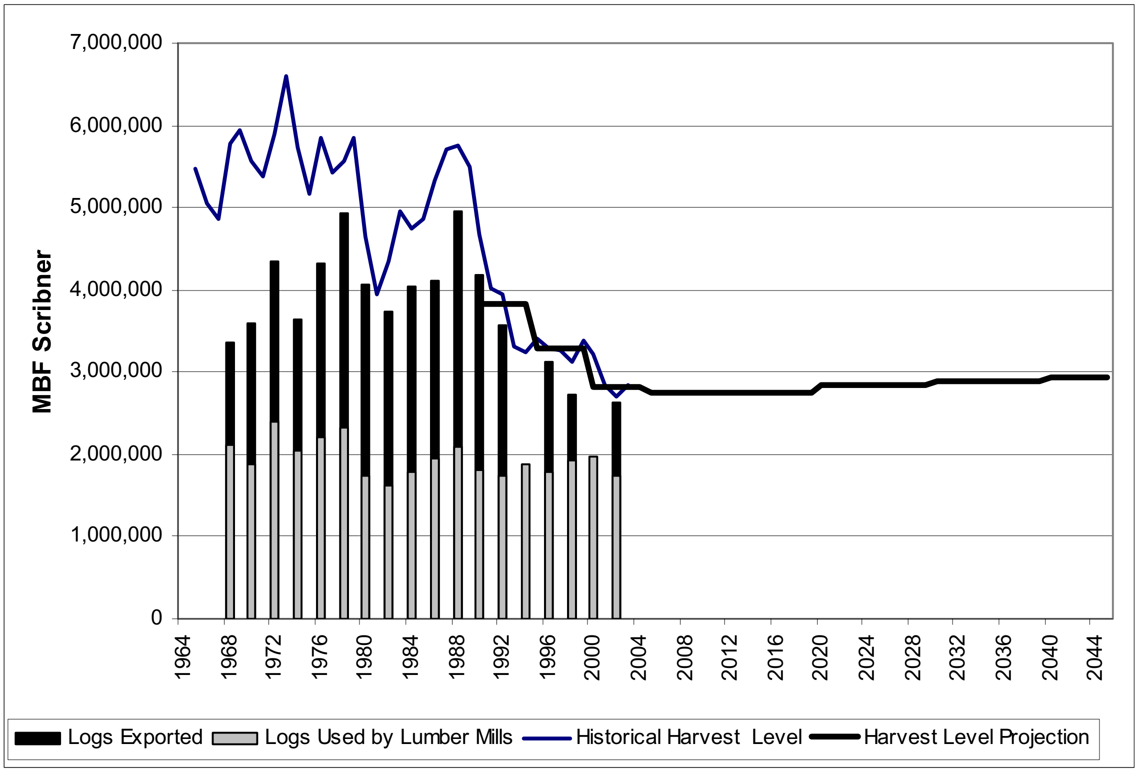


Figure 2. Historical and projected harvest levels for western Washington and historical log consumption levels by western Washington sawmills and log exporting sector.

Figure 2 data are taken from several State sources. The harvest level projection is taken from recent work completed for U.S. Forest Service. We will utilize the timber supply results when they become available.

Figure 2 illustrates three points. The harvest level projection is level to slightly increasing and depends on key assumptions on land-use trends and harvest restrictions. Sawmills are the dominant timber user of harvests within Washington. The export of logs has declined and correlates with the timber harvest level decline. The implication is that Washington timber producers' share of international log markets has declined. We will continue to explore this effect on international competitiveness and how it may have impacted primary and value added products.

The next set of charts utilizes national data that have been aggregated into geographical regions for sake of clarity. The data is taken from FAOSTAT.

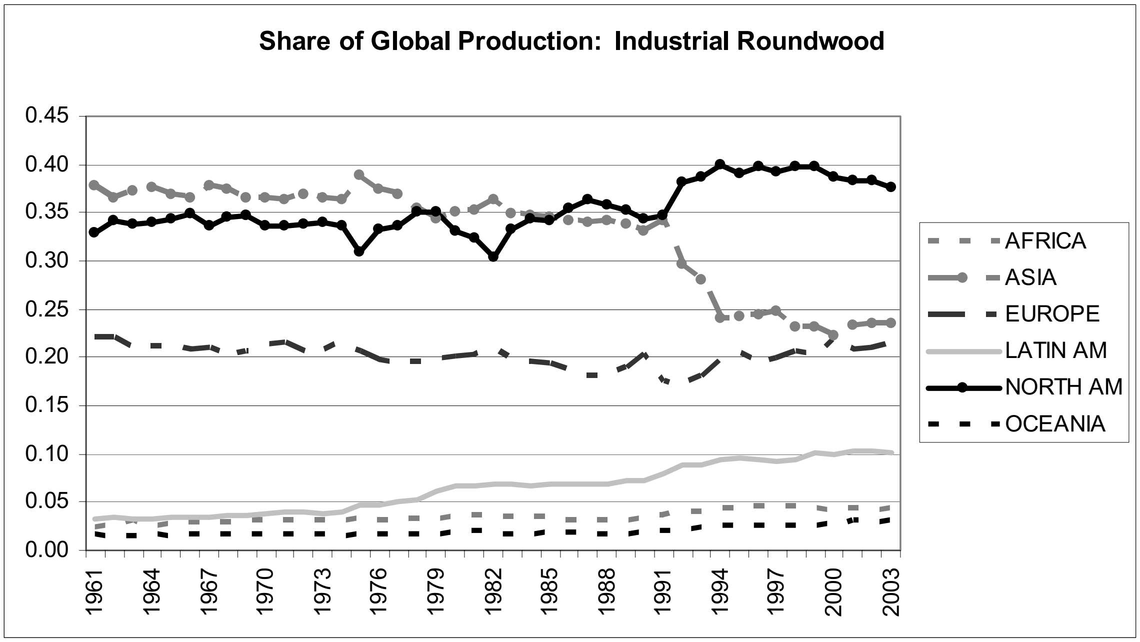


Figure 3. Industrial roundwood production shares.

Figure 3 above illustrates the share of global production for six continental regions. Industrial roundwood includes pulplogs, sawlogs and veneer logs, and excludes firewood. A major trend is the step increase in North American share in production while the Asian share, principally due to the collapse of the former Soviet Union, fell sharply. Also note the increasing trend in share in Latin America.

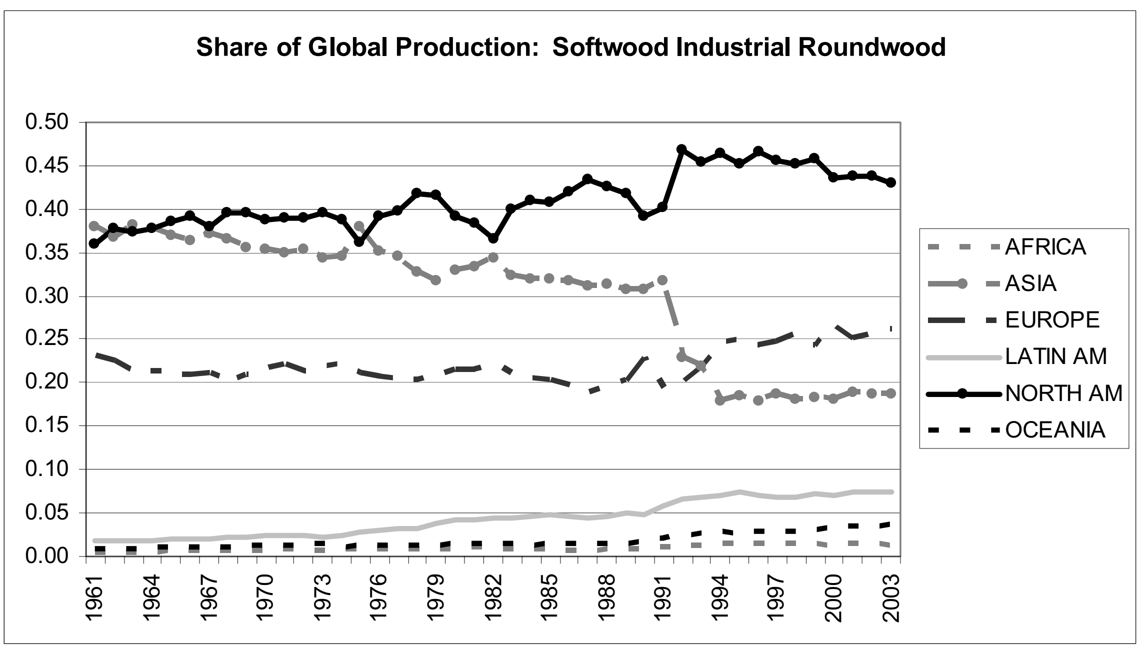


Figure 4. Softwood industrial roundwood production shares.

Figure 4 above breaks out the industrial roundwood production into its softwood component. Since 1992, North America's share has jumped to over 45 percent but has a slight trend downward since. When we consider Figure 1 we note that the increase in its global share has come at a time when Washington's harvest level has declined dramatically.

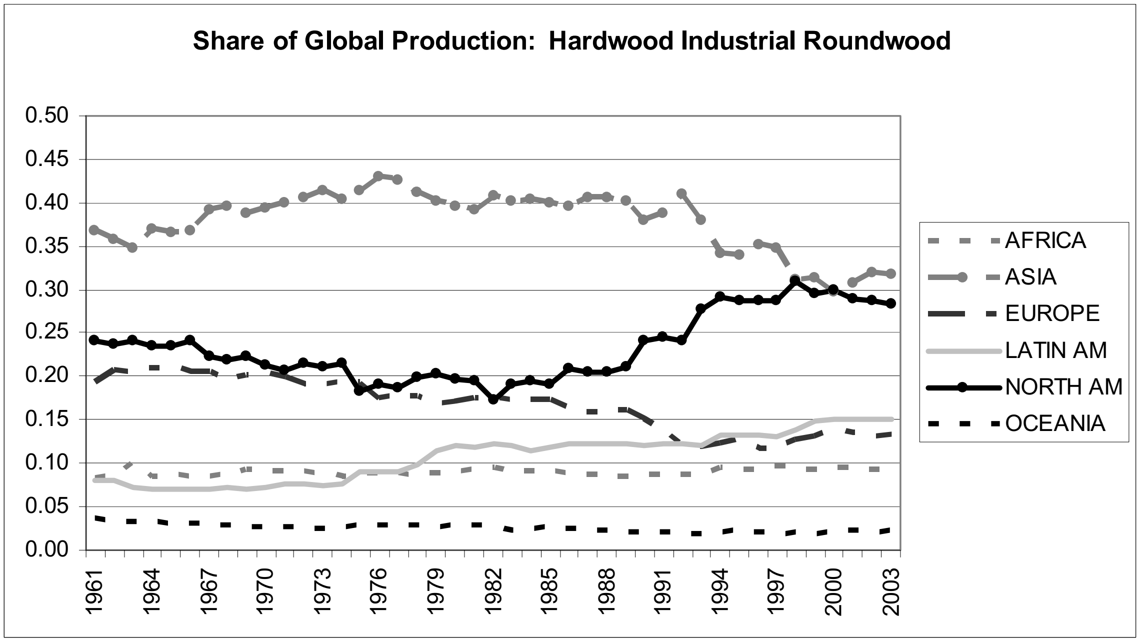


Figure 5. Hardwood industrial roundwood production shares.

Figure 5 above illustrates the growth in the hardwood industrial roundwood production share for North America. Constraints on topical timber harvest levels and the collapse of the former Soviet Union in 1990 lead to a reduction in Asian global share.

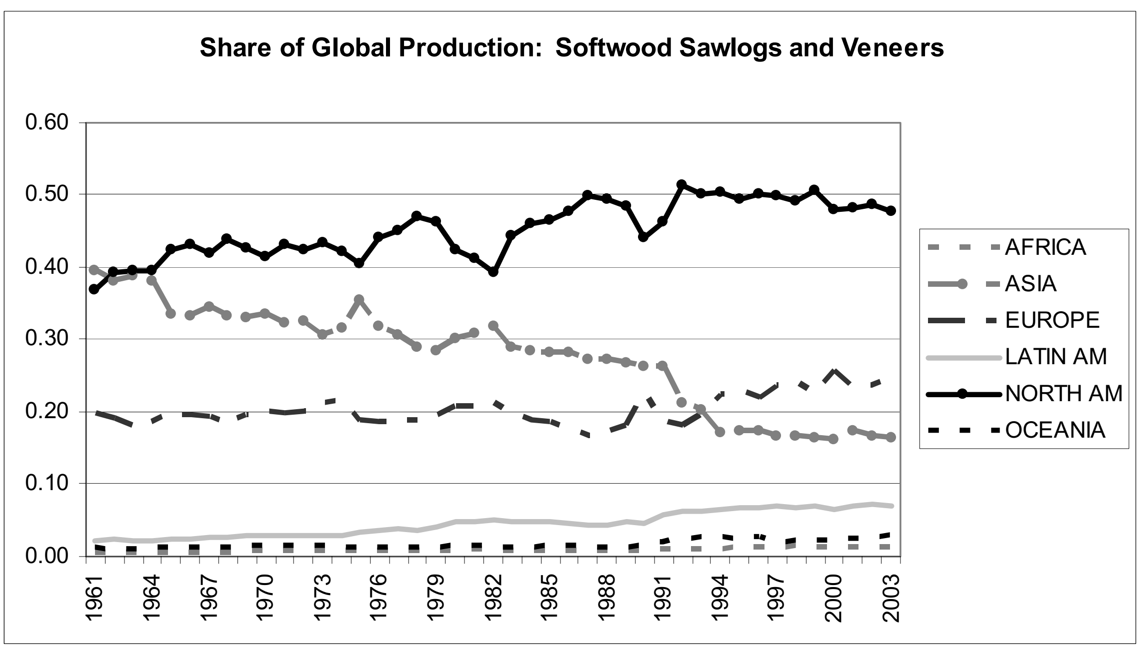


Figure 6. Softwood sawlogs and veneers production shares.

Figure 6 above breaks out the softwood sawlog and veneer log components of industrial roundwood production share. North American timber producers have about half of the world's softwood log market. Latin America, a relatively small geographical area for softwood log production is approaching 8 percent. Currently, Asia's world share is considered low as long as Russia's political economy remains unstable.

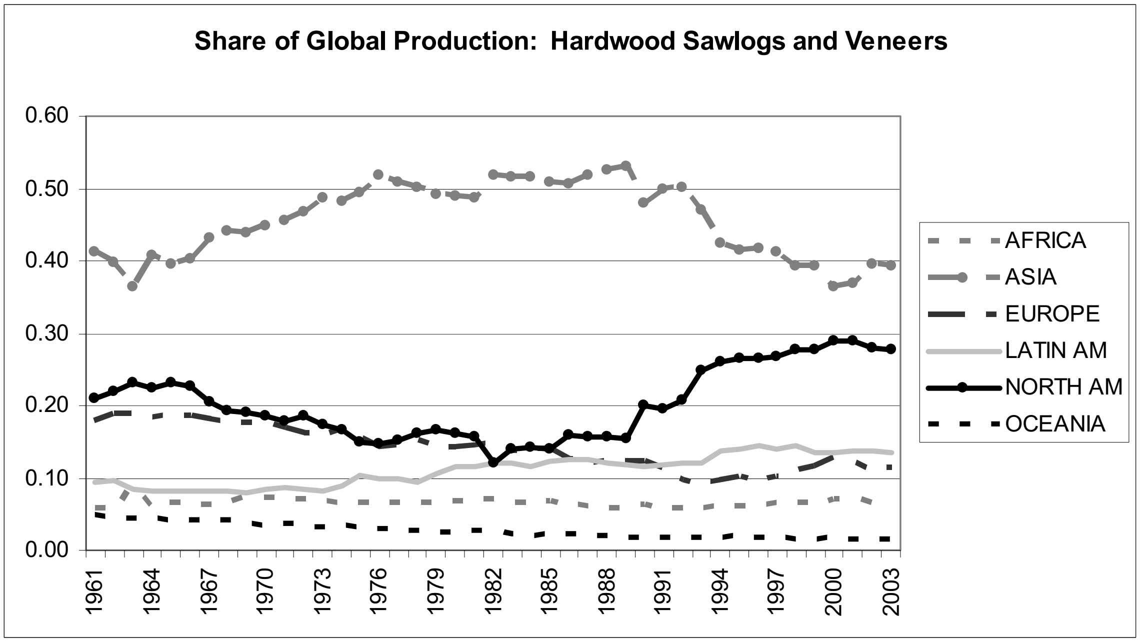


Figure 7. Hardwood sawlogs and veneers production shares.

Figure 7 above illustrates how North America's share of global production of hardwood sawlogs and veneer logs has grown from less than 20 percent during the 1980's to nearly 30 percent in 2003. Washington's role in this growth will be explored. Washington's competitive position based on available hardwood resources will also be examined further.

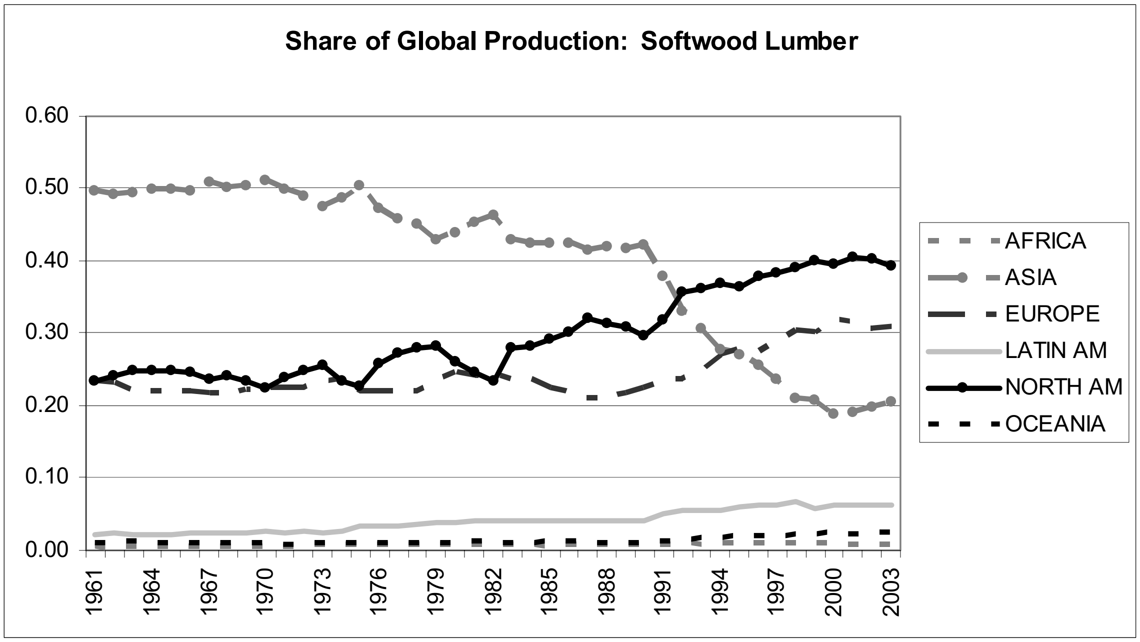


Figure 8. Softwood lumber production shares.

Figure 8 above clearly establishes North America as the predominant producer of softwood lumber. It also illustrates Europe's expansion as well. Part of the growth in share has occurred at the expense of the collapse in Asian share.

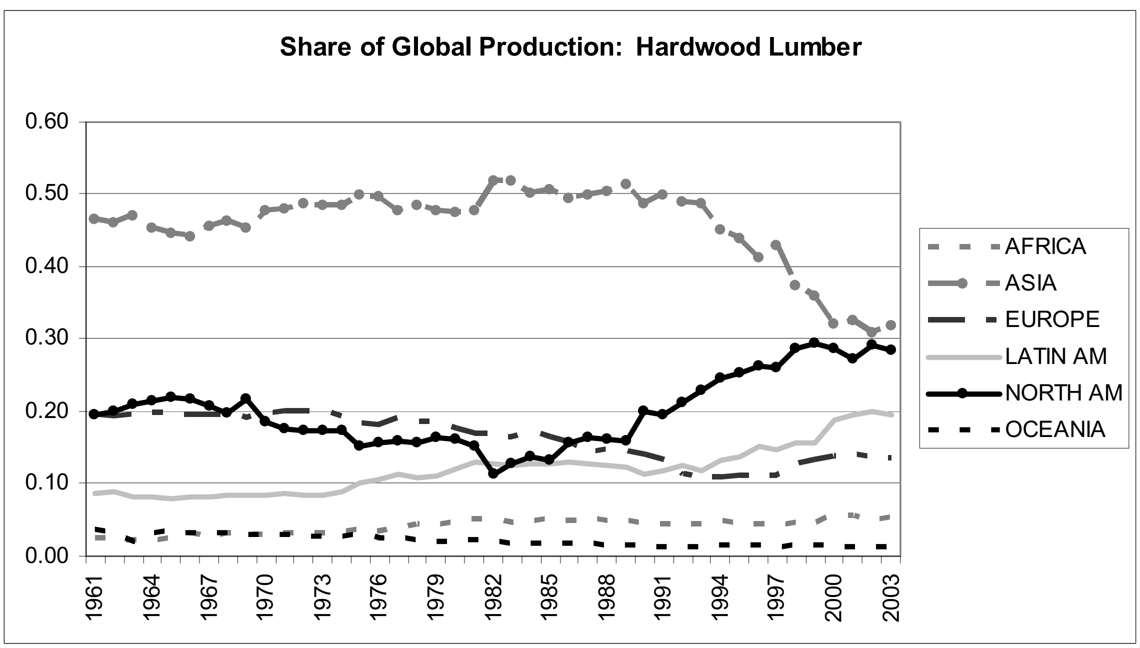


Figure 9. Hardwood lumber production shares.

Figure 9 above suggests that North America's hardwood lumber production share has gained a nearly equal share to Asian producers of hardwood lumber, and has outpaced Latin American producers over the past two decades. We will explore the drivers behind this growth. One possible explanation is a shift from tropical to temperate hardwood use by consumers. More on this as we continue our research.

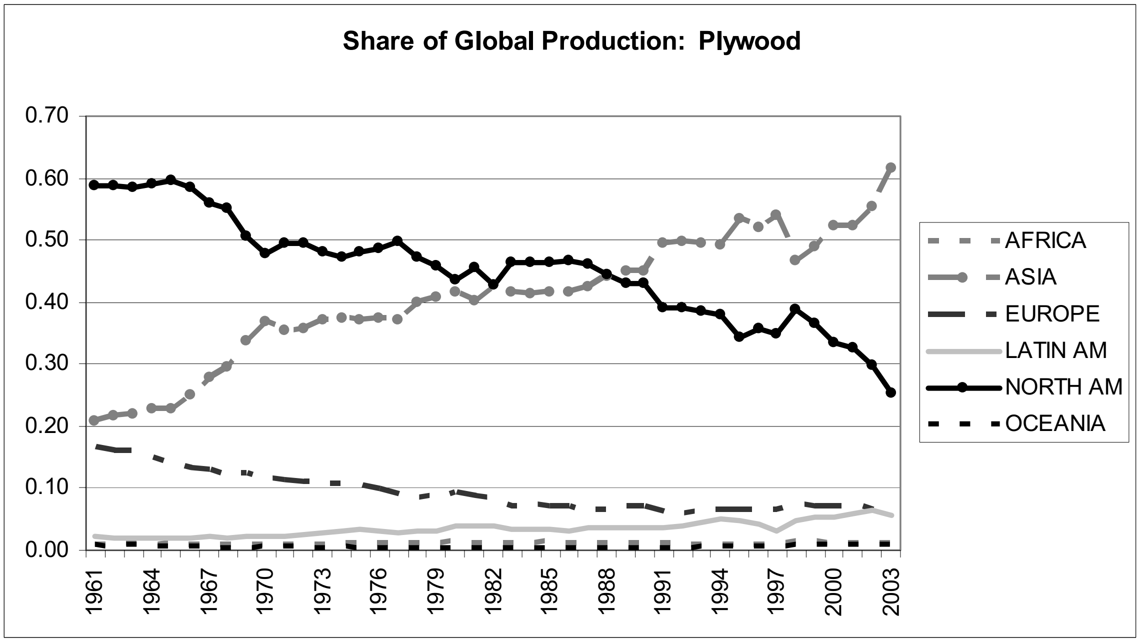


Figure 10. Plywood production shares.

Figure 10 above illustrates the decline in plywood share for North American producers, while Figure 11 below shows fairly well distributed wood-based panel production shares. The plywood panel is a component of the wood-based panel grouping. Asian producers continue to manufacture plywood to meet their needs. I appears that plywood manufacturing in Washington has been eliminated. Oregon however, has maintained a successful plywood manufacturing base. This sector's analytical interest lies in wood quality issue and higher values from longer rotation timber. We will continue to research competitive opportunities for this sector.

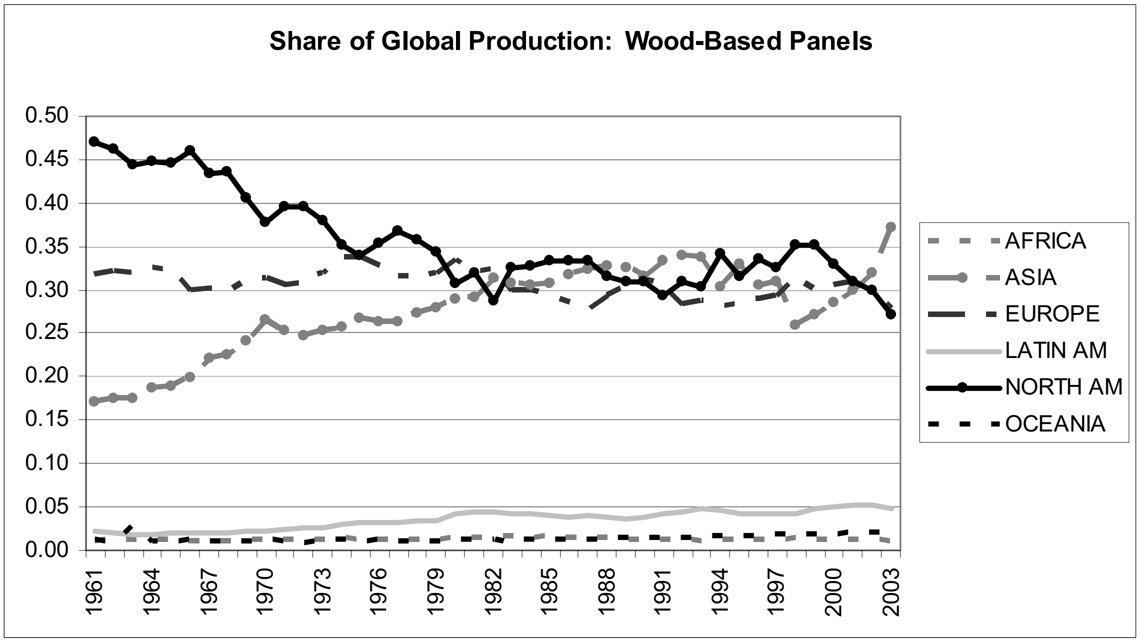


Figure 11. Wood-based panel production shares.

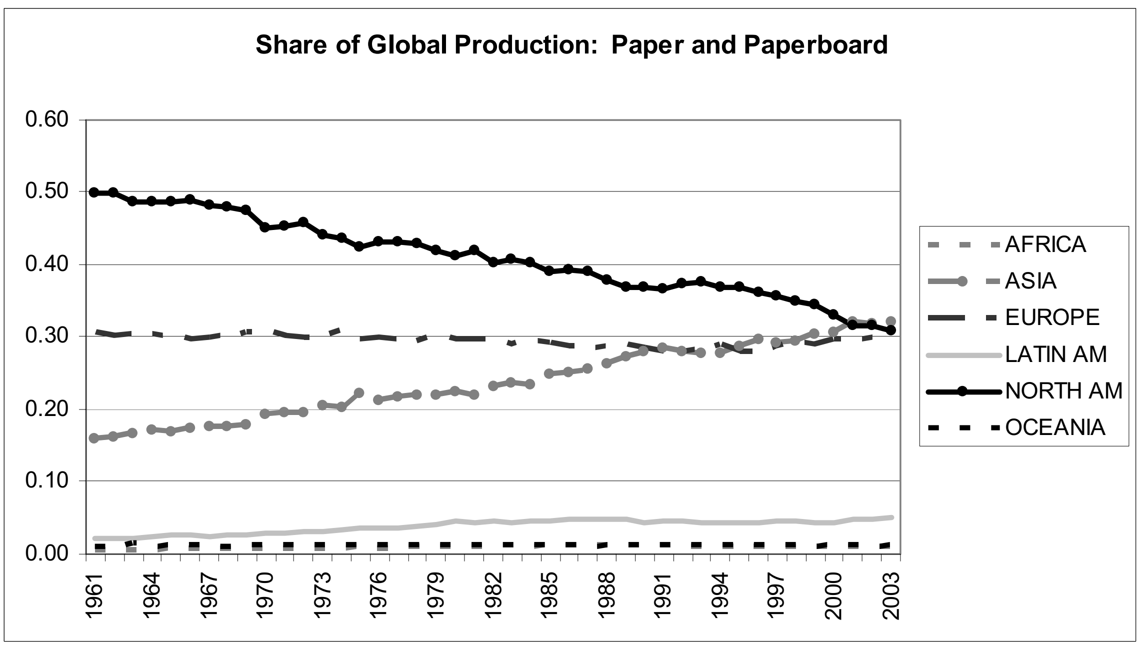


Figure 12. Paper and paperboard production shares.

Figure 12 above illustrates the decline in North American paper and paperboard production dominance, while Asian producers have steadily gained production share.

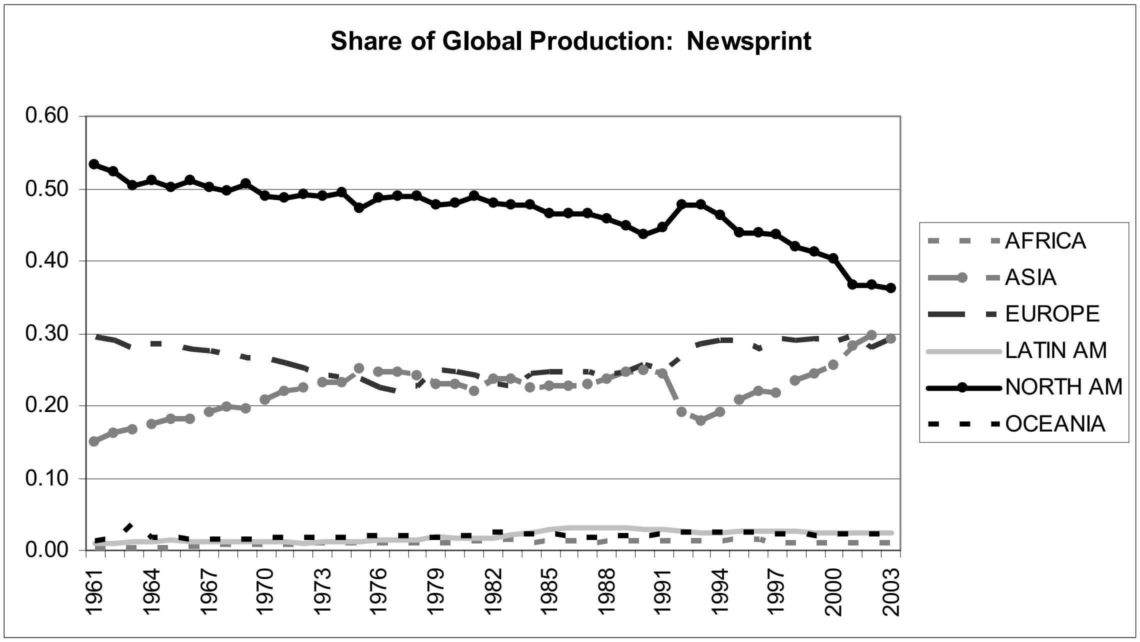


Figure 13. Newsprint production shares.

Newsprint, a component of the paper and paperboard grouping, has been a major reason why North America's share has declined. We are developing the data to better understand the competitiveness of Washington's pulp and paper sector with the declining trends illustrated above. Do alternative uses for woody biomass make economic sense?

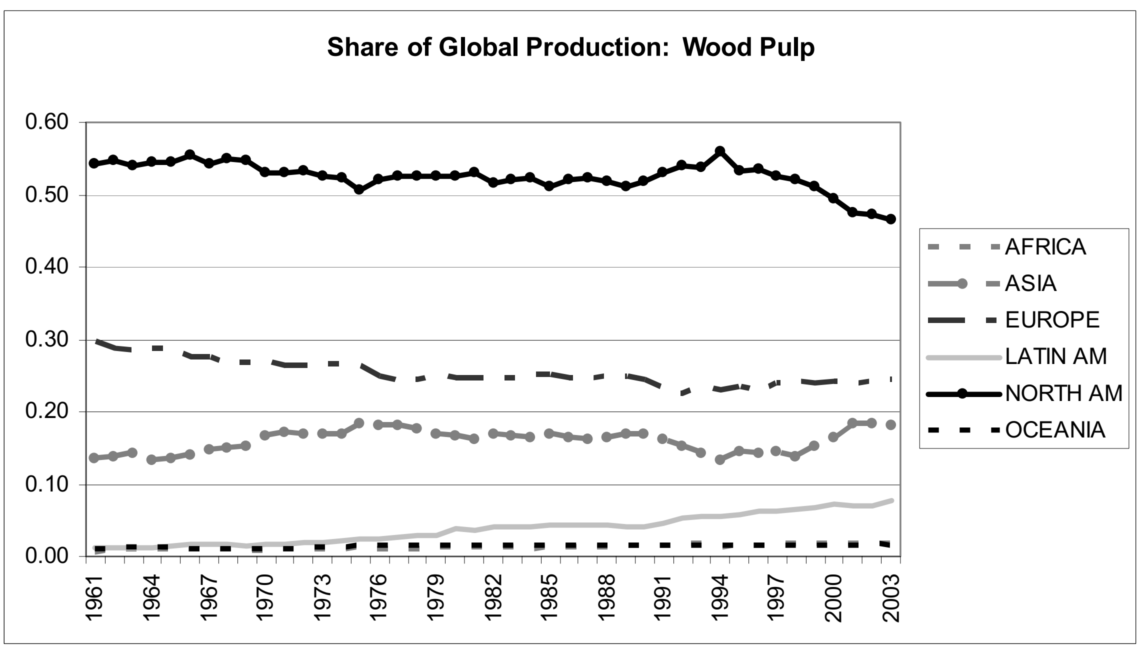


Figure 14. Wood pulp production shares.

Figure 14 illustrates a smaller share in wood pulp production principally since the early 1990's. At the same time Latin America's share of wood pulp production has increased to about 9 percent.

The preceding charts illustrated production shares. In the following graphs we present consumption shares. These trends are important to understand since Washington is a net exporter of wood products. We present global trends using FAO data. Consumption is defined as apparent consumption; that is, production minus exports plus imports. We describe the share in consumption trends for some of the same product groups as above.

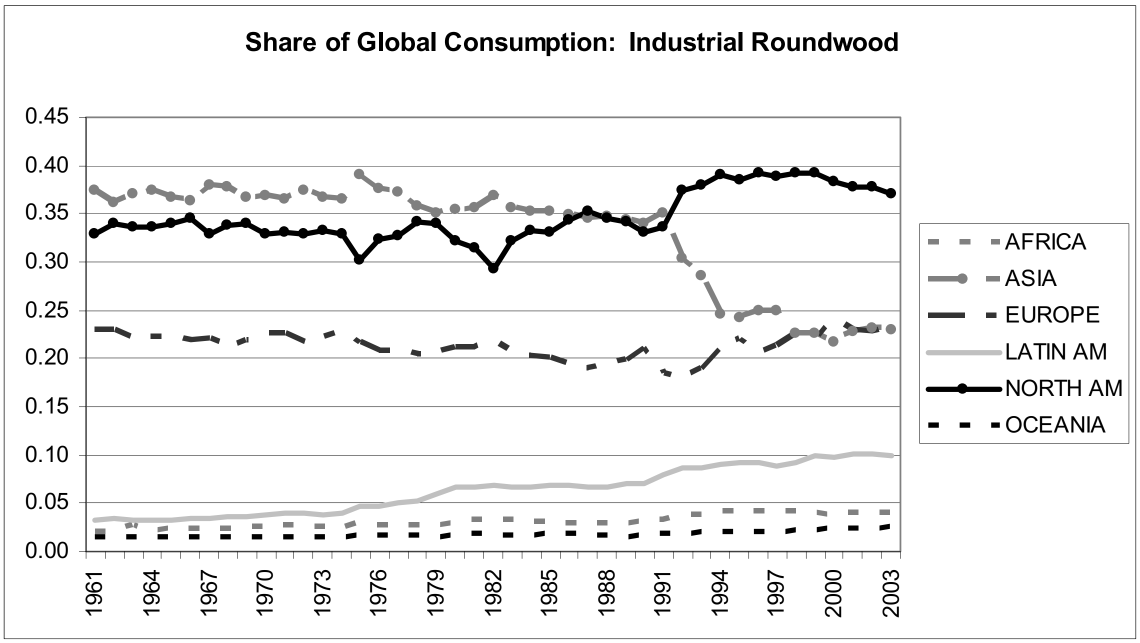


Figure 15. Industrial roundwood consumption shares.

Figure 15 above reproduces the industrial roundwood consumption shares. The fact that the North American consumption share is similar to the production share suggests that North American market is nearly self-sufficient in meeting its consumptive needs for industrial roundwood.

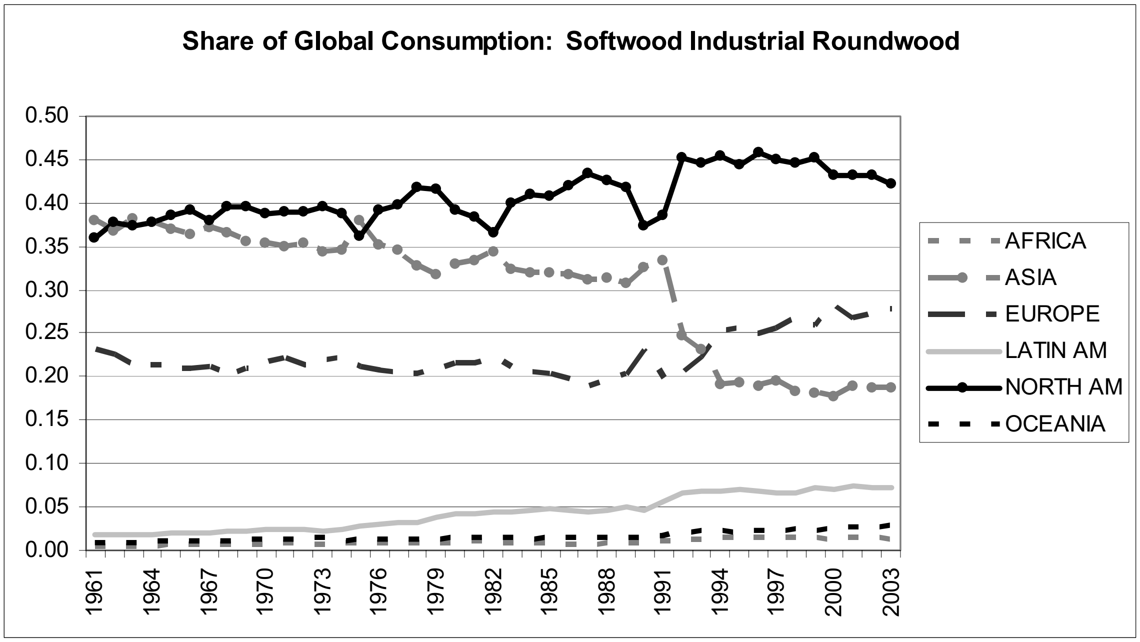


Figure 16. Softwood industrial roundwood consumption shares.

Figure 16 breaks out the softwood industrial roundwood component. In general and at a broad scale of analysis, North America is basically self sufficient in softwood industrial roundwood. We will continue to examine these trends at a finer geographical scale in future work. Similarly, one can conclude at the board scale that hardwood industrial roundwood consumption is being met internally (figure not shown).

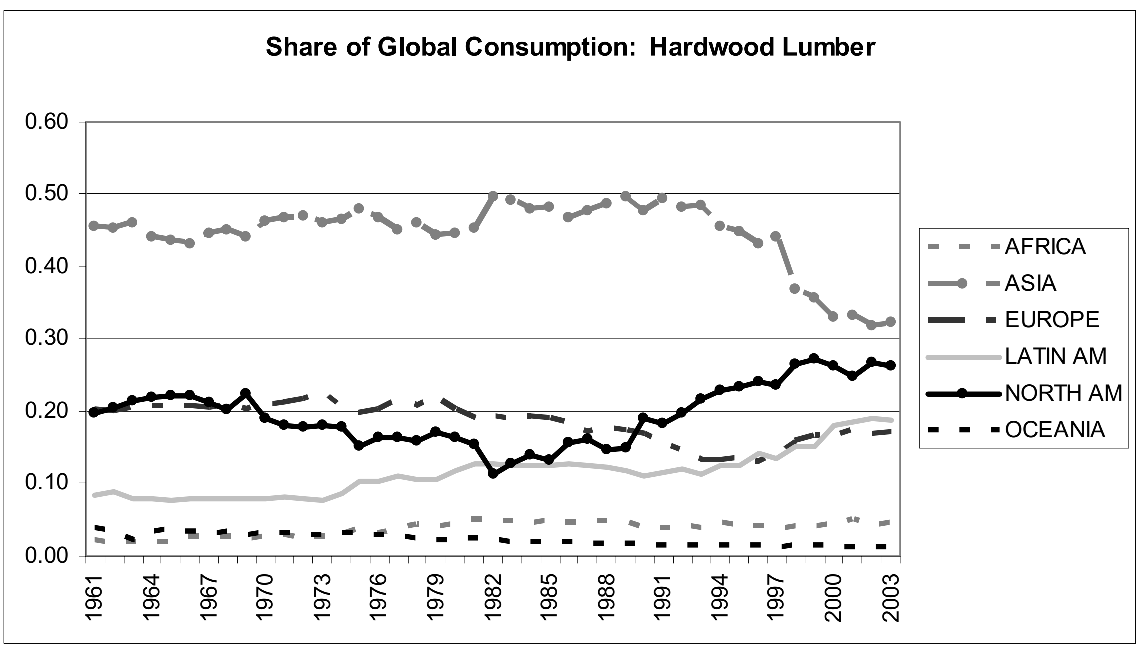


Figure 17. Hardwood lumber consumption shares.

Figure 17 illustrates the global consumption share of hardwood lumber. Note that when compared to production, the consumption share for North America is lower. In this instance, North America is a net exporter of hardwood lumber. The European consumption share is higher then their production share suggesting that Europe imports hardwood lumber in net terms. This suggests market opportunities for hardwood lumber in Europe from North America. We will continue to explore this trend and its competitiveness implications in more detail for Washington hardwood lumber producers.

Note that softwood lumber production and consumption shares are similar indicating, as in the industrial roundwood cases, a self-sufficiency on meeting demand at the board market level (figure not shown).

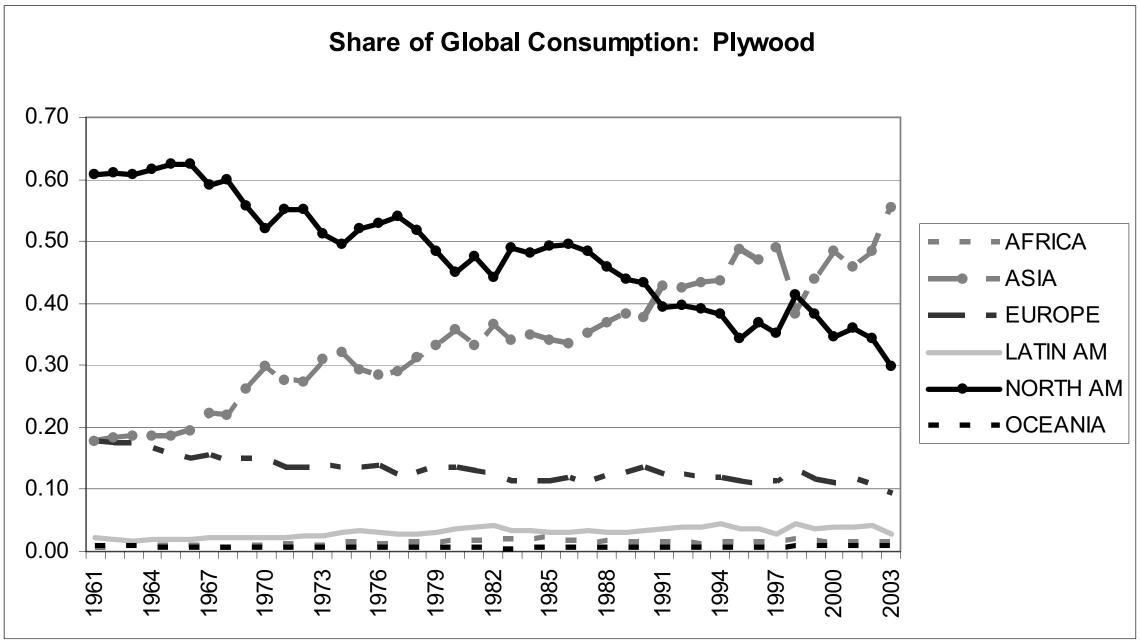


Figure 18. Plywood consumption shares.

Figure 18 suggests North America is a net importer of plywood with Asia and Europe producing more than they consume internally.

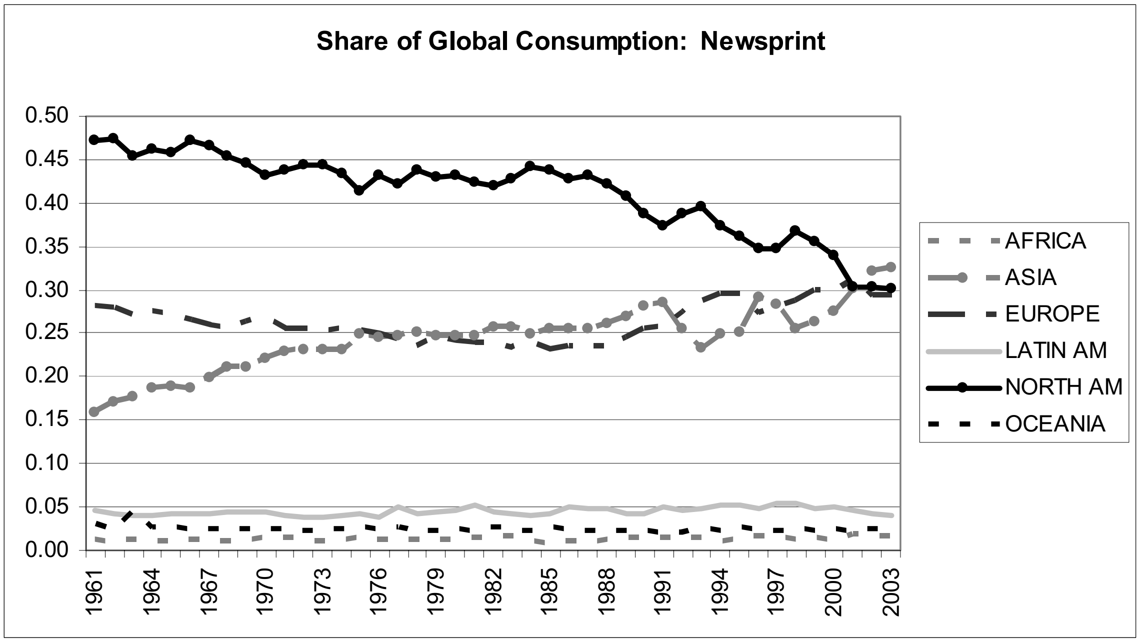


Figure 19. Newprint consumption shares.

Figure 19 suggests North America is a net exporter of newsprint whereas Asia is a net importer. It is also apparent that Latin America has increased its exports of newsprint.

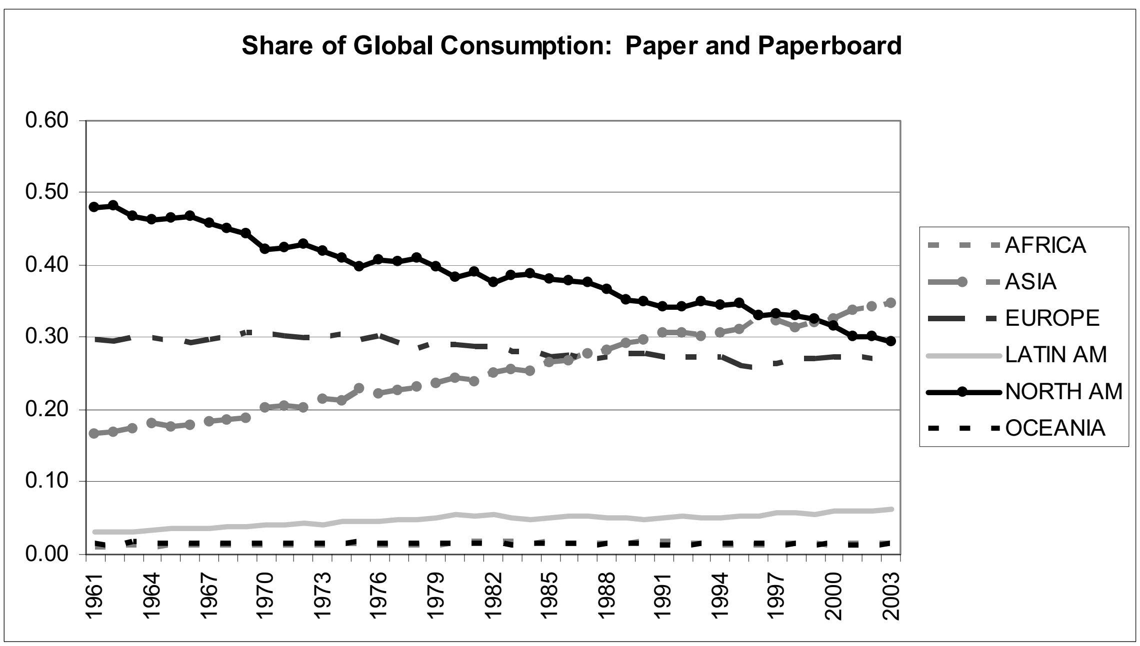


Figure 20. Paper and paperboard consumption shares.

Figure 20 suggests Europe has expanded its exports to Asia of paper and paperboard products.

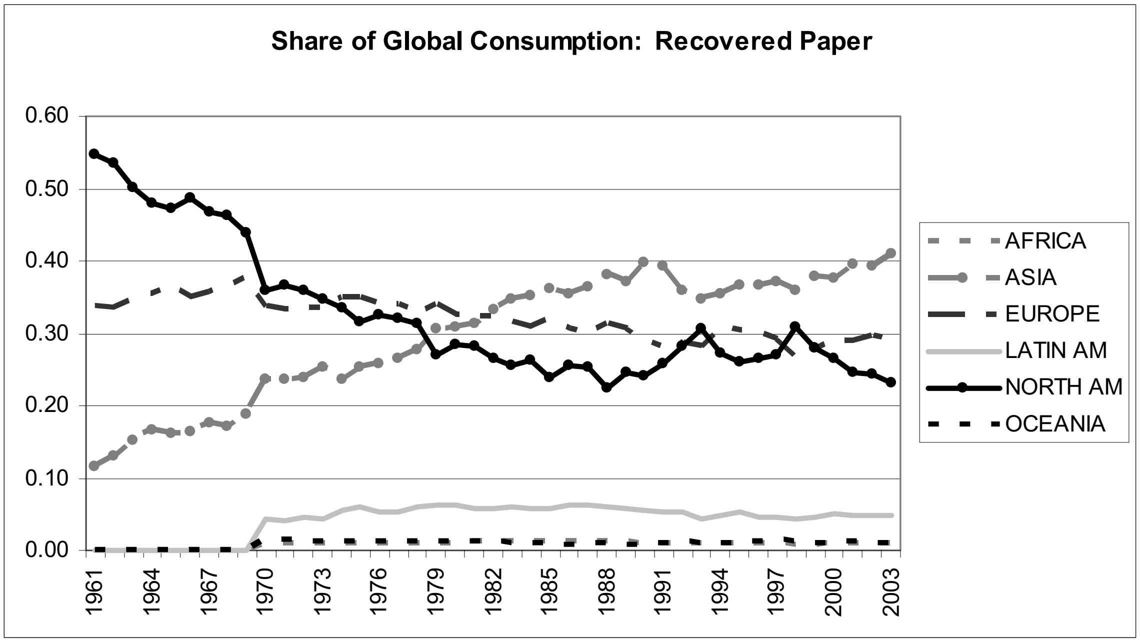


Figure 21. Recovered paper consumption shares.

Figure 21 illustrates 40 percent of recovered paper is consumed in Asia and its trend continues to grow despite the step-down associated with the collapse of the former Soviet Union.

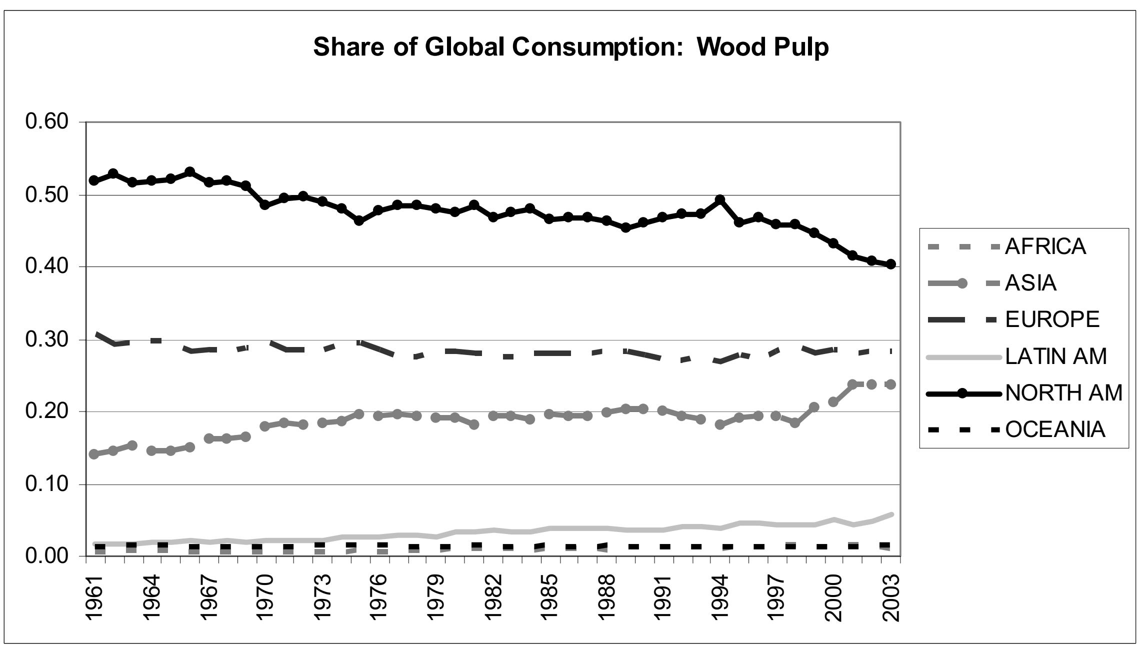


Figure 22. Woodpulp consumption shares.

Figure 22 suggests, in combination with Figure14 that wood pulp is exported to Asia from North America, Europe and Latin America.

We will further explore these trends as we continue analyzing data. We will also represent the data in alternative formats. One such format is to examine the rate of change in trends. We provide a few examples below.

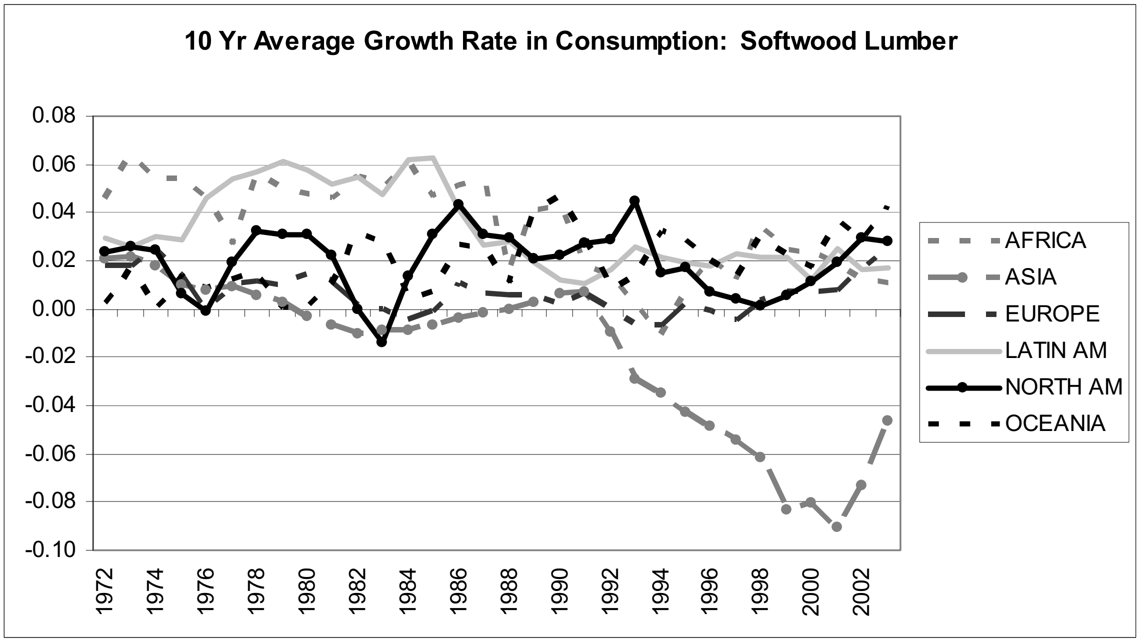


Figure 23. Softwood lumber consumption shares growth.

Figure 23 reproduces 10 year average annual growth rates for softwood lumber demand. It clearly establishes the collapse of the Asian market while other markets have been robust. The trend is similar for the softwood log market (figure not shown) and correlates with the decline in log exports from Washington shown in Figure 2.

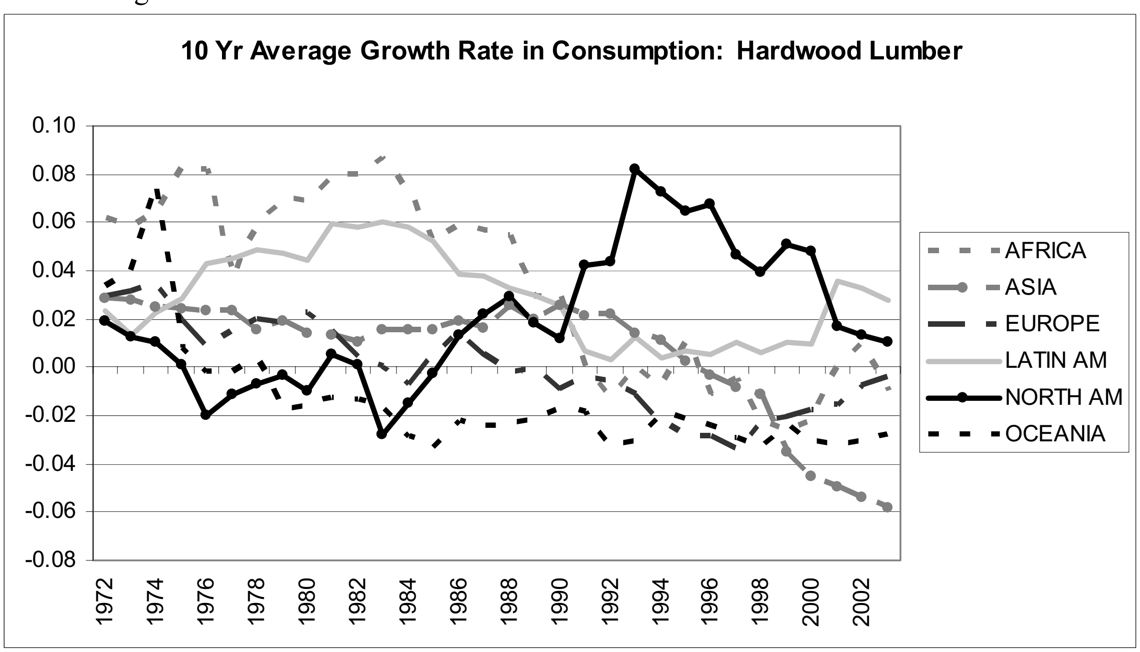


Figure 24. Hardwood lumber consumption shares growth.

Figure 24 indicates that two markets have maintained positive growth for hardwood lumber: North and Latin America. The North American growth rate has declined substantially.

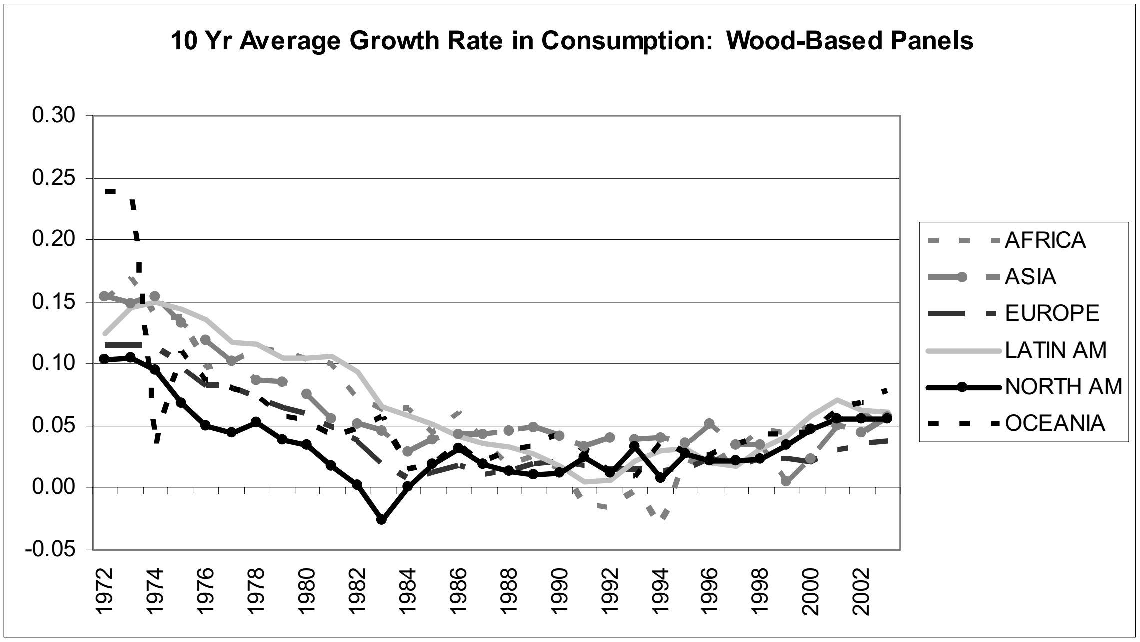


Figure 25. Wood-based panels consumption shares growth.

Figure 25 suggests pretty robust growth for wood - based panel consumption. The demand has been about 5% for all regions.

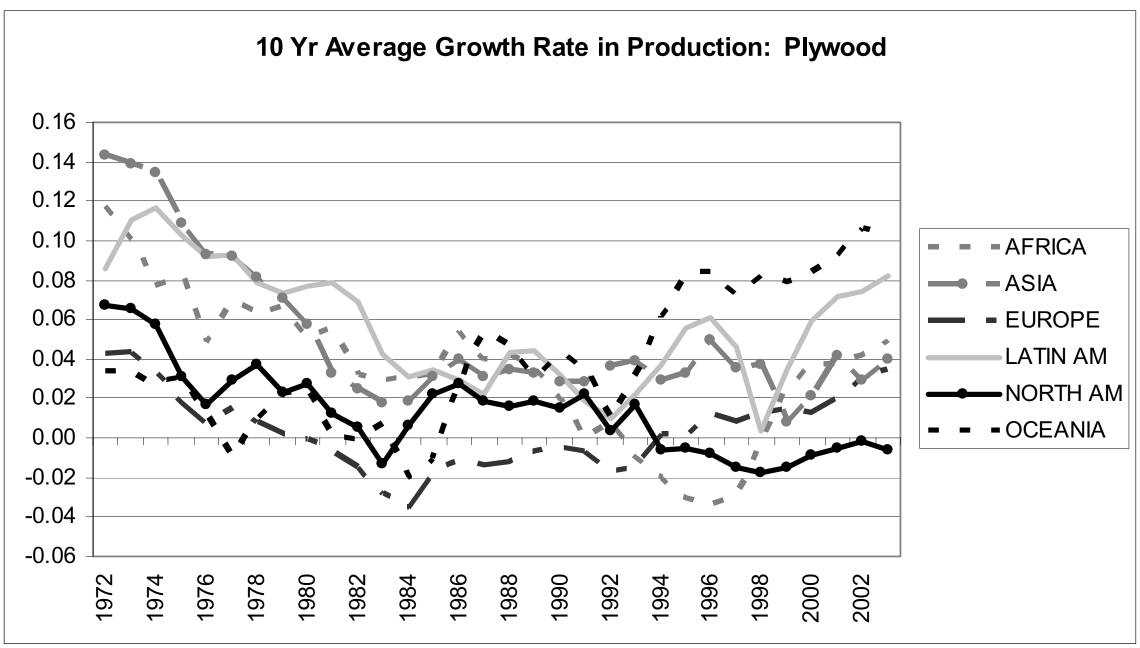


Figure 26. Plywood consumption shares growth.

Figure 26 reproduces the growth rate averages for plywood. While use in North America has declined (a negative growth), other regions, particularly Oceania, have high growth rates.

Similar charts are available for production growth rate averages. We turn to an alternate representation of data that combines the 10 yr average annual growth rate with the share data. We illustrate the case with newsprint. Figure 27 reproduces these data and clearly suggests the decline in the North American newsprint market while emerging markets such as China and Eastern Europe have expanding markets.

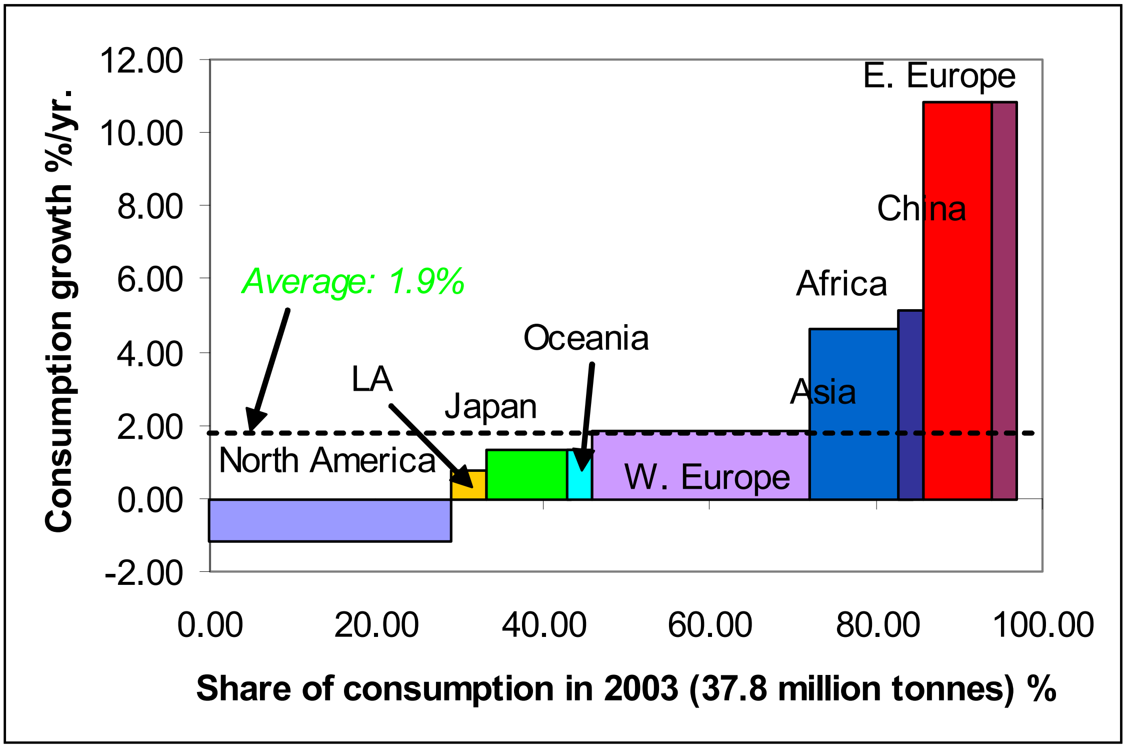


Figure 27. Newsprint market shares.

Study 3: Economic Contribution

Ivan Eastin, Indroneil Ganguly, Daisuke Sasatani

Replaced by Third Progress Report

Study 4: Land Conversion and Cascade Foothills Forestry Viability

Gordon Bradley, Ara Erickson, Lindsay Malone, Alicia Robbins, Luke Rogers

The future of Washington's forests and forestry industries is dependent on various factors: a vibrant forest products market, a commitment to maintain forest land in perpetuity instead of converting to other non-forest uses, and cooperation between the multitude of owners, users, and beneficiaries of the forests and their outputs.

As the changing ownership pattern continues to transfer lands from the traditional large industrial forest products companies to emerging forest land owners (TIMOs, REITs, conservation groups, hobby farmers and foresters), pin-pointing the status of Washington's forests and forestry industries is a challenge. It is difficult to predict the future supply of timber with so many different, and changing, management objectives; conservation groups and TIMOs could have very different management objectives, and thus could drastically alter the future timber supply if the land transfers from one owner to another, or not.

Arguably more important, however, is the transfer of forest land not from owner to owner, but rather from a forest land use (whether for recreation, water, timber) to a non-forest land use (usually residential or commercial development). A 1000-acre tract of forest land converted into 100 20-acre parcels will provide a much changed supply of timber and function as a very different forest ecosystem.

Although it is difficult to predict what the actual ownership make-up and management objectives will be in the future, it is possible to track some of the forest land conversion patterns and associated factors of the past.

Financially, if the rate of return is less for timber than the value of land, then the land will likely be sold. For land owners without pure financial motivations, family forests and conservation groups for example, this rate of return could be lower, depending on their profit goals. When the market for forests and timber is difficult to maneuver and survive, then the region risks losing valuable forest land.

The land conversion study will provide a first-time look at the factors which could lead to forest land being converted to residential or commercial development and some factors and programs which could keep help to keep forest land as forests.

This study:

- Identifies various levels of forest land use change statewide.
- Identifies and assesses factors associated with forest land use conversion.
- Describes forest land use conversion patterns by ownership types with some detailed parcel-level information for specific areas in the state.
- Identifies innovative approaches for valuing non-market forest outputs.
- Identifies incentives and disincentives that alter the maintenance of working forests in areas susceptible to land conversion, and programs that could minimize conversion of forest lands.

Outcomes

- What opportunities could be created for forest landowners to manage forests near urban areas? Are there beneficial strategies for public landowners?
- What market-based or policy incentives will cause landowners to maintain forest ownership and also provide additional environmental outputs (e.g., water, habitat?)
- To the extent that forest land conversion is inevitable, can we create workable interfaces between forest use and development?

- What will be the effects of the 2006 property rights initiative and future zoning? Are there ways to protect forests adjoining converted lands from unreasonable demands, through legislation such as "a right to practice forestry?"
- What steps are we prepared to take to conserve forest lands at risk of conversion?

Accomplishments to Date

- Held first technical review meeting with technical advisory group; discussed study design and research objectives. Technical Advisors are listed in Section I.
- Reviewed final list of factors with respective stakeholders and forest land owners and conservation groups after feedback was received from Forestry Working Group and technical advisory groups. Background paper is provided in Section II.
- Completed draft paper on current incentives and disincentives to maintaining forest land as working forest land. Draft executive summary is provided in Section III.
- Completed land use designation rules for remote sensing analysis for western Washington and ran preliminary statistics on forest land use change. Preliminary forest land use classifications from 1988, 1996, and 2004 for western Washington are shown in Section IV.
- Continued to participate in Cascade Agenda's Forestry Working Group (the main topics of discussion were transfer of development rights and a 15-year forest practices permitting option.) Meeting notes provided in Section V.

Technical Advisory Group

In late May, the land conversion study's technical advisory group convened; membership was determined based on expertise and experience with timberland ownership, Washington zoning and land use planning, land use change analysis, forest land development, and forest-related data stewardship. The following people agreed to serve on the technical review board, playing an important role in review and consultation of the project's study design, goals, methods, and outcomes.

- Jim Nyberg, Real estate consultant
- Stephen Harmon, Washington DNR, Forest Practices Division, Data Steward
- Steve Gibbs, DNR, Resource Protection Division, Forest Stewardship Program Manager
- Tim Trohimovich, Planning Director, Futurewise
- Stefan Coe, Urban Planning, UW, Research Associate
- Miles Logsdon, School of Oceanography, UW, Assistant Professor
- Matt Stevenson, CommEn Space

Potential Factors Associated with Conversion of Forest Land to Non-Forest Uses in Washington State

The first step of this project was the compilation and review of potential factors associated with forest land conversion in Washington State, based on previous work in the state, interviews with key managers and decision makers, and literature from other states and regions experiencing similar levels of forest land conversion. These potential factors form the basis for the spatial analysis of forest land conversion to residential and commercial development that will be performed this summer. Prepared as a stand-alone paper, this valuable piece of information was necessary for a complete study design as well as a reference for a summary of forest land conversion assumptions and future needs in research and decision making.

The forested landscapes of Washington State are changing rapidly. Since the 1930's, Washington has lost approximately 2 million acres of private forestland to non-forest uses. It is estimated that much of this conversion to development is taking place in the low elevation forestland of western Washington, which is among the most productive forestland in the world for softwood lumber products. Of the many factors that contribute to forestland conversion, the highest and best value of forestland for development is one of the primary factors prompting non-industrial and industrial landowners to sell-off or convert their holdings. The effects of urbanization, such as an increasing population in need of buildable land, shift the value of forestland away from timber production to development.

Factors relevant to the state's non-industrial forest land owners, mostly family forest owners, are those of an aging population of landowners faced with retirement investment needs, concern over high estate taxes, and an inability to absorb the costs of managing land to comply with all environmental regulations. Industrial forestland owners acknowledge fiduciary obligations to stockholders to produce investment returns and concerns related to future regulatory uncertainty as other factors they consider when deciding whether or not to retain their forest holdings.

Areas of Washington absorbing the greatest population growth are those most likely to experience conversion of forestland to non-forest uses. Studies addressing the urbanization of rural lands in the eastern and southern regions of United States indicate similar patterns of forestland conversion to non-forest uses. According to professionals working in Washington's forest industry, land conservation organizations and county resource managers; forestland along the I-5 corridor will likely undergo the most conversion in the near future. These experts identified Clark, King, Pierce, Snohomish, and Thurston counties as those likely to see the greatest change. Grays Harbor, Jefferson, Kitsap and Mason counties are also foreseen to undergo increasing rates of forestland conversion. East of the Cascades, Kittitas, Spokane and Stevens counties are anticipated to experience the most conversion of forestland in that region.

Summary

Private forestland ownership constitutes almost 40 percent of the state's forestland base, some 7.5 – 8.5 million acres. Many of these forest holdings are located in the lowland elevation areas attributed to high forest commodity productivity. Yet these are the same areas most threatened by conversion. It is somewhat telling to note that in conversations in preparation of this report that the HBU of forestland being held for development was identified as the leading factor for both the non-industrial family forest owners and the industrial commercial owners. As the state's growing population expands into rural resource lands, there is increasing need for additional buildable land to come from this finite land base; shifting the value of forestland away from timber production to development.

Washington's forestland base is vital not only to the state's economic base, but also for the protection of watershed processes, clean air, fish and wildlife habitat, recreational opportunities, scenic vistas and the quality of life unique to the region. The value of these services is currently not quantified and thus the value of the forestland diminishes, when compared to its developable value.

This report is intended to supplement ongoing research identifying forest areas around Washington where forestland is at risk of conversion. It also identifies potential conversion factors that research institutions, public agencies, and private organizations can address in their efforts to create policies and incentive programs that help landowners retain their land for forest uses.

Washington's Forestland Base and Rates of Conversion

Washington's total land area is almost 42.6 million acres and forestland constitutes nearly 22 million acres, a little more than half the state (WFPA 2005, WDNR 2004). This forestland includes a matrix of public and private lands, protected wilderness areas, and timber stands managed for industrial wood production. Based data from 1989-1991, provided by the U.S. Forest Service's Forest Inventory Analysis program, approximately 17 million acres of this forestland is considered timber land., although not all timberland is actively managed for forestry (Erickson and Rinehart 2005). About 40 percent (between 7.8 and 8.5 million acres) of Washington's total forestland base is privately owned, split roughly in half between industrial and non-industrial landowners (Erickson and Rinehart 2005, WFPA 2005, WDNR 2004).

Since the mid-1930's, Washington's non-federal forest land base has been reduced by 2 million acres, an average net loss of 17,500 acres per year (McClinton and Lassiter 2002). More recently, this rate has increased. Between 1992 and 1997, an average of 44,000 acres/year of rural resource lands were converted to urban and rural transportation uses; approximately 21,000 of those acres each year were conversions from forestland (McClinton and Lassiter 2002).

According to McClinton and Lassiter (2002) Washington's forest land is being converted to other uses at a rate that exceeds the rate of conversion in the Pacific Northwest region and the nation as a whole. To place this in context, of the estimated 620 million acres of forest land in the conterminous United States (Smith et al. 2004), projections estimate that 26 million acres of these forestlands will be converted to urban and developed uses by 2030 in order to accommodate the nation's growing population (Alig and Plantinga 2004). Roughly 1.9 million acres of this forestland is expected to be converted on the Westside of Oregon and Washington (Alig and Plantinga 2004).

Identifying Forestland Conversion Factors

Assessment of scientific literature—both peer reviewed and agency generated—and input from professionals representing Washington's forest industry, land conservation organizations and county resource managers indicates that the primary factors driving forest land conversion in Washington stem from the effects of urbanization and the economic conditions felt by private forest landowners. The close association of these two factors combine to influence the value of forestland; increasingly the highest and best use (HBU) of forestland is that of urban or rural development instead of for timber production (Gabriel and Ketz 2006, Wadsworth 2006, Bill 2005, Dart 2005, Dicks 2005, Dunning 2005, Stinson 2005, Zhang et al. 2005, Alig and Plantinga 2004, Beuter and Alig 2004, CLC 2004, Gobster and Rickenbach 2004, Kline et al. 2004a, Wear and Newman 2004, Xu 1998).

Many of the factors associated with forest land conversion to non-forest uses are related to one another; they drive, influence and further compound the reasons that forestland in Washington and across the United States is being put to other uses (DeCoster 2000). While these factors are often interconnected, this report attempts to differentiate between the various causes associated with forestland conversion in Washington.

Figure 1 summarizes the factors associated with forestland conversion identified through literature review and by individuals contributing to this report.

Primary factor driving landowner decision to convert forestland
- Highest and best use (HBU) value of forestland is for development

Effects of urbanization
- Increasing population density in rural areas
- Growing population-in need of buildable land
- Fragmentation of forestland hinders management of forestland
- Changing urban/rural interface of resource lands spurs cultural differences between residents over value and management of forestlands
- Changing regulatory framework for forestland management

Considerations for family forestland owners
- Aging forest landowners
- Individuals financing retirement
- Adult children less interested in forest management
- Inheritance tax structure
- Landowner frustration with regulations and sense of uncertainty over regulatory future
- Forest and Fish forest practice rules impact on management costs-economies of scale

Considerations for industrial forest landowners
- Regulatory frameworks that reduce ability to manage forestland for desired intensity
- Uncertainty over regulatory future for long-term management
- Obligations to shareholders to maximize profits, prompt conversion of forest holdings with lower HBUs

Figure 1. Factors associated with forestland conversion were identified through review of scientific literature-peer reviewed and agency generated-and input from professionals representing Washington's forest industry, land conservation organizations and county resource managers. The organization of factors under the subheadings follows the general categorization used by individuals as they differentiated between overall factors and those specific to ownership type.

Land values -- HBU (Highest and Best Use) a driving factor

The value of forestland reflects the current use as well as the anticipated use of the land. The growth of Washington's population has led to the increased need for housing which, in turn, has stimulated demand for buildable land. Much of this demand is being met from existing resource lands and this has resulted in increasing the HBU value of forestland for development instead of timber production (Alig and Plantinga 2004, WDNR 2004, Wear and Newman 2004).

The availability of relatively affordable land outside of cities has led new residents and developers to build in rural areas. This urban to rural migration has caused the value of forestland to rise dramatically in response to the demand for residential property. According to Wadsworth (1999) in rural King County, land that has traditionally been worth roughly $1,000/acre for the production of forest products now sells for up to $15,000 - $20,000/acre for residential development. The rise in property value has motivated many traditional forest landowners, both the non-industrial and the industrial, to realize the economic potential of their lands and convert to urban uses (Wadsworth 2006, Dart 2005, Alig and Plantinga 2004, CLC 2004).

While there is a trend of rising land values across the United States, the overall difference in value between forestland and urban lands is far greater in the Pacific Northwest. Alig and Plantinga (2004) assessed forestland values for 38 counties in western Oregon and Washington and found average land values to be $1,483/acre in forest use and $165,947/acre in urban use. Among 14 counties across western Oregon and Washington, they found that land values were as much as $200,000/ acre in urban use and $2,000/acre in forest use. Comparatively, their assessment of counties in the Southeast U.S. found average forestland values to be $415/ acre and $36,216/ acre for urban use.

They concluded that areas with increasing shifts to urbanized land-use are determined primarily by changes in the relative profitability of alternative uses for forestland such as development (Alig and Plantinga 2004). Complementary to their analysis are Wear and Newman's (2004) findings in the Southeastern U.S.: the sooner development is anticipated, the greater the value attached to the forestland. This is supportive of a strong incentive for conversion of forestland being economic as the potential for land development creates alternative land uses of higher value (Dart 2005, Xu 1998). Consequently, forestry-based use of land becomes less attractive in terms of the value to landowners compared to the value of development options.

Population increases in rural areas affect value of forestlands

Washington's population rose by 21 percent between 1990 and 2000, placing the state as the tenth-fastest growing in the nation, with a growth rate much higher than the national average of 13.2 percent. According to the National Census Bureau, Washington's population was about 5.9 million in 2000, and the state's population is expected to be more than 7.8 million by the year 2025 (OFM 2002). Nationally, both urban and rural populations have grown dramatically over the past two decades, causing some rural counties to triple their populations within that time span. This growth contributes some significant impacts to nearby forested landscapes (Alig and Plantinga 2004, WDNR 2004). According to McClinton and Lassiter (2002), Washington's population growth, coupled with economic expansion are two of the leading causes of forestland conversion in Washington, particularly around the Puget Sound region.

Wear and Newman's (2004) assessment of forestland values for the southern United States shows evidence that increased population densities and higher income levels have an effect on near by resources lands. In Georgia, it was observed that in areas with populations with fewer than 150 people per square mile (ppsm) rural land uses remained dominant. A value of 200-350 ppsm represented a transitional zone between urban and rural influences on land values. However, in counties and areas beyond 350-400 ppsm, forestland values were such that long-term timber production was highly unlikely (Wear and Newman 2004). The study found that the amount of forestland valued for conversion rises in counties with higher population densities.

Changing urban-rural interface: cultural differences in management of forestlands

Rural communities are growing, resulting in an increase in new forest landowners with smaller-sized forest parcels, changing the complexion of private forest landowners in Washington (Creighton et al. 2004). Urbanization and the growing populations of communities have an impact on forestland management far beyond urban boundaries (Munn et al. 2002). The urban-rural interface is not only a geographic area where forest management meets urban development, but it is also a political arena where people holding different values for the forest interact (Vaux 1982). Urban migrants have attitudes, needs and values that are often very different from those of long-term residents (Egan and Luloff 2000). New forest neighbors hold expectations that are at variance with the way their neighbors manage their forests (Shands 1991). These differences can result in conflicts that are evidence of opposition to traditional forest management practices (Gabriel and Katz 2006, Alavalapati et al. 2005, Bill 2005, Dart 2005, Dicks 2005, Dunning 2005, CLC 2004, Munn et al. 2002, Egan and Luloff 2000, Sampson and DeCoster 2000, Wadsworth 1999, Barlow et al. 1998, DeCoster 1998, Shands 1991). The typically cited conflict is that of new residents building homes in rural areas and then considering their neighbors' timber harvest practices a nuisance. This spurs concern by both non-industrial and industrial forest landowners that these new residents will influence the actions of decision makers who approve forest policies; such that they will face greater regulatory pressure from new ordinances for more restrictive forest management practices (Gabriel and Katz 2006, Creighton and Baumgartner 2005).

Frustration and concern with Washington's regulatory framework

In order to ensure the provision of public goods from forestland, Washington has developed some of the most comprehensive sets of Forest Practice Rules (FPR) in the United States (Creighton and Baumgartner

2005). The intent of these provisions is to improve environmental conditions by regulating such forest practices as road building, harvesting methods, and the use of chemicals. However, these regulations can make forestry operations more costly, and can in fact act as perverse incentives for non-industrial and industrial landowners to convert forest to other uses (Nelson 2005, Zobrist 2003).

Considerations for family forest landowners

In Washington, between 15 and 20 percent of the forestland, or 3.2-4.2 million acres are owned by private non-industrial landowners (WFPA 2005, WDNR 2004). Of that segment, family forest landowners own approximately 3.0 million acres of the state's forestland (FFF 2006). Many of the state's private non-industrial owners identify themselves as family foresters who feel a close tie to their land and see the implications of the conversion of surrounding forestland as a threat to their quality of life (Dart 2005, Dunning 2005, Stinson 2005).

The demographics of Washington and the nation's private non-industrial forest landowners, particularly family foresters, are shifting (Butler and Leatherberry 2004). As forestlands become increasingly parcelized the number of family forest owners is increasing in Washington and across the nation (Dart 2005, Butler and Leatherberry 2004, DeCoster 1998). The average age of family forest owners in the western United States is 62 (Butler and Leatherberry 2004). Survey findings for Washington State indicate the average age of family forest landowners is between 57 and 67 years old (Creighton et al. 2002). Nearly half (48%) of the land owned by family foresters is held by individuals that are 65 or older (Creighton et al. 2002).

Many of these landowners have adult children who lack interest in managing their parents' forestland; though their parents have a close tie to their land and see it as an economic investment (Dart 2005, Dunning 2005). Consequently, these older landowners often look to liquidate portions of or all of the forestland assets for retirement purposes or to cover other expenses (Dart 2005, Dunning 2005, Stinson 2005, Zhang et al. 2005, Xu 1998). In some instances when family foresters do pass down land, the high value of the forestland -- be it because of the quality of timber or its potential for development -- can force the landowner's heirs to subdivide in order to cover the high cost of estate taxes (Stinson 2005).

Family foresters have expressed frustration with regulatory restrictions at the federal, state and county levels such that they feel that the respective governments and administering agencies lack trust in them to steward their forestlands under appropriate forest practices (Creighton and Baumgartner 2005, Dart 2005, Dunning 2005, Stinson 2005). Furthermore, increases in land-use regulations driven by environmental statutes and litigation are reinforced by state government regulations that require forest landowners to absorb the costs of property improvements to protect environmental attributes (Creighton and Baumgartner 2005).

Conversion can also be triggered out of frustration with the regulatory environment or uncertainty of the regulatory future (Dunning 2005, Stinson 2005, Xu 1998). At present, attention in Washington is directed at Forest and Fish forest practices rules, where riparian buffer widths required by the Forest Practice Emergency Rules have had a disproportionate impact on small-scale family forests, than on industrial lands (Calhoun 2005, Creighton and Baumgartner 2005, Stinson 2005). The complex rules and approaches to riparian management require technical expertise to implement, which many of these landowners cannot afford (Bill 2005, Dart 2005, Stinson 2005). Given these conditions the HBU value of a landowner's holdings is often a reason to sell or convert their forestland to development (Dart 2005, Dunning 2005, Stinson 2005, Zhang et al. 2005, WDNR 2004, McClinton and Lassiter 2002, Xu 1998).

Concerns of industrial forest landowners

In Washington, approximately 21 percent of the state's total private forestland, or about 4.5 million acres, is owned by nearly 60 large industrial private landowners (Erickson and Rinehart 2005, WFPA 2005). The effects of urbanization on resource lands and the HBU value of forestland for development uses are factors that industrial forestland owners are keenly aware of (Dart 2005, Dicks 2005, Nelson 2005, CLC 2004). Their fiduciary obligation to shareholders to maximize profit may dictate that they sell portions of their high-valued timberland holdings for even higher-valued. development. (Gabriel and Katz 2006, Dicks 2005, Dart 2005, CLC 2004).

Industrial owners of Washington forestland have indicated that they have chosen to sell their holdings in counties with high development pressure, to avoid the difficulties of conducting forest practices in an increasingly urban landscape (Gabriel and Katz 2006, CLC 2004). Concern over the perceived unpredictability of the regulatory climate of Washington is also a factor that weighs heavily in their decisions to retain forestland in rotation for timber harvest (Gabriel and Katz 2006). One example pertains to the current Forest and Fish practices under the Forest Practice Rules. While industrial forest landowners have invested time and finances to comply with these management practices, there is continued environmental pressure for additional species protection. With anticipation of such restrictions they see limitations to their ability to meet the management objectives of their forests and their potential profitability (Gabriel and Katz 2006, Dart 2005, Dicks 2005). In response to increasing regulations, many industrial forest owners are selling their commercial tree farms at an increasing rate, replacing thousands of acres of contiguous forest with residential development lots ranging from 5 to 20 acres (Creighton and Baumgartner 2004). Most forest products companies now have real estate development divisions and are actively marketing properties (Wear and Newman 2004).

Where Forestland Conversion is Predicted to Take Place

The conversion of forestland to development is influenced significantly in many cases by location (Alig and Plantinga 2004). Unlike Oregon, where much of the forestland is buffered from development by its geographic isolation, steep slopes of the coastal mountains and poor accessibility (Kline and Alig 2005); Washington's forestland is in areas experiencing urban growth. The low-elevation forests of western Washington are among the most productive in the world for softwood products (McClinton and Lassiter 2002) and these are the areas where most of the state's forestland is predicted to be lost. Forestlands around the state that are susceptible to development pressure are those nearby urbanizing areas with roads and transportation infrastructure to support population expansion (Dicks 2005, Kline and Alig 2005, Munn et al. 2002, Barlow et al. 1998).

According to Washington's forest industry, land conservation organizations and county resource managers, forestland along the I-5 corridor will likely undergo the most conversion. For the Westside of the Cascades, they identified Clark, King, Pierce, Snohomish and Thurston counties as those likely to see the greatest change (Bill 2005, Dart 2005, Dicks 2005, Dunning 2005, Stinson 2005). They also foresee that Grays Harbor, Jefferson, Kitsap, and Mason counties will undergo forestland conversion (Gabriel and Katz 2006, Dart 2005, Dicks 2005). In eastern Washington, they anticipate that Kittitas, Spokane and Stevens counties are likely to undergo the most conversion of forestland (Dart 2005, Dunning 2005).

Forestlands in other regions in Washington are also at risk for conversion, while Stein et al. (2005) reported in *The Forests on the Edge* report that areas in Whatcom and Skagit counties are likely to have housing densities increase by 20-40 percent on private forestlands, Dart (2005) has indicated that most of Whatcom County's timberland is rugged and mountainous and not suitable for development. Largely, Dart (2005) reports that the lands likely to be converted for development are rural agricultural lands.

Incentives for Forestland Owners

In addition to investigating potential factors associated with forest land conversion, this project reviews potential incentives and disincentives for forest land owners to maintain their lands in forestry uses or convert to non-forestry uses. These incentives and disincentives will be presented in another stand-alone paper in the coming months; in the meantime, an executive summary is presented below:

In the absence of high timber values, private forest landowners in Washington State are motivated to sell their properties for the next highest and best value, which is rapidly becoming the real estate or residential use value. This is of concern because privately-owned timberlands and forestlands provide the public with many market benefits (such as wood products) as well as many non-market benefits (including environmental services such as clean water, air, wildlife habitat, forest beauty and aesthetics). If these forests are permanently converted into residential or other non-forested properties, then both the market and non-market benefits are lost. It is thus important to understand whether or not there are economic incentives and other policy tools that can substitute for higher timber values and thereby reduce the rate of conversion.

Potential Incentives for Maintaining Working Forestlands

- Direct Payments
  - Grants and Cost Share
  - Private Deals
- Regulatory Relief
- Tax Relief
- Social License
- Technical Assistance
- Market Innovation and Additionality

In this paper, six potential incentives for maintaining working forestlands are identified. First, direct payment programs offer payments to landowners for changing particular aspects of their management to meet conservation objectives or for placing a portion of their land in a conservation easement. These payments are often in the form of grants and cost share programs. The largest ones are offered by federal or state agencies, Many of the federal programs with impacts on forest landowners are funded through the Farm Bill. In 2005, Washington landowners received $101 million in conservation payments for programs funded through the Farm Bill, placing the state 10th (relative to other states) in terms of the dollar value of these payment programs . The payments available through the Farm Bill are primarily directed at agricultural producers, and only a few of the programs are applicable to forest landowners. Payments through the Forest Service's Forest Legacy Program provided an additional $2.7 million in 2005; Washington again ranked 10th (relative to other states) in overall funding support for this program. The Department of Fish and Wildlife also offers programs to support specific species and habitat protection. Additional payment programs are available or administered through the Washington Department of Natural Resources. In 2005, these programs provided $4.7 million in support of several conservation programs for small forest landowners. Direct payment arrangements may also be negotiated between private parties, and include conservation easements purchased by conservation organizations and land trusts.

Second, regulatory relief programs provide assurances that as long as landowners adhere to particular management requirements, they may be considered exempt from current or future more stringent regulations. In some cases, alternate management plans based on particular site specific needs may be developed to help landowners continue operating while meeting the goals of particular regulations (such as the Forest and Fish Law). Third, tax relief offers relief from various taxes for landowners. Fourth, forestland owners have identified a diminishing "social license" to practice forestry as a reason that they (or their heirs) divest of forestlands. Improving public awareness may help increase the perceived social license. Fifth, technical assistance programs include educational programs aimed at teaching landowners how to implement new regulations, new technologies or management plans.

Sixth and last, there are newly emerging opportunities for market innovation and additionality. In recent years, there has been a large effort to develop mechanisms to bring "ecosystem services" (described above) to market. Other parts of the Washington Forest Futures study address the traditional market benefits provided by forests. It is important to understand these other "non-market" values. There is much evidence that the value of non-market attributes can be quite high, since government agencies expend great efforts to protect habitat, water, air, and such through regulation, and have increasingly looked at incentives to improve diminishing returns on those investments.

The increase in volume in the voluntary carbon market, wetland mitigation and biodiversity conservation banking, debt for nature swaps, and use of tax breaks such as New Market Tax Credits, demonstrate the growth in payments for ecosystem services. To date, these examples represent the disparate efforts of a few organizations and companies and an actual market may be a long way off. It is likely that efforts aimed at monetizing ecosystem services will continue to gain momentum as there is a growing recognition that the traditional regulatory approach aimed at preventing environmental damages may not achieve all of its intended goals.

Forestland Conversion in Western Washington

As privately-owned forests are converted into residential and commercial development, owners of Washington's working forests are finding it increasingly difficult to maintain their lands in productive forestry uses. The conversion of these forested areas also constrains the social, biological, and ecological functions of remaining forested areas. As an expanding exurban population places increased development pressures on Washington's forests, it is becoming more important to fully understand where conversion is occurring, what factors are associated with the conversion, and how the rate of conversion might be slowed through innovative land owner and institutional programs.

While there are many groups in Washington working on these important issues, there is no single data source or analysis that cohesively describes the status of the forest land base across the entire state. This study provides a rare opportunity for some of these groups to work collaboratively to build a conceptual model for analyzing and displaying both the current status of forest land area statewide, along with factors that may be associated with the potential conversion or non-conversion of working forests.

Statewide trends in forest land conversion are being extracted from data completed for a project for the USDA Forest Service's Forest Inventory Analysis (FIA) program – a regional assessment of land use change on non-federal lands in western Washington using Landsat satellite imagery and a series of spatial overlay analyses in a Geographic Information System (GIS). Since Federal lands rarely, if ever, are converted from forest land or other resource and wild land uses to developed lands, only non-Federal lands are included in this analysis. Land use designations were based on the following methods and assumptions.

Land Cover Classifications

Two segmentation levels were used to differentiate between large areas of relatively homogeneous land cover and small areas of development. This resulted in two different land cover classifications: a general land cover classification (e.g., forest or irrigated lands) and a developed (e.g., concrete, rooftops) land cover classification.

- *Dark Forest:* Mature evergreen forest cover
- *Light Forest:* Sub-mature and deciduous forest cover with increasing likelihood away from floodplains and in higher elevations
- *Regeneration:* Bare or nearly bare soil with increasing likelihood away from floodplains and in higher elevations
- *Irrigated:* Irrigated agricultural lands with increasing likelihood in or near floodplains and in lower elevations
- *Soil:* Bare soil with increasing likelihood in or near floodplains and in lower elevations
- *Mixed Ag/Soil:* Heterogeneous lands with some irrigated agricultural and bare soil often with some dispersed development
- *Residential:* Low to medium density residential developments including rural developments and large-lot urban residential areas
- *Urban:* Dense residential developments, urban centers and industrial lands
- *Water:* Oceans, lakes, streams and reservoirs, etc…
- *Haze:* Clouds partially block view of earth surface
- *Clouds:* Clouds completely block view of earth surface
- *Shadow:* Dark areas adjacent to *Clouds*
- *Unclassified:* Spectrally indistinguishable areas which can not be classified

- *Built:* Impervious surfaces, such as concrete, rooftops, gravel (classified at the fine-scale segmentation level)

Land cover was grouped by *land cover classifications* for calculation of *contiguous land cover classification acres*.

- *Forest:* Dark Forest, Light Forest and Regeneration land cover classes
- *Agriculture:* Irrigated, Soil and Mixed/Ag Soil land cover classes
- *Developed:* Residential and Urban land cover classes
- *Clouds:* Cloud land cover class
- *Shadow:* Shadow land cover class
- *Unclassified:* Unclassified land cover class

Land Use Polygons

Land use polygons were generated from the coarse scale image objects by dissolving objects less than 10 acres in size and not classified as water. While any minimum mapping unit could have been used it would have been difficult if not impossible to classify land uses in areas less than 10 acres (~7 x 7 pixels) with the resolution of the Landsat imagery. Land use polygon acres were calculated as a metric for calculating land use.

Percent Developed and Development Density

The percent developed is the amount of concrete or other developed land cover that is within each land use polygon. The percentage developed of each land use polygon was calculated by overlaying the fine scale developed land cover classification on the dissolved coarse scale general land cover classification.

Development density is the number of individual developments per square mile. The fine scale developed land cover classification was grouped into individual developments. Developments could be of any size ranging from approximately ¼ acre to 169,000 acres in the Seattle metropolitan area. The number of these unique developments in each land use polygon was normalized to a per square mile development density figure.

Adjacent *land cover classifications* were combined to create contiguous areas of land cover classes. Contiguous land cover classification acres were calculated as a metric for calculating land use.

Adjacent *land cover classification groups* were combined to create contiguous areas of similar land cover classes. Contiguous land cover group acres were calculated as a metric for calculating land use.

Land Use Designations

- *Wildland Forest*
  a. Description: Industrial and non-industrial forestlands, parks, municipal watersheds and other forested lands that have very few paved roads or residential developments.
  b. Definition: At least 640 contiguous forest group acres and no more than 5% developed with a development density of 4 per square mile or less. The land use polygon must be in a forest land cover classification group.
- *Rural Forest*
  a. Description: A mix of forestland types with some dispersed residences.
  b. Definition: At least 640 contiguous forest group acres and no more than 20% developed with a development density of between 4 and 8 per square mile. Contiguous forest group acres less than 640 and no developments or the land use polygon is greater than 640 acres and no more than 5% developed. The land use polygon must be in a forest land cover classification group.

- *Other Forest:*
    a. Description: Areas that are primarily forest but have too many developments to be considered rural forest.
    b. Definition: Any remaining land use polygons that are in a forest land cover classification group and not wildland forest or rural forest.
- *Intensive Agriculture:*
    a. Description: Agricultural and livestock lands dominated by irrigated crops or grassland, bare soil and dispersed farm buildings.
    b. Definition: At lest 640 contiguous irrigated or soil acres and no more than 5% developed with a development density of 9 per square mile or less. Contiguous irrigated or soil class acres less than 640 and less than 1% developed or mixed ag/soil land cover classification and less than 1% developed.
- *Mixed Agriculture:*
    a. Description: A mix of agricultural and livestock lands with some additional residences unrelated to agriculture and an occasional small development. Often includes non-irrigated and cleared lands and occasional industrial buildings.
    b. Definition: At least 640 contiguous class acres in an agricultural land cover group and no more than 20% developed with a development density of 12 per square mile or less.
- *Other Agriculture:*
    a. Description: Agricultural and cleared lands that have a development density equated to 20 or 40 acre parcels that may be single-family residences, hobby farms or small agricultural operations.
    b. Definition: Any remaining land use polygons that are in an agriculture land cover classification group and not intensive agriculture or mixed agriculture.
- *Low-Density Residential:*
    a. Description: Large areas of development in suburban and rural settings where parcel sizes are large and the landscape is dominated by roads, homes and commercial buildings.
    b. Definition: At least 40 contiguous class acres that are in a forest or agricultural land cover classification group and are between 20% and 50% developed.
- *High-Density Residential:*
    a. Description: Large areas of development in dense urban settings or in large rural developments. Small parcel sizes. Around 50% of the land surface is impervious surface like roads, roofs, sidewalks and driveways.
    b. Definition: Land use polygons that are in the developed land cover classification group and less than 50% developed or less than 40 contiguous class acres and greater than 50% developed or in a non-developed land cover classification group and greater than 50% developed.
- *Urban:*
    a. Description: Dense urban development. Over 50% of the land surface is impervious surface with little vegetation. Airports, industrial parks, urban centers, multi-family residential and very high density residential development.
    b. Definition: At least 40 contiguous class acres that are in a developed land cover classification group and greater than 50% developed.
- *Water:*
    a. Description: Oceans, lakes, reservoirs and streams.
    b. Definition: Any land use polygon in a water land cover classification group.

- *Unknown:*
    a. Description: Any land cover that could not be classified due to spectral ambiguity, cloud cover, haze or shadow.
    b. Definition: Any land use polygon in an unknown land cover classification group.

The data and maps presented in this progress report are in the preliminary stages and have yet to be fully verified or checked for accuracy. Final data and maps will be made available in subsequent progress reports and at the conclusion of the study. Similar data is being produced for eastern Washington as part of this study.

Table 1 shows the estimated acres of forest land uses, agricultural and mixed land uses, and developed land uses on non-federal lands in western Washington from 1988, 1996, and 2004. As shown in bold, the amount of forest land use has decreased from approximately 6.77 million acres in 1988 to 5.47 acres in 2004. Much of this land went either to developed lands or agricultural and mixed lands. The amount of developed land in western Washington increased from an estimated 0.56 million acres to 1.1 million acres between 1988 and 2004.

The maps shown in Figures 1, 2, and 3 are based on the data from Table 1. The light brown colors are the federal lands not included in the analysis. As evident from these preliminary maps, the amount of developed lands (high- and low-density residential and urban lands) has increased from 1988 to 2004. Additionally, the amount of agricultural lands appears to be increasing; this is due to the difficulty in distinguishing the typical rural developments common throughout western Washington (hobby farms and large lots cleared of trees) from many of the pastures and fields used for agricultural purposes.)

Figure 4 shows acres of land that changed from a forest land use to either agriculture/mixed or developed land uses between 1988 and 2004. Each bar represents the total amount of forest land in 1988 and the area that changed to the respective land use by 2004 (as well as how much stayed in forest land use). Once again, these numbers are preliminary estimates and are not yet finalized.

Table 1. Land Use on Non-Federal Lands in Western Washington (Preliminary Numbers)

Estimated Acres of Land Uses on Non-Federal Lands in Western Washington (All numbers rounded to the nearest 1000)						
	1988		1996		2004	
LAND USE	Private/ Other Public	WA DNR	Private/ Other Public	WA DNR	Private/ Other Public	WA DNR
Wildland Forest	6,390,000	1,681,000	5,486,000	1,609,000	4,644,000	1,502,000
Rural Forest	44,000	1,000	20,000	1,000	17,000	2,000
Other Forest	334,000	35,000	506,000	57,000	807,000	102,000
Total Forest	**6,768,000**	**1,717,000**	**6,012,000**	**1,667,000**	**5,468,000**	**1,606,000**
Intensive Agriculture	494,000	20,000	438,000	29,000	482,000	37,000
Mixed Agriculture	393,000	11,000	692,000	24,000	685,000	26,000
Other Agriculture	113,000	4,000	281,000	14,000	357,000	19,000
Total Agriculture/ Mixed	**1,000,000**	**35,000**	**1,411,000**	**67,000**	**1,524,000**	**82,000**
Low-Density Residential	219,000	5,000	323,000	9,000	502,000	21,000
High-Density Residential	150,000	3,000	208,000	5,000	257,000	8,000
Urban	189,000	3,000	313,000	5,000	384,000	6,000
Total Developed	**558,000**	**11,000**	**844,000**	**19,000**	**1,143,000**	**35,000**
Note: Since land use objects used in analysis do not necessarily follow ownership boundaries, land uses are not perfectly aligned with ownership information. For example, Washington DNR may not have 36,000 acres of developed land, but the overall land use in the area of those lands is residential or urban.						

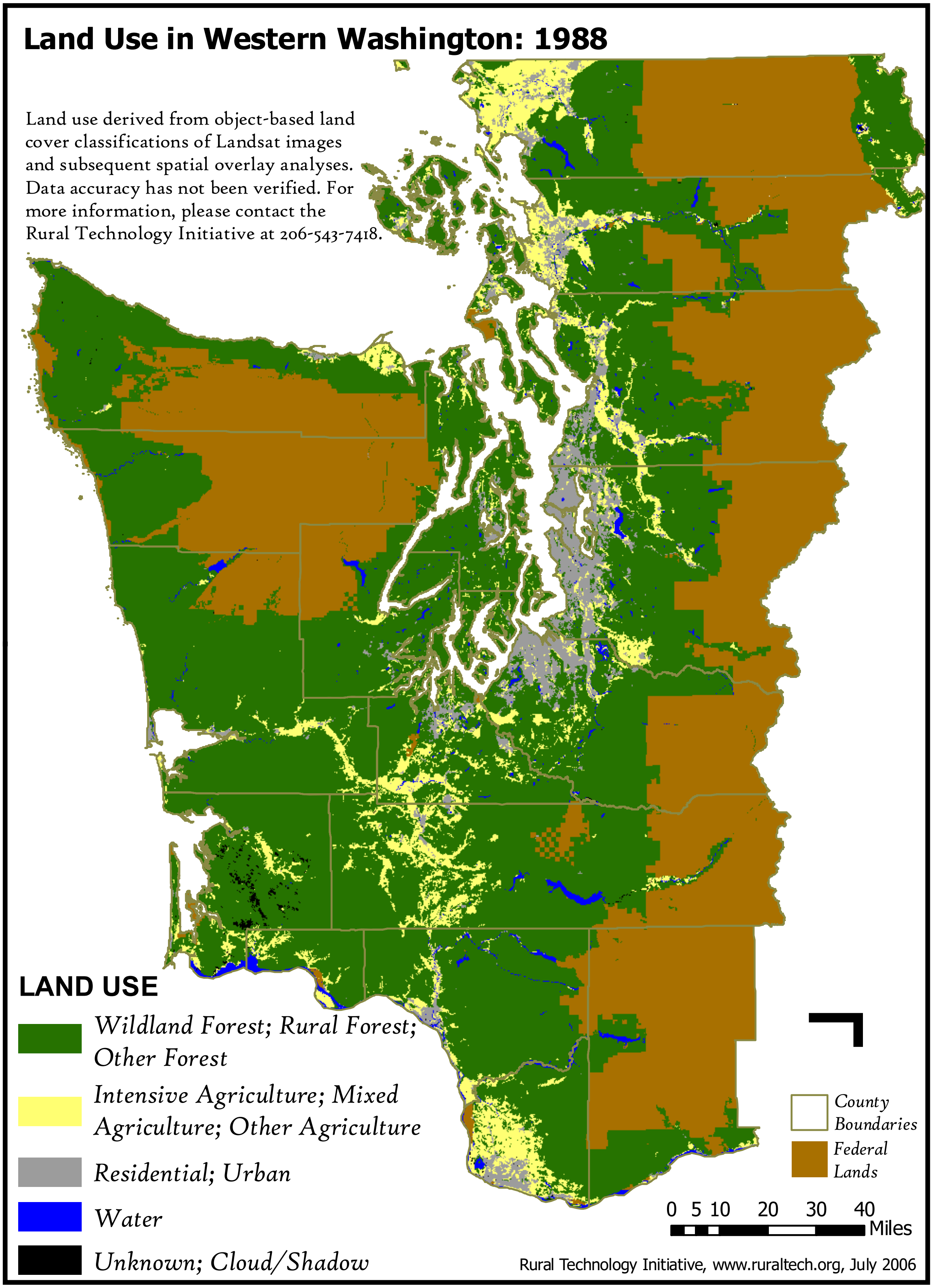


Figure 2. Land Use in Western Washington in 1988

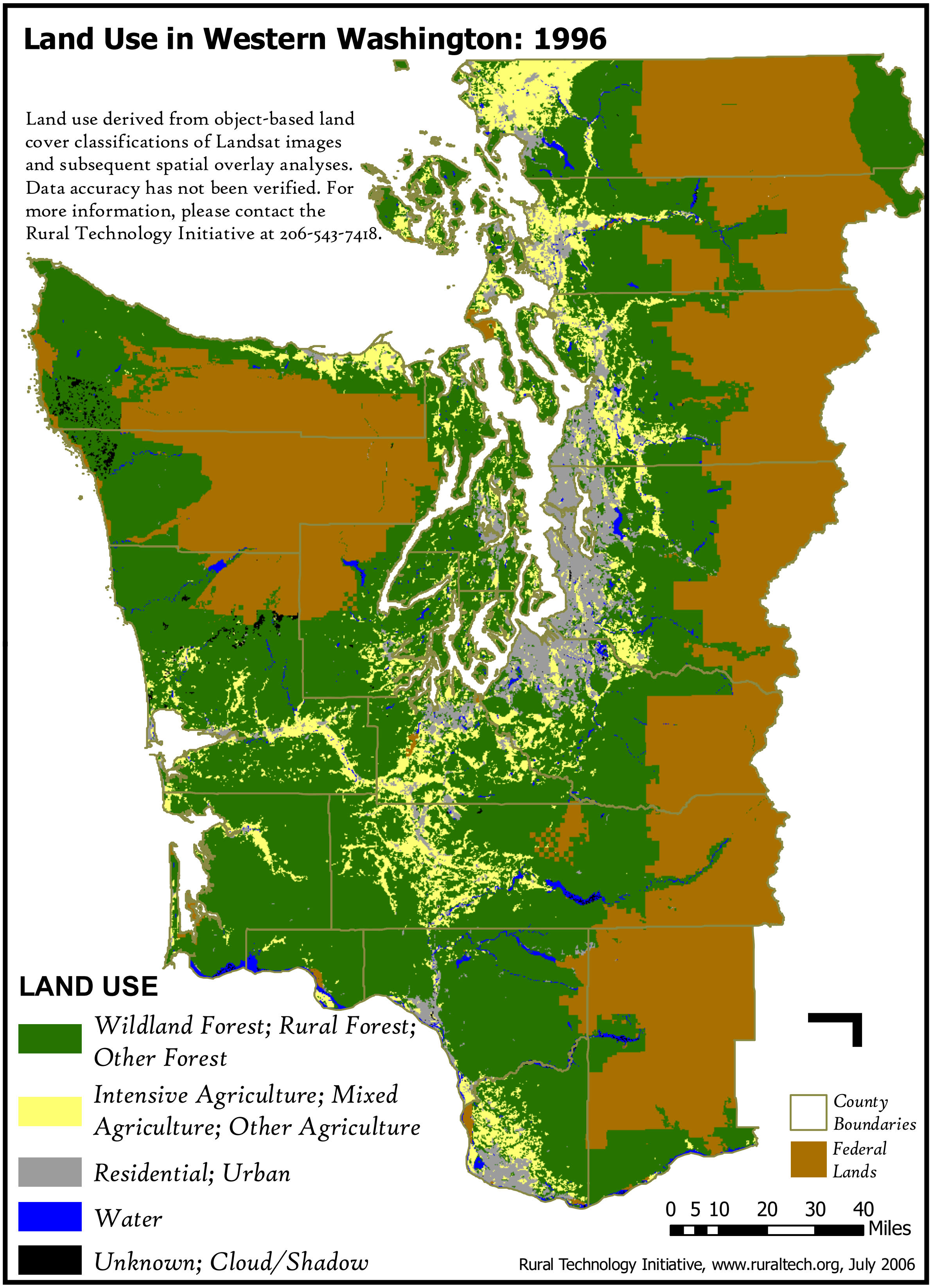


Figure 3. Land Use in Western Washington in 1996

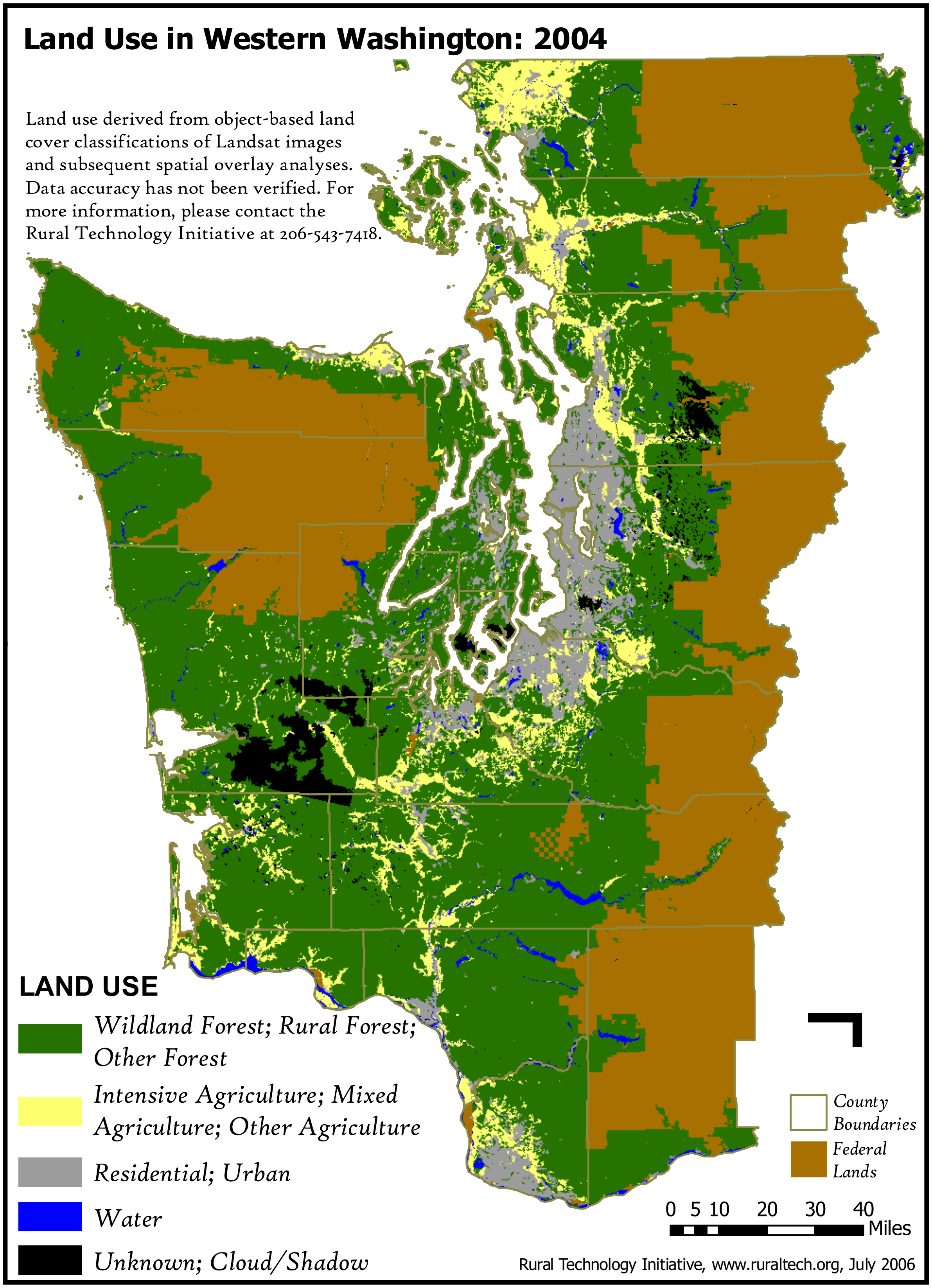
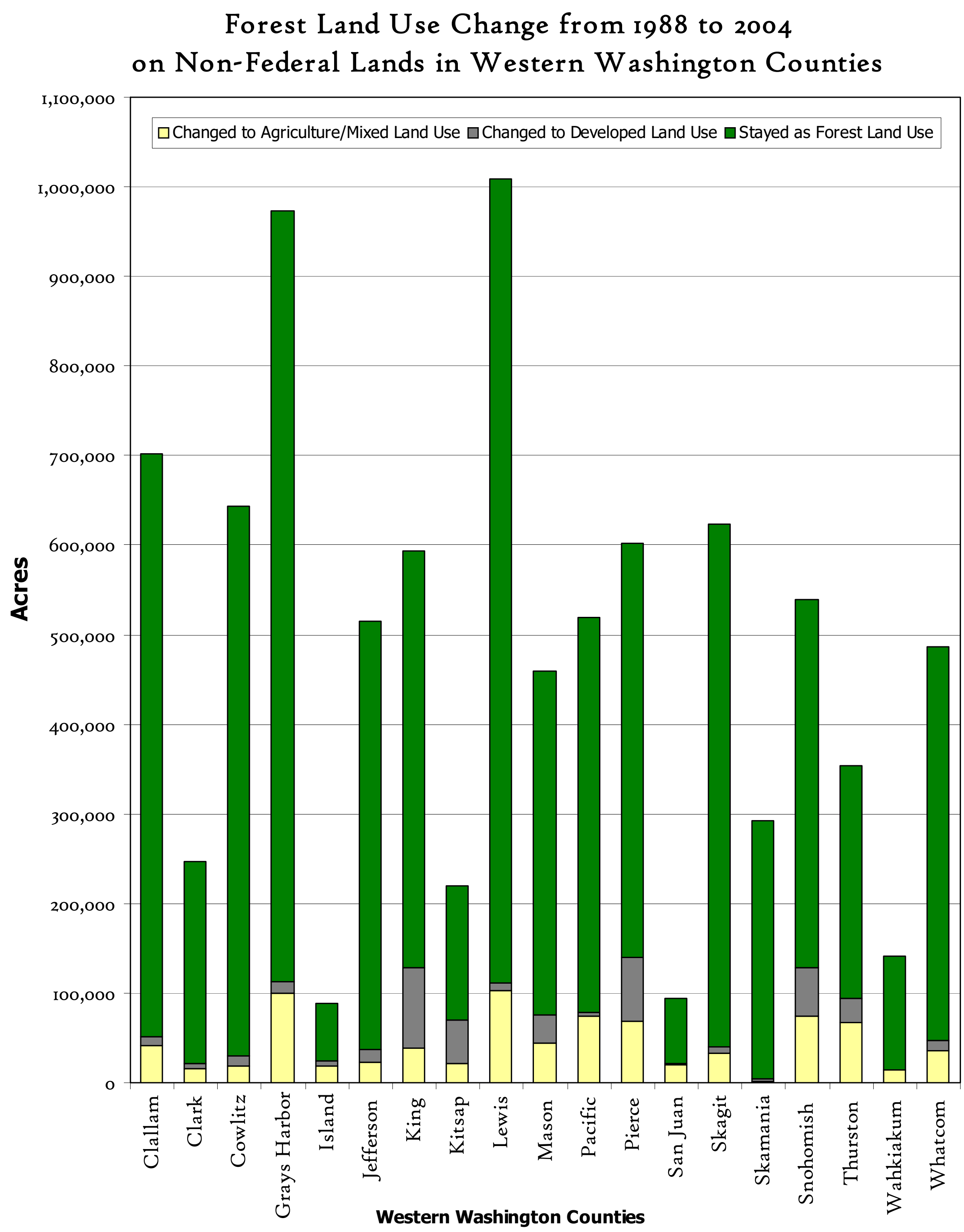


Figure 4. Land Use in Western Washington in 2004.



This graph only represents acres of land that changed from a forest land use to other land uses between 1988 and 2004. Although additional land use changes were analyzed, such as agricultural land uses to developed land uses, that data is not represented in this chart. For example, Clark County has experienced more development than represented in this chart since most of the development took place on agricultural or mixed lands rather than forest land.

Figure 5. Preliminary Estimates of Forest Land Use Change on Non-Federal Lands in Western Washington between 1988 and 2004 by County.

Cascade Agenda Forestry Working Group

The Cascade Agenda's Forestry Working Group (convened and led by the Cascade Land Conservancy) has been meeting bi-monthly since January. The group includes the following members:

- Charley Bingham, Co-Chair, Former Weyerhaeuser executive
- David Thorud, Co-Chair, Dean Emeritus, College of Forest Resources, UW
- Brian Boyle, Northwest Forest Resource Center
- Gordon Bradley, UW College of Forest Resources
- Bonnie Bunning, WA State Dept. of Natural Resources
- Nina Carter, Washington Audubon
- John Davis, Hancock Timber Resources
- Ara Erickson, UW College of Forest Resources
- Ken Miller, WA Farm and Forestry Association
- Colin Moseley, Green Diamond Resource Company
- Heath Packard, Washington Audubon
- Bill Pope, Owner Mazama Country Inn
- Charlie Raines, Sierra Club
- Court Stanley, Port Blakely Timber
- Steve Sundquist, Cascade Land Conservancy expert volunteer

Forestry Working Group Tracking: Meeting Attendance and Progress

Meeting Date	Attendees	Work Plan	Action Items
1/24/2006 Group Meeting at CLC	**David Thorud** Court Stanley Nina Carter Ken Miller Charlie Raines Colin Moseley Bill Pope Steve Sundquist Brian Boyle Gordon Bradley John Davis Ara Erickson *Michelle Connor* *Erik Steffens* *Andrew Galbraith* *Alison Van-Gorp* *(italics indicates CLC staff,* **bold indicates co-chairs***)*	Cascade Agenda (CA) staff provided an overview of the problems facing working forestlands in our region that were identified in the dialogues. These all fell under the umbrella of preventing conversion of forestland to residential development. We identified family forest landowners as a group under pressure to convert and discussed ways to incentivize them to remain in forestry. The group also discussed the issues surrounding cutover forestland coming on the market and the need to maintain these lands in long term forestry.	The group agreed that conversion was the greatest threat to forestland in our region. They identified high real-estate value as the greatest challenge for landowners wishing to remain in forestry. Small forest landowners also were concerned with regulatory certainty and complexity as issues to discuss later.
2/14/2006 Conference Call	**Charley Bingham** **David Thorud** Court Stanley Nina Carter Ken Miller Rick Dunning Colin Moseley Bill Pope Steve Sundquist Brian Boyle Gordon Bradley John Davis	The group confirmed that they would like to focus on the issue of HBU and real-estate value. The group decided that they would like to learn more about Transfer of Development Rights (TDR) programs and how they could be used to help forest landowners see value for their properties development potential without converting. Brian Boyle provided the group	Cascade Agenda staff will prepare a presentation on the basics of TDR programs and on examples nation wide.

	Ara Erickson *Michelle Connor* *Andrew Galbraith*	with updates on the activities and progress of the Forest Forum.	
2/28/2006 Group Meeting at CLC	**Charley Bingham** **David Thorud** Bonnie Bunning Nina Carter Ken Miller Rick Dunning Colin Moseley Bill Pope Steve Sundquist Ara Erickson *Michelle Connor* *Andrew Galbraith* *Eric Steffens* *Alison Van-Gorp*	CA staff gave a presentation on TDR programs. The group asked questions and began discussion on how to make it apply to Washington forest lands. Washington Farm Forestry Association (representing family forest landowners) asked the group to consider their plan to ask DNR to approve a 15-year alternate management plan. Rick Dunning of WFFA presented to the group on 15-year permitting.	CA Staff will start working with the group members to create a set of recommendations on how TDR programs can best apply to working forest lands. WFFA will provide CA staff with more information on 15-year permitting to send out to the group. Discussion will continue on this issue.
3/14/2005 Call	**Charley Bingham** **David Thorud** Court Stanley Heath Packard Charlie Raines Bonnie Bunning Ken Miller Rick Dunning Colin Moseley Bill Pope Brian Boyle John Davis Ara Erickson *Michelle Connor* *Andrew Galbraith* *Erik Steffens*	Group discussion on 15-year permitting - Rick Dunning gave the following updates; $250,000 in Governor's Budget for state agencies. Pilot projects will be developed. The group agrees that the concept is sound and that we should stay involved and recommend endorsement if the plan is sound. Discussion on TDR sending-Group advocates for: strong markets, private transactions, fairness to landowners, and streamlined transactions. They are concerned over lack of conservation easement (CE) back door and concerned about county regulation overlap and need for a "right for forestry".	Staff will track the progress of the 15-year plan. We will stay in touch with WFFA to time our endorsement for maximum impact. Staff will take the group's recommendations on TDR sending sites and develop a draft document.
3/28/2006 Meeting	**David Thorud** Nina Carter Charlie Raines Ken Miller (phone) John Davis Ara Erickson *Michelle Connor* *Andrew Galbraith* *Erik Steffens*	TDR Sending discussion: Discussion of eligibility and prioritization of sending sites. Discussion of issues and resale values for CE restricted lands. Discussion of certification- It has value, but probably not for this group.	Staff will revise documents and continue discussion.
3/29/2006 1 on 1	Court Stanley *Andrew Galbraith*	TDR Sending discussion	
4/11/06 Call	**Charley Bingham** **David Thorud** Nina Carter Charlie Raines Bonnie Bunning Ken Miller Brian Boyle John Davis Ara Erickson Steve Sundquist	Staff presented the complete draft of the TDR recommendation white paper. The group discussed this draft. The group also began the discussion of how to participate in the TDR planning process that will take place in Pierce and Snohomish.	Create new draft of white paper strategy for participation in county TDR process.

	Michelle Connor *Andrew Galbraith*		
4/25/2006 Meeting	**David Thorud** Charlie Raines Ken Miller(phone) Colin Moseley(phone) Bill Pope(phone) Brian Boyle Steve Sundquist(phone) Ara Erickson *Michelle Connor* *Andrew Galbraith* *Erik Steffens* *Alison VanGorp*	The group reviewed new maps of parcel ownership and zoning in Pierce and Snohomish counties. Final discussion of TDR sending site prioritization. Staff provided updates on the work of the CA Innovative Finance Group and the Rural Growth Group. UW CFR requested time at the next meeting to review their study.	Edit Innovate Finance White paper to reflect group input. Update TDR paper to reflect discussion on prioritization. Schedule time for CFR to present and for King County to present on greenhouse gas sequestration efforts.
5/23/2006 Meeting	**David Thorud** Brian Boyle (phone) Bonnie Bunning (phone) John Davis Ara Erickson Andrew Galbraith Lindsey Malone Ken Miller Cindy Mitchell Colin Moseley	Doug Howell of King County presented to the group on green house gas and King County's plans to join the Chicago Climate exchange. Overview on how sequestration projects work, and how forest sequestration projects work. Discussion on how carbon markets could provide benefits to forest landowners who manage their forests for carbon.	Doug and the County will follow up with the group on how they can help with this process.
6/27/2006 Meeting	**Charley Bingham** **David Thorud** Brian Boyle (phone) Bonnie Bunning (phone) Dennis Dart (phone) Ara Erickson Andrew Galbraith Bill Pope Charlie Raines	The group reviewed the successes and challenges and how to move the working group forwward	

Goals and actions for spring 2006 work session

TDR strategies for conserving working forests

<u>Goal</u>

- The group is developing recommendations on TDR "sending sites", market mechanisms for implementation and long-term forest management strategies. The group will be providing input into the creation of pilot programs in Pierce and Snohomish counties. These recommendations are focused on ensuring TDR programs will be a valuable tool for conservation of working forests.

<u>Process</u>

- *Completed*-Staff has provided detailed information to the group on how TDR programs work, how other programs are structured nationwide and on the actions of The Cascade Agenda to promote TDR programs locally.
- *Completed*-The Group has discussed the goals for using TDR to preserve working forests in our region and how to create programs that work for landowners and the environment.
- *Underway*-The group has provided input that can be utilized in TDR program management and creation.
- *Underway*-The Forestry Working Group will now formalize recommendations and develop a plan for participating in county TDR planning.

Outcomes

- Production of draft document "Transfer of Development Rights programs and Forest Landowners".
- Group develops and implements strategy for participating in county planning and advises staff in this process.

Support for Family Forest Landowners

Goal

- Provide support to Washington Farm Forestry Association on a proposal to create 15-year management plans for small forest landowners

Process

- *Completed*-The Group has been educated on the proposal and discussed the merits of the idea.
- *Underway*- Washington Farm Forestry Association has recommended a delay of formal support until the proposal reaches the Forest Practices Board in the fall. The Group anticipates tracking the progress of the proposal in the interim.

Outcome

- A well designed 15-year permitting process for Family Forest Landowners is approved. The permits will encourage long-term management and protect forest resources.

Next Steps

- Continuing to collect data related to the potential factors associated with forest land conversion to use for spatial analysis of forest land conversion.
- Acquiring satellite images for eastern Washington land use change analysis.
- Classify eastern Washington satellite images into land uses and run land use change analysis.
- Begin spatial analysis in King and Spokane counties as case studies of the role residential and commercial development play in the conversion of forest land to non-forestry uses.

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Study 5: State Granted Lands

This work has just begun in July.

APPENDICES

Study 1 Appendix A. Benefits/Avoided Costs of Reducing Fire Risk [1]

Costs Associated with Forest Fires:

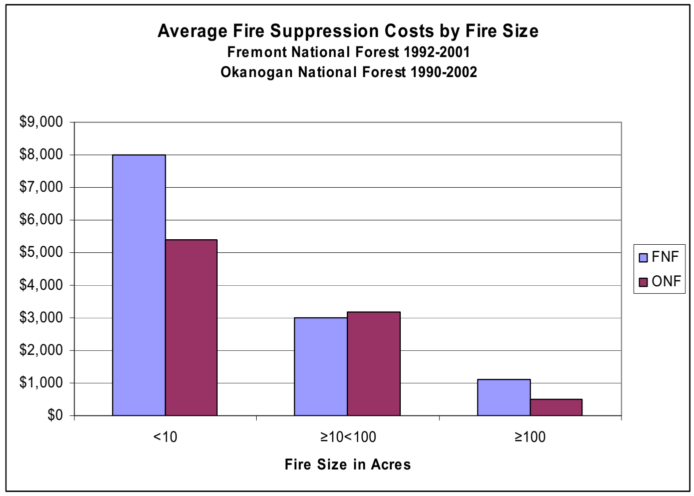


Figure 1. Average fire suppressions costs per acre - Fremont and Okanogan National Forests.

An analysis of fire risk and hazardous forest fuels on the Fremont (OR) and Okanogan (WA) National Forests indicates that the negative impacts of crown fires are underestimated and the benefits of government investments in fuel reductions are substantial. Perhaps most obvious is the escalating cost of fighting forest fire, which nationally has been in the billions of dollars during recent years. Similarly, there is the value of avoiding facility losses and fatalities that result from forest fires. Communities value a lower fire risk and reduced smoke. Forest fires destroy visual aesthetics and limit recreational opportunities. The United States Congress has historically placed a very high value on species protection as evidenced by laws such as the Endangered Species Act or the National Forest Management Act yet irreplaceable habitats for threatened and endangered species may be lost when forests fires are more destructive than historical norms. Valuable timber resources are destroyed. Fires also convert the carbon stored in forest biomass to smoke reducing the opportunity to produce long lasting pools of carbon stored in forests and products while adding to greenhouse gas emissions and global warming. Fires consume biomass that otherwise could be used for clean energy conversion and green energy credits.

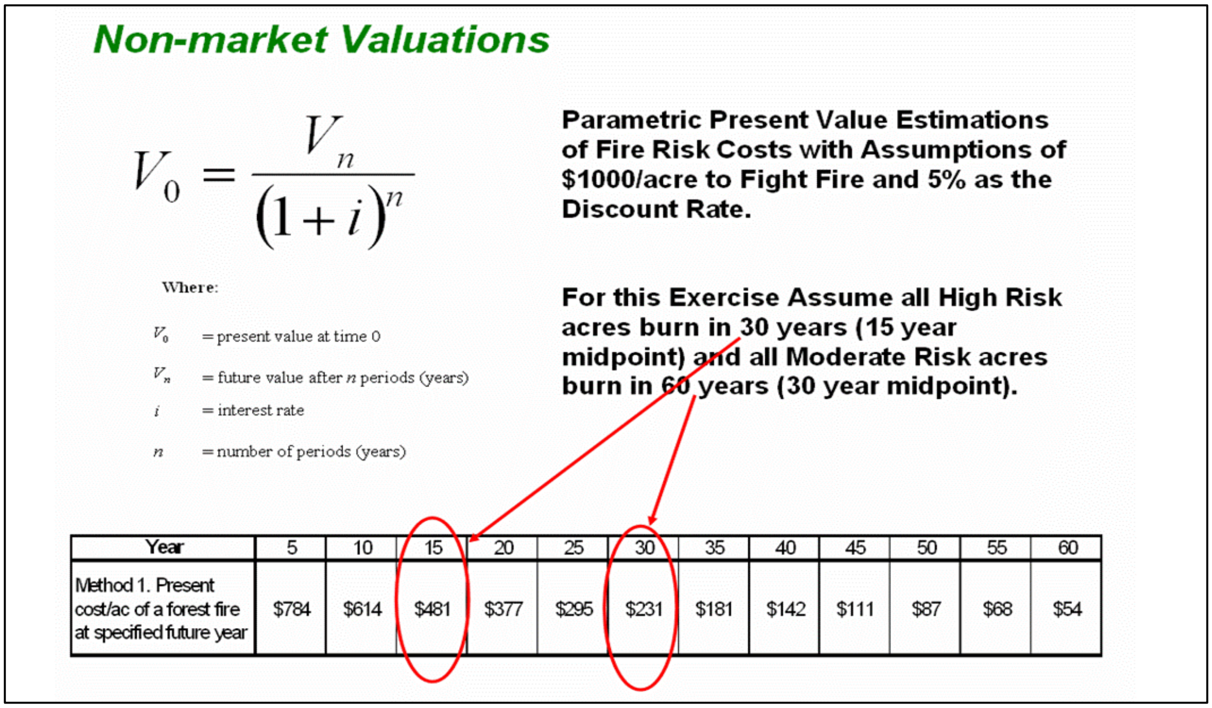
Regeneration after fires is problematic and costly and rehabilitation investments are often needed to avoid serious erosion, sedimentation, and water contamination. If forests are thinned, the resulting increase in available surface water could benefit salmon habitats, municipal reservoirs, and agricultural irrigation. Rural economic development benefits would result from the taxes and rural incomes generated by fuel reduction activities. Since economic activity in these regions has been in decline as a consequence of lower federal timber harvests, any reduction in unemployment has higher than normal leverage on state and local finances by lowering assistance costs.

Estimating the Avoidable Costs of Destructive Fires:

Many scientific studies have shown that forests thinned to remove fuel loads are unlikely to experience crown fires. Accounting for the full value of this reduced risk exposure, however, must take into consideration both the predicted costs and the timing of future fire events. While it is impossible to predict exactly when a future fire might occur in a specific location, we do know that due to decades of fire suppression, the time since last ignition in many forests is well beyond previous fire return cycles and that present fuel loads are well outside of historic levels. Many fire ecologists argue that the question is not whether these forests will burn but when.

To illustrate how the relative costs and benefits of investments in hazardous fuels removal treatments to reduce risk of crown fires might be considered, a parametric table can be constructed to display the present value of anticipated future costs associated with failure to reduce risk. For this example, we will assume that that all acres of forests with a present high risk, if left untreated, will burn sometime in the next 30 years while all those forests considered at moderate risk will burn sometime in the next 60 years. If there is an equal probability of each acre burning in any year during the assigned interval then for approximation purposes we can assume that an average time for all acres to burn is equivalent to one-half the interval. More complex models have been evaluated producing similar results.

[1] Examples from a report prepared for The Forest Health Strategy Work Group and published as “A Desirable Forest Health Program for Washington’s Forests.” Report prepared in response to Second Substitute Senate Bill 6144. DNR 2004.



Year	5	10	15	20	25	30	35	40	45	50	55	60
Method 1. Present cost/ac of a forest fire at specified future year	$784	$614	$481	$377	$295	$231	$181	$142	$111	$87	$68	$54

Figure 2. Parametric present valuation estimation of non-market values

In other words, an equal probability that all acres burn sometime in 30 years means an average time to burn of 15 years and correspondingly, given a 60-year interval, the average burn time will be 30 years. If we further assume, as is often done for financial analysis, that an inflation-adjusted interest rate of five percent is representative of the average anticipated cost of money throughout the risk interval then we have what we need to discount future cost estimates to present dollars. In the example above, an estimated future average fire fighting cost of $1000 per acre is used to demonstrate the present value of a future liability. This example shows that every dollar that will be needed to fight forest fires during the 30-year period for high risk represents $0.48 of anticipated cost exposure today and during the 60-year period for moderate risk represents $0.23 today. Conversely, investments in fuels removals today are worth the savings represented by these present value estimates of costs avoided if fires do not occur. Other non-market values of interest can be similarly assessed and then summed to estimate broad present benefit from investment in risk avoidance.

The following table shows present value estimates of avoided future losses associated with a number of market and non-market values. Also displayed for comparison are Forest Service contract preparation costs and operational costs. Future values are taken from a variety of governmental and non-governmental information sources while contract and operational estimates are derived from figures provided by the Okanogan and Fremont National Forests as well as from interviews with harvest contractors. Treatments are assumed to be forest thinnings within the understory that leave approximately 40-100 of the biggest trees per acre (TPA). A more rigorous explanation of this estimation methodology and source information can be found in the publication *"Investigation of Alternative Strategies for Design, Layout, and Administration of Fuel Removal Projects"*, in the Market and Non-Market Values section, at www.ruraltech.org

Table 1. Summary table of costs and benefits from fire risk reductions

Treatment Benefits	Value per acre	
	High Risk	Moderate Risk
Fire fighting costs avoided	$481	$231
Fatalities avoided	$8	$4
Facility losses avoided	$150	$72
Timber losses avoided	$772	$371
Regeneration and rehabilitation costs avoided	$120	$58
Community value of fire risk reduction	$63	$63
Increased water yield	$83	$83
Regional economic benefits	$386	$386
Total Benefits	**$2,063**	**$1,268**
Treatment costs		
Operational costs	($374)	($374)
Forest Service contract preparation costs	($206)	($206)
Total Costs	($580)	($580)
Positive Net Benefits from Fuel Removals	**$1,483**	**$706**

Additional benefits from fuels reductions such as habitat restoration, water quality protection, carbon credits, and others are more difficult to estimate but are generally considered to be of high public value. Further research is needed to quantify such benefits; however, it should be apparent that addition of such considerations would serve to increase further the net value of public investments in forest fire risk reduction.

Potential negative offsets to these avoided costs that might be associated with harvest activities to reduce hazardous fuel loads should also be considered, including environmental impacts of soil compaction, damage to leave trees, and road sediments. However, these costs are difficult to estimate and in general can be avoided with due diligence. Compromises to habitat quality for some species may decline while others increase, creating tradeoffs that are difficult to evaluate, but these changes are not likely to be as harmful as the impacts of catastrophic wildfires.

While the values assigned to the benefits from fuels reductions that have been listed above can rightly be considered coarse estimates, they have been shown to be legitimately defensible and intentionally conservative. These figures suggest that the benefits of fire risk reduction are of high value and generally of much higher value than any market losses resulting from thinning to reduce the fire risk. It is worthy to note that many areas of the forests studied in this investigation showed positive net returns from log sales after thinning simulations when some larger trees were removed as part of the fuels reduction activity. However, even with an assumed net cost of fuel reduction operations, the results of this cost/benefit analysis clearly show that the future risk of catastrophic fire is far costlier to the public than investments made today to protect against such eventuality.

Magnitude of Potential Benefits:

An analysis of Fremont and Okanogan National Forest inventory data indicated that 1,307,667 acres (greater than 75 percent of the total forest area) are at moderate to high risk of crown fire. Based upon present value estimations above, the total no-action liability for these at-risk forests is greater than two billion dollars. The net public benefit of hazardous fuels reductions after subtraction of operations costs for just these two National Forests is estimated to be greater than 1.3 billion dollars.

Study 1 Appendix B. Fire Preparedness, Suppression, and Prevention Costs [(2)]

Fire Fighting Costs

The cost of fighting fires is large compared to any effort by those responsible for fighting fires to prevent fires. Figure 1 shows that fire preparedness costs (personnel and equipment) for DNR protected land have increased over the last two biennia largely in response to a more than doubling of fire suppression costs (fighting fires). Over the last two biennia, fire suppression costs have increased by $25 million to reach almost $60 million per biennium. Fire suppression costs are more random from year to year than preparedness costs depending upon drought and other weather conditions.

Figure 2 shows that the fire suppression costs per acre burned appear to have more than doubled over the last several years from just under $1,000 per acre to over $2,000.

Table 1 shows the suppression cost for the Okanogan/Wenatchee National Forest as a function of the number of acres burned. While the cost is very large for small tracts it is somewhat lower for the very large tracts. Federal forests tend to have larger blocks of contiguous acres, which are also generally at greater distance from populated areas so the suppression activity can be less concentrated on larger tracts. The increasing costs for smaller fires makes it clear that suppression activities are targeted at putting out fires with the per acre cost of fires only reduced by those that get out of control and become very large. In that sense the intent is to spend much more than the average cost in order to put out fires.

While there is some funding devoted to prevention activities such as education and technical assistance, the amounts are minimal relative to the cost of preparing to fight fires and trying to suppress them once they start, and these suppression costs do not include the costs associated with the damage created by fires and post-fir restoration activities.

Investing in Treatments to Reduce Costs

The cost of thinning treatments that would reduce the risk of fires represents an investment that would be expected to lower the cost of fighting fires over time. If other non-market values are considered, the benefits can be expected to exceed the investment in treatment costs very quickly. Even if just the avoidance of future firefighting costs is considered as a payback for the treatment cost there will likely be a positive benefit for treating high risk acres since the probability of preventing a fire by treatment increases year after year i.e. the treated acre would eventually have been in the path of a fire.

The cash flow or value benefit of avoiding firefighting costs and producing other non-market benefits is shown in Figure 3. The returns from the investment cost of thinning a high fire risk stand turns positive in as little as three to four years when many of the identified non-market benefits are included. When the cost of fighting fires is as high as $2,000 per acre, the avoided costs of fighting fires results in a positive return in about 10 years. When a number of other non-market values are included the breakeven to a positive return is as short as three years. Considering non-market values in the fire treatment decision results in both a quick pay back to society with the magnitude of the payback rising to more than a $1000 per acre in about 10 years.

[(2)] Examples from a report prepared for The Forest Health Strategy Work Group and published as "A Desirable Forest Health Program for Washington's Forests." Report prepared in response to Second Substitute Senate Bill 6144. DNR 2004.

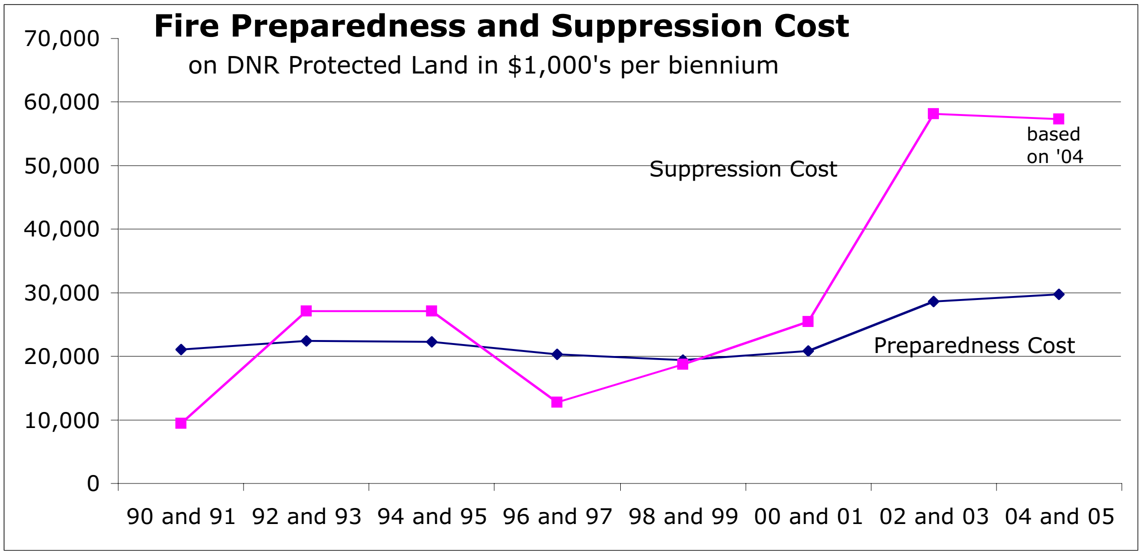


Figure 1.

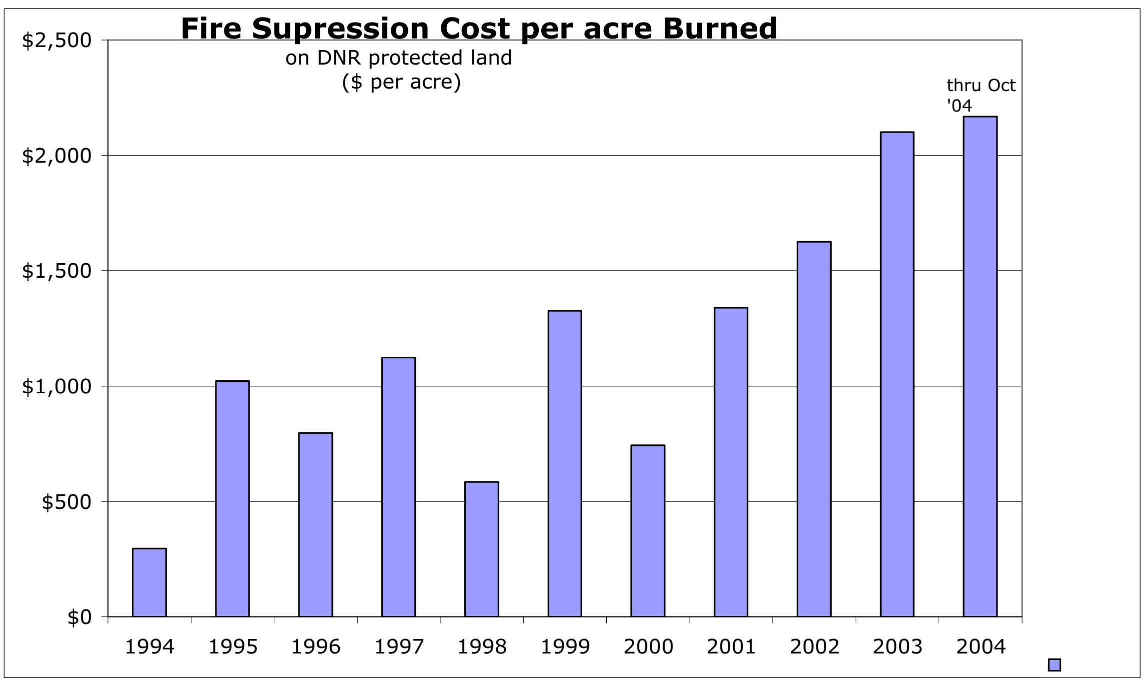


Figure 2.

Table 1.

Okanogan-Wenatchee Fires 1990 – 2002			
Size Class	**Suppression Costs**	**Total Acres Burned**	**Average Cost per Acre**
A (0-.25 acres)	**$1,359,382**	**188**	**$7,231**
B (.26-9.9 acres)	**$4,769,332**	**948**	**$5,031**
C (10-99.9 acres)	**$8,484,542**	**2,662**	**$3,187**
D (100-299.9 acres)	**$6,736,500**	**3,379**	**$1,994**
E (300-2999.9 acres)	**$27,646,681**	**10,530**	**$2,626**
F (3000-4999.9 acres)	**$27,767,956**	**28,419**	**$977**
G (5000+ acres)	**$100,474,867**	**280,450**	**$358**

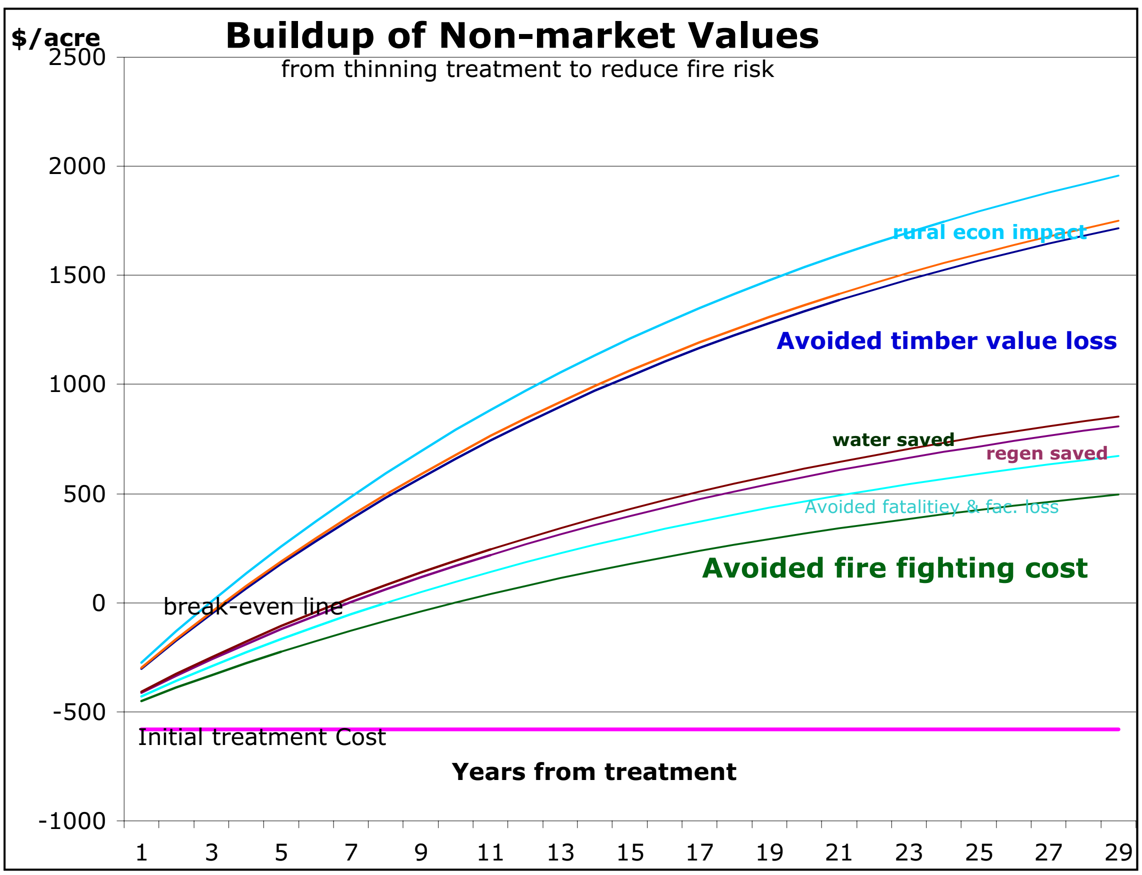


Figure 3.

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Study 1 Appendix C: Wildlife Habitat Modeling Based on Tree-list Projections

Forests of the Pacific Northwest are the home for a multitude of wildlife species. Wildlife habitat is impacted by forest management and represents one of the more important ecosystem services provided by forests. It is difficult to estimate the value of habitat and the relationships are complex because there are many different species to consider. Many types of wildlife habitat models have been developed that can estimate habitat quality and quantity based on tree and understory information available in existing forest inventory data. We use the Landscape Management System (http://lms.cfr.washington.edu) to link specific habitat models with current and future forest inventories, project the inventories with the Forest Vegetation Simulator (FVS) growth model and provide current and potential future habitat conditions in response to forest growth and management treatments. Westside and Eastside case studies are summarized to characterize the linkages between these different types of information. The Westside case study at Satsop Forest in Southwest Washington demonstrates that providing wildlife habitat and harvest revenues within a forest management framework are not mutually exclusive. The Eastside case study on the Okanogan and Fremont National Forests illustrates that taking no action to reduce wildfire risk may put wildlife habitat at risk but also that pre-fire suppression forest conditions did not provide the same kind of support for habitat as current conditions.

Case Study 1: Satsop Forest

The Westside case study uses a Habitat Evaluation Procedure (HEP, USDI 1980) within LMS to meet the requirements of a wildlife mitigation agreement on Satsop Forest (Marzluff, et al. 2002, Ceder, 2001). Habitat assessments used previously defined Habitat Suitability Index (HSI) models. This agreement focused on the habitat needs of 5 species including the spotted towhee (Pipilo erythrophtalmus), Cooper's hawk (Accipiter cooperii), southern red-backed vole (Clethrionomys gapperi), pileated woodpecker (Dryocopus pileatus), and black-tailed deer (Odocoileus hemionus columbianus). The species were chosen to track changes in a variety of habitat types with the spotted towhee tracking changes in brush habitats; the Cooper's hawk tracking changes in mixed hardwood-conifer forests; the southern red-backed vole tracking changes in closed canopy forests; the pileated woodpecker tracking changes in mature forests; and the black-tailed deer, a habitat generalist, tracking overall changes.

Twenty potential management alternatives for Satsop Forest were developed ranging from a no harvest alternative to 40-year clearcut rotations with varying amounts, timings and levels of thinning between these management intensity extremes. Assessments of each alternative determined the amounts of habitat and wood volume that could be produced over an 80-year planning horizon. Figure 1 identifies the trade-offs between habitat for the four specialist species and harvest volume for the twenty management alternatives. The alternatives are ranked from lowest to highest management intensity. Results indicate that, through active management, amounts of available habitats almost identical to no management or passive management could be created in five of the twenty scenarios. Cooper's hawk, southern red-backed vole, and spotted towhee habitat values were relatively insensitive to management even under the highest harvest levels suggesting that most management alternatives were able to consistently supply habitat needs somewhere on the landscape over time. As expected, habitat available for the pileated woodpecker, which is associated with older forest structures, decreased with increasing harvest levels and shortened rotations. Harvest levels exceeding approximately 40% of the maximum rate or 30.1 MMBF were not able to maintain existing habitat quantities for the pileated woodpecker under these simulated management regimes. These results suggest that harvest and habitat are not mutually exclusive, but there are tradeoffs between high harvest levels and species requiring old forest structures. While opportunities such as variable retention harvest exist to increase harvest levels while maintaining old forest structures critical to some species (Bunnell et al, 2003), the capability to model the impacts of these treatments using the individual tree distance independent growth and yield models used for this timber supply analysis does not exist at this time. While habitat models that incorporate spatially explicit landscape level assessment techniques exist, data resolution of the FIA and CVS plots used for the timber supply analysis is insufficient to support these types of habitat models.

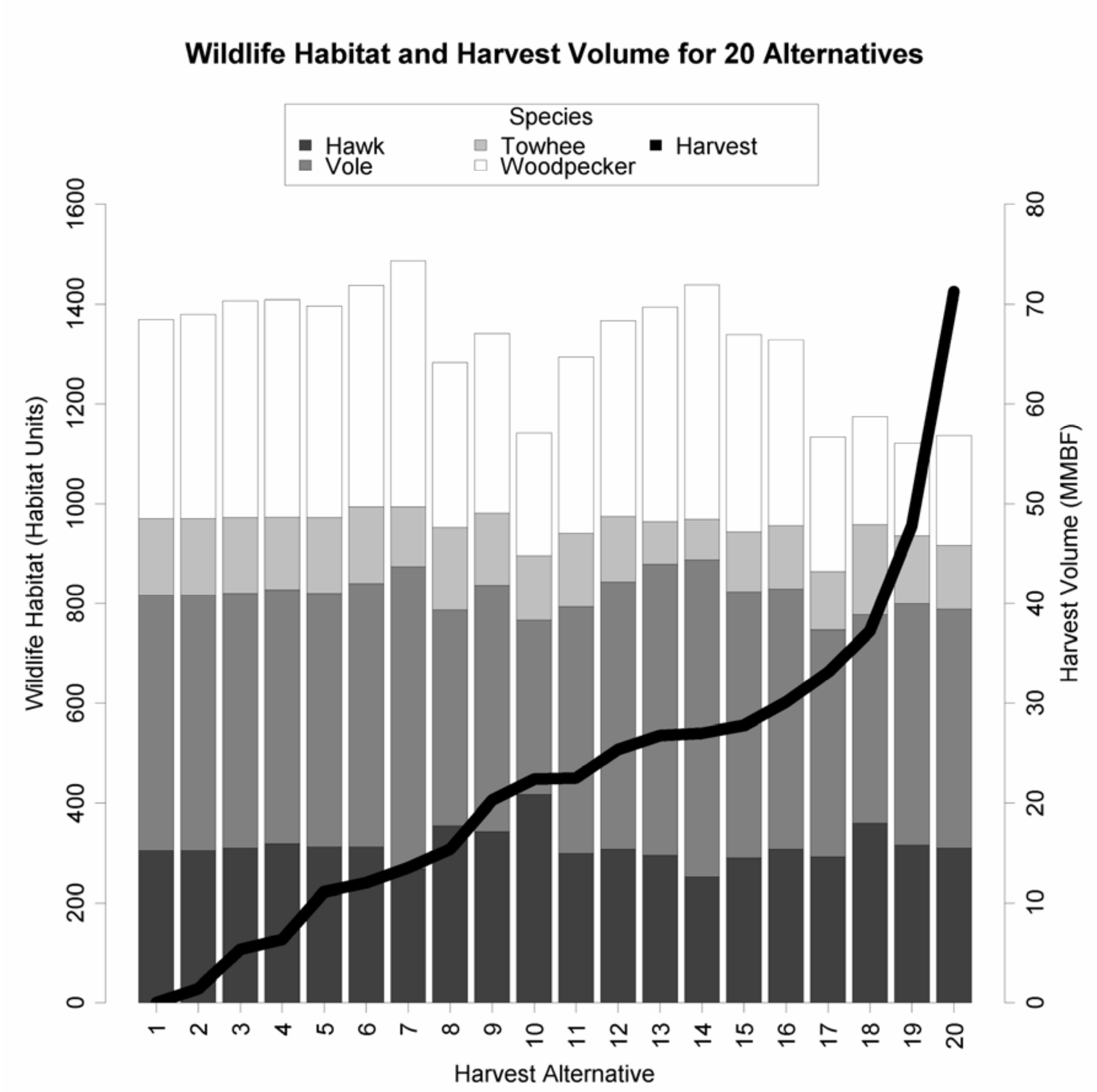

Figure 1: Habitat and volume production for 20 potential 80-year management alternatives for Satsop Forest.

Case Study 2: Habitat Assessment for Fuel Reduction Treatments on Eastside Forests

Habitat modeling was included in the Investigation of Alternative Strategies for Design, Layout and Administration of Fuel Removal Projects (Mason et al 2003). The project examined effects of five fuel removal treatments and a wildfire simulation using data from the Fremont and Okanogan National Forests. Changes in wildlife habitat were assessed for northern goshawk (Accipiter gentilis), Lewis's woodpecker (Melanerpes lewis), white-headed woodpecker (Picoides albolarvatus), and Williamson's sapsucker (Sphyrapicus thyroideusis) using HSI models. Wildlife habitat matrices from the ICBEMP report (Wisdom et al. 2000) were used for the Canada lynx (Lynx canadensis), grizzly bear (Ursus arctos horribilis), pileated woodpecker, northern flying squirrel (Glaucomys sabrinus), and Townsend's big-eared bat (Plecotus townsendii). Assessments of lynx and grizzly were done only for the Okanogan National Forest, as they do not occur on the Fremont National Forest.

Initial habitat and fire risk relationships showed that stands with high and moderate risk provided more habitat for the majority of the species than the low risk stands on both forests. This was particularly evident in species that are associated with older forest structures such as the northern goshawk, pileated woodpecker, and northern flying squirrel on both forests and the lynx and grizzly on the Okanogan (Figure 2).

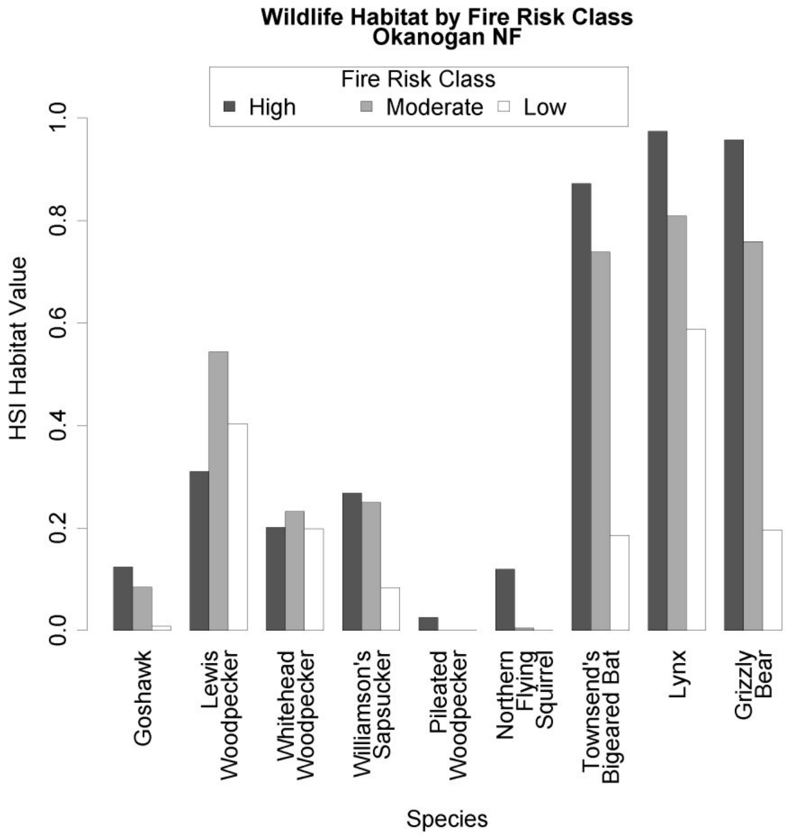

Figure 2: Habitat levels for High, Moderate, and Low risk stands on Okanogan NF. Wildlife species, left to right in each graph are: Northern goshawk, Lewis woodpecker, white-headed woodpecker, Williamson's sapsucker, Pileated woodpecker, northern flying squirrel, Townsend's big-eared bat, Canadian lynx, and grizzly bear.

Response to treatments varied among species and treatments. Species associated with older forest structures had habitat levels more severely impacted by the treatments than species associated with open forest structures. As stand density was reduced through thinning, habitat for most species decreased when compared with the no action, no disturbance alternative. One exception was the Lewis's woodpecker, which thrives in open forests. When regeneration was included, available habitat increased, but still remained lower than no action. Grizzly habitat on the Okanogan, which was originally reduced by the thinning, returned to levels higher than no action after 30 years. All treatments that reduced fire risk also reduced habitat levels for all species except Lewis's woodpecker.

Wildfire simulations greatly reduced or eliminated habitat for all species associated with older forest structures. Both forests are in fire regime condition class 2 or 3 (FRCC, Hann et al 2003), meaning that the fire regime has diverged significantly from historical conditions and the risk of severe fires is high. With this in mind, questions can be asked about historical habitats for some of the species now present in the dry interior forests: Are current habitat levels, because of fire exclusion and suppression, reflective of historical levels? If forest managers perform fuel treatments to reduce the current fire risk, how is habitat availability for old forest species affected? If habitats for some species are at high risk and need to be preserved, what are the most effective methods of creating low risk fuel and fire breaks to protect the high risk areas from wildfire?

Uses, Limitations and Opportunities

The models of choice may be dependent upon the region and species of interest. Appropriate models provide managers and planners with the ability to analyze many alternatives quickly and easily while holding all other assumptions constant. This consistency in assumptions provides uniform comparability between simulations so relative tradeoffs between treatment alternatives can be assessed.

One of the key limitations to using habitat models within forest simulation systems is the need for field verification, particularly as many of the available habitat models are theoretical and have not been field verified.

A second limitation in the use of habitat models is the lack of understory models that are compatible with forest growth models. Understory vegetation is a key component for many wildlife species and associated models. Local understory/overstory relationships can be developed, as was done for the Satsop Forest project, where mean values for understory measures for each forest cover type were derived. Such site specific approaches do increase the cost and complexity of an analysis and restrict it to more local use. With these limitations in mind, habitat analysis using habitat models implemented in LMS, or other forest simulation tools, can be very useful to assess habitat availability and risks to habitat as well as to communicate the potential tradeoffs among different treatments and management strategies.

HEP, HSI, and the ICBEMP WHR matrix models implemented in LMS represent only a portion of the possibilities for habitat analysis. Several other approaches to habitat modeling are available. For example, empirical models can be derived from tree measures, as with the bird population models of Hansen (1995), who generated regression models relating trees per acre in specific diameter classes to bird population. The Washington State Department of Natural Resources quantified Nesting, Roosting and Foraging (NRF) habitats for the northern spotted owl based on tree and snag measures (WAC 222-16-085). Other models include the Wildlife Habitat Relationships for Washington and Oregon (Johnson & O'Neil, 2001) and the California Wildlife Habitat Relationships (CWHR). These models identify forest structures that can be quantified using forest inventory measures. Roloff et al (2001) ranked wildlife habitat matrix models as the most favorable of all habitat model types based on the applicability, the structure, and the output of the models. Of all the potential habitat modeling choices, the Johnson & O'Neil wildlife habitat matrix models offer the most promising opportunity to integrate habitat models with forest inventory for a wide range of vertebrate species in Washington State. The forest structures and habitat elements used as inputs to the habitat matrices, including snags and downed wood, are available in the forest inventory databases used for the timber supply analysis. Data from the wide range of simulated timber supply management scenarios can be input into these matrix models to determine how scenarios might affect a wide array of species of concern.

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Study 1 Appendix D. Shifting Economics of Alternative Species in Western Washington

Log Price Comparisons

Red alder (*Alnus rubra*) and western red cedar (*Thuja plicata*) have long been recognized by tree farmers as good species to plant in areas that are wet, nutrient poor, infected by Swiss needle cast or root rot or in other ways unsuitable for Douglas-fir (*Psuedotsuga Menzeisii*). A strong performance by both alder and cedar log prices when compared to Douglas-fir prices may lead some foresters to consider planting alder and cedar on their best sites as well. The following graph (Figure 1) displays prices, adjusted for inflation to 2002 dollars, for comparable grades of Douglas-fir, alder, and cedar logs from 1970 to present in the Puget Sound region of western Washington.

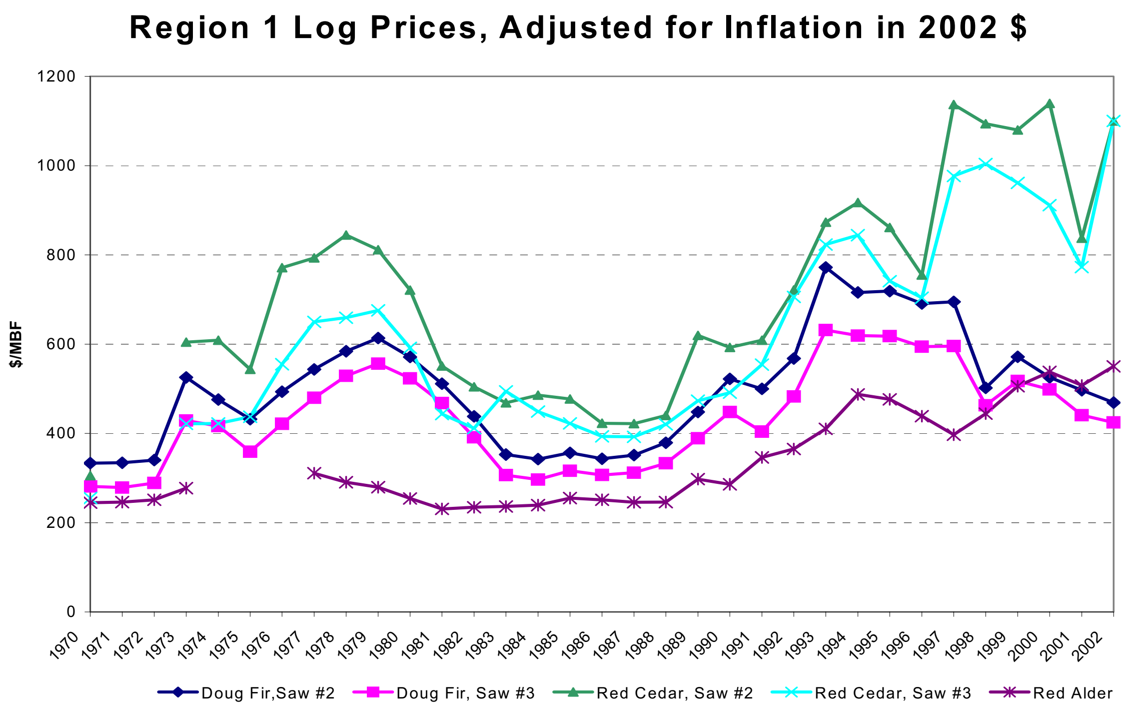

Figure 1: Region 1 Log Price Comparisons.

Source: Log Lines, Timber Management Plus. Inflation adjusted to Consumer Price Index

Alder prices surpassed Douglas-fir for the first time in history in 2000 and continue to increase. Cedar logs are currently worth more than twice the value of Douglas-fir logs. Douglas-fir production is largely dedicated to commodity lumber products that compete with other product alternatives, both alder and cedar are niche species producing products unique to the PNW. A decline in large fir and hemlock logs as a consequence of both declining federal harvests and the transition to second growth on private lands has reduced the premiums that once existed in these markets (Mason 2002). Declining exports are also eroding fir and hemlock prices. Douglas-fir saw logs over 24" that once received large premiums are now discounted. These changes are all reflecting long term structural changes taking place in timber markets.

Species/Management Alternatives

Financial performance simulations can help in making species yield comparisons. For demonstration purposes, assumptions will be that plantations are hardy and on good site, a single rotation is to be examined where prices remain constant, 5% is the expected rate of return, results are reported before taxes, and yield estimates are consistent with growth expectations described in the literature.

Seven simulations are displayed here.

- **DF-45.** A 45-year Douglas-fir rotation; no commercial thin. (30 mbf & 70 tons)
- **DF-55.** A 55-year Douglas-fir rotation with commercial thin. (40 mbf & 100 tons)
- **DF-55E**. A 55-year Douglas-fir rotation with commercial thin and a $150/mbf export premium on 20% of the log volume at final harvest. (40 mbf & 100 tons)
- **RA-35.** A 35-year Red Alder rotation. (20mbf & 30 tons)
- **RA-40.** A 40-year Red Alder rotation; same volume as the 35-year rotation. (20mbf & 30 tons)
- **WRC1-55.** A 55-year Red Cedar rotation with a commercial thin and a final harvest volume equal to 75% of Douglas-fir for the same harvest rotation length. (30mbf & 100 tons)
- **WRC2-55.** A 55-year Red Cedar rotation with a commercial thin and a final harvest volume equal to 100% of Douglas-fir for the same harvest rotation length. (40 mbf & 100 tons)

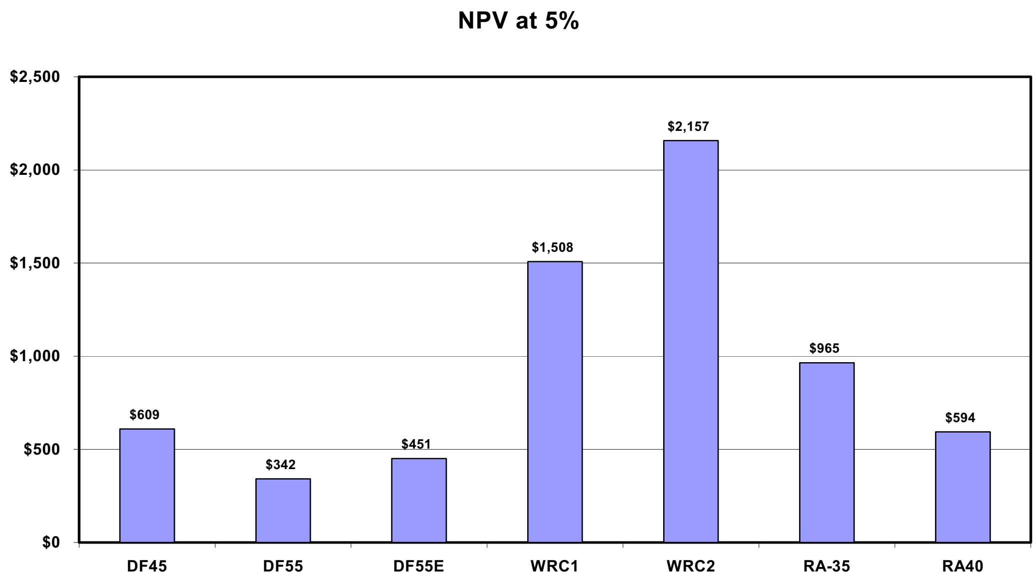

Figure 2: NPV Comparisons

The above display of Net Present Value (NPV) calculations by species shows that western red cedar out performs both Douglas-fir and red alder with alder performing better than fir. Many landowners express reluctance to plant western red cedar because of difficulties associated with browse damage. The above simulations include additional cost at time of planting cedar of $320/acre for browse control (tubing). Cedar's remarkable financial performance at present prices would indicate that tree farmers could make even larger investments in browse control strategies and still enjoy returns greater than those of Douglas-fir or alder. An examination of Douglas-fir simulation outputs shows that, even with increases in growth and the benefits of export price premiums on 20% of the harvest, the 55-year rotation (DF55E) cannot compete favorably with the shorter 45-year rotation alternative (DF45).

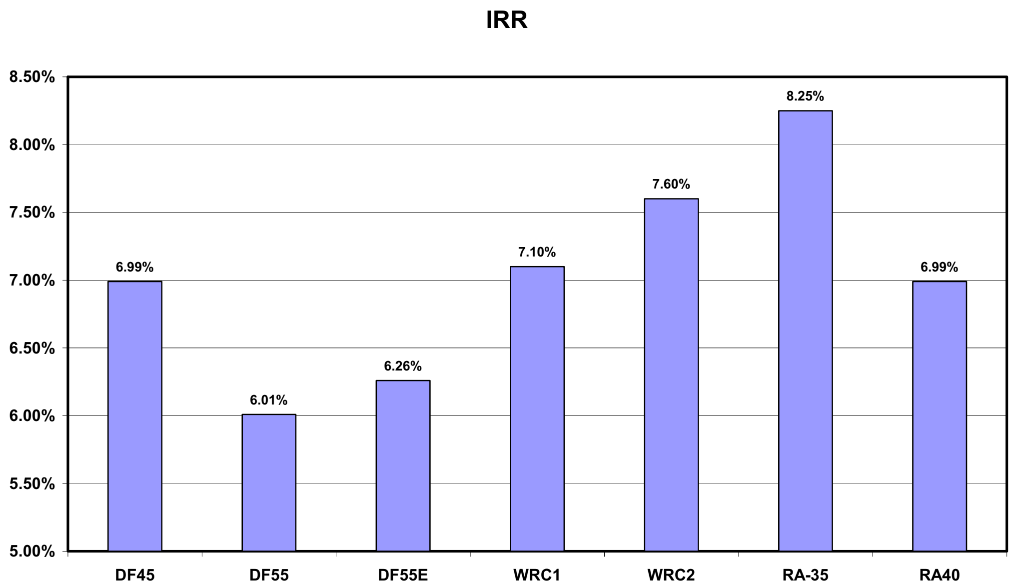

Figure 3: IRR Comparisons

Internal Rate of Return (IRR) for the same simulations (Figure 3) reflects the benefit to forest landowners from shorter rotations. In this case, alder on a 35-year rotation is clearly the winner. It is interesting to note that if it takes just 5 more years to complete the alder rotation (RA40) both of the cedar simulations offer better returns on investment. Even the 40-year alder rotation, however, is very competitive with Douglas-fir.

Management Implications

Douglas-fir may be poorly positioned to compete in the small log production of commodity lumber against less costly product alternatives and imports. Subsequently, prices for small diameter Douglas-fir logs may remain low. The closure of large log mills over the last decade has meant that larger Douglas-fir logs are worth less than small logs. The unique properties associated with higher quality Douglas-fir trees have experienced declining demand. Prices for larger Douglas-fir logs are likely to remain low. Red alder and western red cedar logs provide raw material for niche manufacturers that produce products unique to the PNW. Niche markets more readily absorb high regional production costs and appear to be less price sensitive to competition from product alternatives. Alder and cedar are commonly planted in areas unsuitable for fir regeneration. Rising prices and potentially short rotations may make red alder and western red cedar very attractive species for forest regeneration investments on sites traditionally planted to Douglas-fir. However, unfavorable conditions will limit red alder and western red cedar growth success on dry, hot, or frost-prone planting sites. Western red cedar may be targeted for browse by deer and elk until stems reach a height of 4-6 feet. For the simulations conducted above, $320/acre was calculated as an additional cost outlay at time of planting to allow for tubing of cedar seedlings for browse protection. Financial returns from cedar appear sufficient to cover investments in browse protection.

However, given the historic lack of interest in alternative species planting and recent increases in regulatory constraints on harvest activities in riparian zones, there may be some question about whether naturally-regenerated raw material supplies of alder and cedar will be sufficient to support existing manufacturing infrastructure until plantation crops become available. Estimations of available future volumes of alder and cedar saw logs will be helpful to better inform future market potentials.

Species diversity brings value to investment portfolios as well as to forest environments. Planting of multiple species can reduce risk from disease or market fluctuations while improving cash flow from staggered harvest revenues.

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Study 1 Appendix E. Wood Biomass and Renewable Energy

With growing concerns about global warming, there is an international sense of urgency to reduce consumption of fossil fuels by shifting to clean and renewable energy sources. The 2002 U.N. World Summit on Sustainable Development adopted a *Political Declaration and a Plan of Implementation*, which includes "Clean Energy" as one of its five most important global policy imperatives. The U.S. State Department (2002) followed with implementation of the Clean Energy Initiative. Current U.S. energy policy includes legislated incentives and tax credits for renewable energy development (Sissine 2005). The State of Washington also provides incentives and premiums for expansion of renewable energy (Database of State Incentives for Renewable Energy 2005).

Wood biomass is currently second only to hydro power as the largest source of renewable and clean energy in Washington. Wood is uniquely versatile in that it can be a source of firm power generation or can be used to produce liquid fuels for transportation needs. Residuals from the manufacture of forest products are a readily available and cost-effective source of biomass feed stocks for energy generation. Forest management residues, typically burned in piles after timber harvests, represent another large source of woody biomass that is currently underutilized. In eastern Washington, declines in forest health associated with overstocking, past management practices, insect infestations, drought, wildfire, and other factors have become widespread, making treatments that restore forest health of prime importance (Western Governors Association 2001 and 2002). Biomass removals from Eastside forests can provide secondary benefit as feedstock for renewable energy development (Mason et al. 2003).

Biomass, which includes all plant and plant derived materials, can be utilized to create clean and renewable energy. Biomass is the only currently renewable source of energy that can create liquid and gaseous transportation fuels or can be combusted for heat and electricity. A study, entitled *Biomass as Feedstock for a Bioenergy and Bioproducts Industry; The Technical Feasibility of a Billion-Ton Annual Supply*, released by the U.S. Departments of Energy and Agriculture estimates that the combined forest and agricultural biomass that could be available for energy generation is equal to more than one billion tons per year (Figure 1) and, if utilized, could displace 30 percent or more of the country's present petroleum consumption (Perlack et al. 2005).

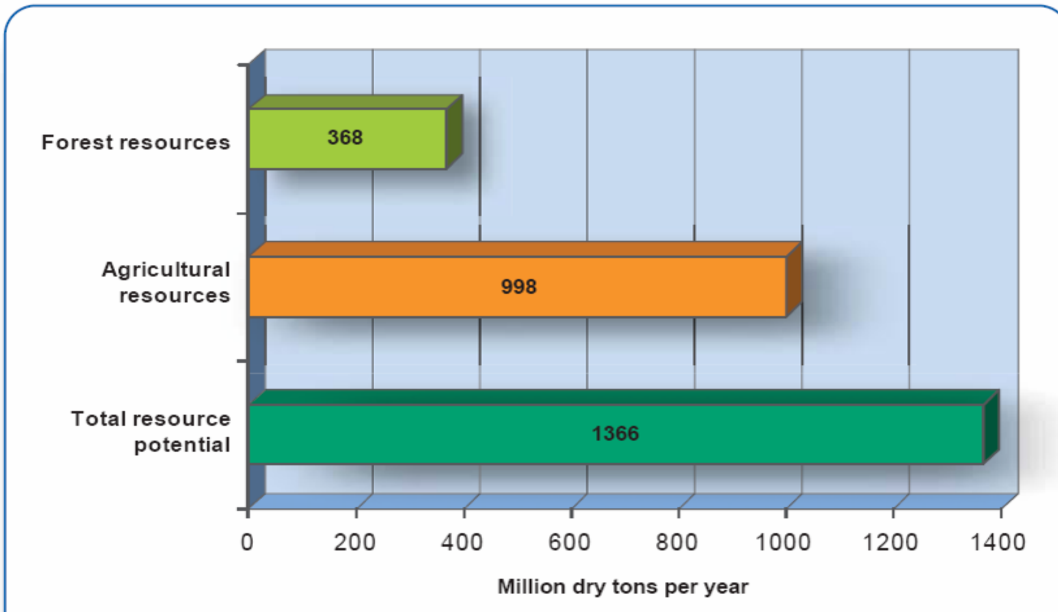
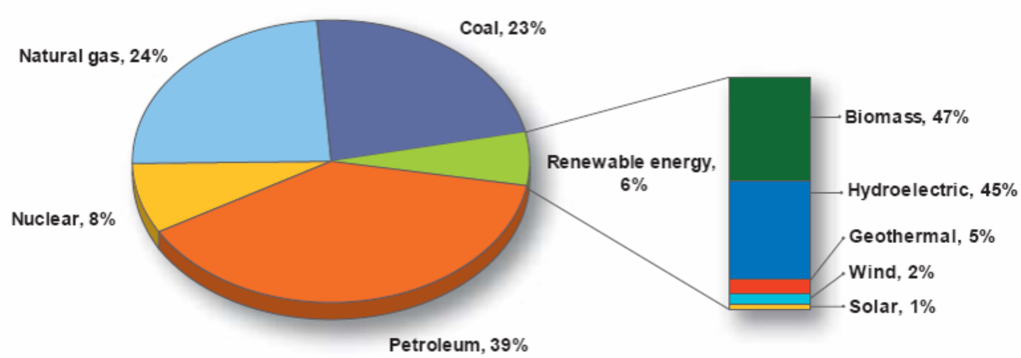


Figure 1: Annual biomass resource potential from forest and agricultural resources



Biomass Consumption	Million dry tons/year
Forest products industry	
Wood residues	44
Pulping liquors	52
Urban wood and food & other process residues	35
Fuelwood (residential/commercial & electric utilities)	35
Biofuels	18
Bioproducts	6
Total	**190**

- Forestlands and agricultural lands contribute 190 million dry tons of biomass - 3% of America's current energy consumption.

Source: EIA, 2004a & b

Figure 2: Summary of biomass resource consumption

In 2003, biomass contributed nearly 2.9 quadrillion British Thermal Units (BTU) to the nation's energy supply, nearly 3 percent of the total U.S. energy consumption. Biomass accounts for 47 percent of renewable energy consumption and recently passed hydropower as the nation's largest single source of renewable energy (see Figure 2). More than 50 percent of biomass consumption for energy generation comes from wood residues and pulping liquors created by the forest products industry. In 2003, biomass accounted for approximately 13 percent of renewably generated electricity, 97 percent of industrial renewable energy use, 84% of residential renewable energy use, 90 percent of commercial renewable energy use, and 2.5 percent of U.S. transportation fuels.

Biomass-to-Energy; New and Existing Technologies

Cogeneration

Cogeneration is the term used to describe the simultaneous production of heat and electricity from a single fuel. Cogeneration is also commonly called combined heat and power (CHP). This is the most common industrial use of wood biomass for energy. Wood biomass or other fuel is burned to create steam and the steam is run through a turbine to generate electricity. Important to successful operation of a cogeneration facility is the profitable utilization of heat and steam, as well as electric power.

Gasification

Gasification of wood and charcoal was used extensively in Europe during World War II to fuel both road and marine transportation systems. These gasifiers were downdraft and air blown, but updraft and side-draft gasifiers were also used as a source of direct heating energy. Today, new systems for gasification are being developed. Gasification, also called pyrolysis, occurs when organic materials are decomposed by heating in the absence of oxygen or other reagents. Gasification is used to make synthetic fuels and chemicals such as methanol, ammonia, and diesel fuel.

Cofiring

Cofiring refers to the practice of introducing biomass as a supplementary fuel for use in coal-fired generating facilities. Cofiring is a low-cost option for utilizing woody residues and reducing coal emissions. Biomass can be successfully substituted for 10-20% of the total fuel need.

Liquid Fuels

Ethanol is made from wood through the use of hydrolysis and fermentation technologies. Ethanol burns much cleaner than gasoline and has a high octane rating.

Methanol is created from wood through gasification to create syngas. The syngas is then converted to methanol. Methanol has a lower density than ethanol but can be made with high yields.

BioOil (pyrolysis oil) is a liquid also made from a gasification process with medium heating value. BioOil can be used to generate electricity and heat or it can be used as a non-polluting diesel additive.

The Benefits of Biomass Energy Production

Biomass energy generation represents an opportunity to combine two separate and important functions: renewable energy production and environmentally productive disposal of wastes and residues. Processing methods include combustion for heat, steam, and electricity; co-firing with fossil fuels for reduction of green house gas emissions; gasification for production of biofuels and industrial chemicals; and fermentation for conversion to ethanol. In addition to direct contribution of waste disposal and clean energy production, biomass-to-energy provides many ancillary benefits such as avoided costs, environmental improvements, rural economic development opportunities, and greater energy security.

- Bio-energy serves national energy needs and offsets use of fossil fuels.
- Reductions in fossil fuel consumption lower green house gas (GHG) emissions reducing risk of global warming and long-term climate change.

- Fossil fuel offsets, from domestically produced energy alternatives such as bio-energy, help to strengthen strategic assurance of a secure national energy supply while providing local utilities a price hedge against unanticipated spikes in energy costs.
- Domestically produced energy offers positive economic adjustment to U.S. trade deficits while generating job and tax benefits for local economies (direct jobs – 4-5/MW; tax revenues ~ $47,000/MW).
- Energy generated from biomass that is otherwise municipal solid waste (MSW) reduces garbage volumes sent to landfills.
- Biomass utilization to produce energy results in significant reduction of smoke and particulate emissions from open burning of agricultural and forest residues (controlled combustion for energy releases carbon emissions that are < 5% of green fuel weight; open fires release carbon emissions that can be as much as 50% of green fuel weight).
- Biomass utilization adds value to forest product industry raw material returns which re-enforces infrastructure sustainability while broadening opportunities for forest restoration activities.
- Biomass-to-energy projects are often located in rural areas at the end of the transmission grid. Development of rural distributed power installations can result in voltage stabilization and transmission load reductions with avoided line losses. The EPA estimates 9% of electricity is lost to line loss.
- Biomass is the largest source of U.S. renewable energy. Unlike wind or solar energy, bio-energy is firm, on-demand, and available for electricity, heat and steam. Biofuels can be provided as solids, gases, or liquids.
- Biomass is a renewable feedstock for sustainable generation of clean.

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