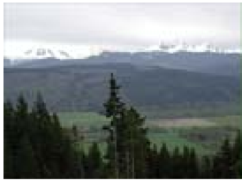

The Future of Washington's Forests and Forestry Industries

UNIVERSITY OF WASHINGTON
College of Forest Resources

THE FUTURE OF WASHINGTON'S FORESTS AND FORESTRY INDUSTRIES

Third Progress Report: October 2006

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

Executive Summary and Explanation of How to Read this Report Alongside Progress Report 2 of July 2006

Introduction

This Third Progress Report on the Future of Washington Forests and Forestry Industries extends the information provided in the Second Progress Report of July 2006. It is intended to fill in additional information that will be used in the final stages of this project but has value now for identifying issues that will be important for policy consideration.

Study areas

This report is organized around the first four 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*

Timber Supply and Forest Structure Study

The Second Progress Report characterized the projection errors in prior timber supply studies and developed in some detail future management alternatives responsive to commercial and environmental objectives for both the Westside and Eastside. This Third Progress Report begins the process of extending these findings for landscape level analysis, including stream protection and management intensity projections on the Westside and a more intense look at the role of climate change on forest health and treatment alternatives for the Eastside. It then goes on to develop the basis for projecting industrial owners' management intentions and their impacts on economic activity and infrastructure.

Westside Forest Structure, Economics, and Fish-Bearing Streams

In this Third Report we have provided a county level case study describing how the Forest and Fish rules impact private and industry owners in particular ***(Estimating the Impact on Fish-Bearing and Headwater Stream Protection Across Large Areas).*** It is generally easier to understand these impacts by taking the analysis one step at a time, first at the stand level, then at a larger landscape level, as in our case study, and finally stratified across all owners and all regions across the state. The Second Progress Report provided a preview of the management alternatives that will ultimately be stratified by owner and timbershed to derive a baseline projection of harvest levels, forest economics, forest structure and related ecological attributes.

We ask what are the likely impacts to streams and fish, with management changes, and in particular in the context of Study 4, concerning Forestland Conversion?

Eastside Forest Health, Insects, Fire, and Climate

In the Second Progress Report it was noted that 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. Fire events so interact with management treatment schedules that one cannot simulate the future of a treatment without considering the dynamic fire response itself, which will be treatment-sensitive to the timing and magnitude of hazard reduction implementation across the landscape. In this Report we have provided a summary of a simulation for the Okanogan National Forest (ONF) to demonstrate how effectively certain treatments could reduce fire hazard and also how the pace of phasing in these treatments results in very pragmatic limitations on their effectiveness ***(Impacts of Thinning and Implementation Schedules on Fire Hazard Reduction Effectiveness, Carbon Storage, and Economics in the Inland West***). We use this example to show the interaction between treatments and their timing on economics including avoided future costs, carbon, and acres burned as example metrics of primary importance. While the ONF has more acres classified as high fire hazard than the private sector, the illustration is still instructive as a demonstration of the degree of complexity needed for an analysis to characterize important dynamic processes imposed by fire regimes and aggravated by climate change.

Our Eastside mortality analysis provided in the Second Progress Report led us to characterize management alternatives that reduced stand density thereby reducing the risk of both insect attacks and fire. Ongoing research appears to show that carrying capacity is very sensitive to climate, and the Eastside temperature and vapor pressure deficit over the last few years have been outside the 200-year historic dynamic range. The mortality implications for the more sensitive species such as pine are huge and bring into question whether any of the treatments that have been suggested based on previous studies will contribute to forest sustainability if the climate metrics remain outside of the historic dynamic range. We have included an update chapter to the Second Progress Report entitled **Eastern Washington Mortality and Climate Change Trends with Implications for Eastern Washington Timber Supply** to at least introduce the issues being raised as a consequence of climate change.

Research currently underway suggest that the links between climate change and the current forest health problem may be so strong that basing predictions on past relationships may need to be rethought. Eastside temperature is above its very long term average, and vapor pressure deficit (moisture) is below its very long term average. Beatle attacks and pine mortality are correlated with these conditions at lower levels than present conditions and if current research holds up it may suggest that pine, making up 40% of these forests, cannot survive if the climate remains outside of its historic range. This calls into question the treatment strategies that have been developed to restore the pine overstory that historically was fire resistant. Pine overstories may not be sustainable under current conditions. Other inland species may also be threatened. In the two years since the Forest Health Working Group Report was published, none of the solution-oriented recommendations have been acted upon, and pine mortality has increased dramatically.

We ask what should be the priorities for research, technology transfer, and cooperation? Can cooperative management alleviate the Federal forests' contribution to the forest health problem? We also note studies showing 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. *Can these values be used in an institutional framework to support public investments and how might that be done?*

Declining Private Eastside Harvest, Biofuels, and other Alternatives

Declines in private harvest on the Eastside are likely in the near future given the high private (and tribal) harvest rates that appear to have offset much of the Federal decline. With the anticipated decline in Eastside harvest, there appears already to be erosion in the infrastructure, with several existing mills planned for closure. The result will be longer hauls, less competitive bidding for timber, and lower returns for timber investments, just the opposite of desirable conditions to sustain acres in forestry.

Yet there is also a possibility of a substantial increase in volume removed to reduce fire hazards, particularly on Federal land, with some volume being merchantable as potential offsets to declining harvest and some more suitable for biofuel use. There are also growing opportunities for salvage. It appears from the FIA inventory data that DNR should also be able to increase its harvest and health restoration activities although this needs to be verified using DNR inventory data.

Are there steps that may contribute to solving both the declining harvest problem and the mortality and high fire hazard problem? What is needed to keep enough mills open to sustain forest management?

Biofuels as a renewable resource are also viewed as an essential part of biomass removal efforts. Increasing the value of biomass in order to pay for the cost of removing small diameter wood to reduce fire and insect hazard is motivating consideration of this material as an energy source. We provide a brief introduction to the problems associated with biofuel processing (***Bioenergy Development*).**

There are many different methods for using biomass as a biofuel or in products that substitute for fossil fuels yet we are not aware of studies that demonstrate either best methods for producing biofuels or identification of obstacles that need to be removed.

Is there a need for more information to support biofuel processing investments?

Management Changes and Impacts on Regional Economics

In the section ***Private Sector Management Intentions***, we summarize the change in management intentions from prior studies as it provides rather clear evidence that, as with environmental policy, management intentions have changed substantially since the prior studies were completed in 1992 (Westside) and 1995 (Eastside).

We develop the link between stand level management alternatives and harvest volume forecasts with the economic analysis provided, not just for the landowner, but also in examination of how forest supplies of wood as raw materials contribute to downstream processing jobs and ultimately to indirect employment and tax impacts that ripple across the economy ***(Impact of Management Treatment Alternatives on Regional Economic Activity)***. This information provides the necessary link between a top down state-level economic analysis (Study 2), and a bottoms-up stand-by-stand timber supply evaluation of impacts. While in a short-term context supply/demand interactions cause prices to rise and fall, we accept the interpretation of economists, that over the longer term, timber prices are residual values determined by national and international markets based on what the final product market will pay for timber, rather than supply competition at the local level. In that context, if the competition for producing timber is very high, and the price is low, the value of timber may decline but the volume of harvest, linked to investment commitments made decades prior, will be predisposed to not decline. What will change, however, is the value of current investments in future timber crops which will be correlated with the present and anticipated future price and economic return realized from prior timber investments.

Can we anticipate future investments and ways to enhance opportunities to invest in forest resources?

Timber has historically been considered a long term investment commitment as returns have generally been deferred longer than for most other financial investment alternatives (40 to 100 years). Recently, higher and more stable returns have been experienced by timber land investors, contributing to many commercial timberland ownership shifts from vertically integrated forest products companies to timber investment management organizations (TIMOs) and real estate investment trusts (REITs). Tax advantages are a contributing factor. The degree to which they will remain long term investors is unclear. Developing ecosystem service markets may also contribute to future changes in ownership strategy.

To what degree can we determine the long-term timber interests of newer management structures?
Which if any ecosystem service markets improve timber investments?

Finally we summarize with some extensions to the more prevailing driving issues that were articulated in the Second Progress Report ***(Management Treatment Issues Revisited).***

Competitive Position Study

The Competitive Position section continues to characterize the position of Washington's forest products industry nationally and internationally identifying its competitors in key domestic and international forest products markets. In this section we provide a global overview of who produces and consumes, a review of Washington production, and an assessment of competitors to Washington producers. The section of the Timber Supply study, ***Impact of Management Treatment Alternatives on Regional Economic Activity,*** links these findings to the management issues.

Will the industry lose its competitive ability, despite its current vitality, if conversion losses, infrastructure changes, and ownership alterations continue unabated?

Economic Contribution Study

This section's data supplant that provided in Report 2, and it has been significantly updated. An increasingly complex array of forest owners and investors suggests a business climate that views forests as a financial, rather than an industrial, asset. The lack of a diversified and competitive forest products industry to process the logs, small diameter timber, and thinnings removed from the forest undermine the ability to manage forests in Washington in a sustainable manner and reduce the range of management options available to forest managers in the state. The lack of competitive markets for intermediate forest products derived from forest management operations undermines the economic rationale of forest management, adversely affects forest health and ultimately results in increased fire risks. At the same time, the forestry and forest products industries make significant contributions to the economy of Washington state, particularly in rural, timber dependent communities.

What effects will investor changes, supply changes, infrastructure changes, forest health, climate, have on the status of the industry in Washington?
If the industry diminishes as a significant economic player, what will be the ensuing condition of environmental resources, such as fish and wildlife, and what will be the impact on regional economies?

Forest Land Conversion and Cascade Foothills Study

Between 1978/1979 and 1988/1989, 95,000 acres of timberland transferred between private owners. This pattern almost doubled between 1988/89 and 2001, with 281,000 acres transferred. The amount of timberland in private ownership converting to urban uses increased from 56,000 acres to 123,000 acres in the same time periods. If this trend continues uninterrupted, western Washington's industrial forest lands could be facing a significant decrease in acreages, with much of the land transferring to other private owners and then into urban and residential land uses. The pattern of industrial forest land transferring to other private ownership and then into urban lands is shown in Figure 5 of the Report.

Since the Second Progress Report was completed in July 2006, work has been done to finalize the review of incentives and disincentives for forestland owners to conserve working forest lands, the general land use analysis has undergone preliminary accuracy assessment, a comparison of land use change and FIA data has been completed, and a detailed, parcel-level analysis of some of the main factors related to forest land conversion in King County (as a case study) are close to being complete.

The land use change data, compared to the FIA data, estimate that approximately 800,000 (raw data) to 1.4 million (trajectory-based data) acres of western Washington have changed from forest land uses to either mixed agricultural or residential and urban land uses between 1988 and 2004. That is a substantially larger estimate than FIA's approximately 600,000 acres loss of timberland from 1978 to 2001. As mentioned, however, the land use data are measuring overall land use, rather than the timber production of a certain area. Even with these considerations, based on the accuracy of the land use change data combined with the large scope of the data (a seamless analysis of all of western Washington), it can safely be assumed that the scope of forest land conversion is larger than expected. Continuing with a 0.58% (raw) to 1.04% (trajectory-based) loss of forest land use per year, western Washington could experience a sizable loss of forest land in the future years.

One issue still to be addressed is the proper designation of "mixed agricultural" land uses. Simply grouping this land use with intensive agricultural lands may be overestimating the agricultural presence in western Washington. The mixed agricultural land use is a combination of farms, pastures, cleared forest land, homes, and roads; some land use experts call this "rural land."

Two case studies, in King and Spokane counties, will allow a more refined look at the other factors that contribute to the conversion (or non-conversion) of forest land into other uses, such as number and size of parcels, presence of Class IV General Forest Practice Applications, and development permits issued. This information will be presented at the upcoming Forum discussions and will help determine if certain factors can help determine locations, rates, and trends of forest land use in Washington state.

Is the rate of land use change tolerable? Controllable?
Are the recent forest land ownership (REITs, TIMOs, MLPs) capable of sustaining a viable forest base within their economic structures?

State Granted Lands Return on Investment Study

Progress on this study is not being included in this Third 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, Alicia Sullivan, Hiroo Imaki

Moving Beyond a Stand Level Analysis – extending the road map:

The Second Progress Report provided a preview of the management alternatives that will ultimately be stratified by owner and timbershed to derive a baseline projection of harvest levels, forest economics, forest structure and related ecological attributes. As noted in the section "Prior Timber Supply Projection Errors and Issues Raised" environmental policy change appeared to provide the largest source of projection errors in prior supply studies. While the intent of regulations may be more stable than at the time of the prior Washington timber supply study, it is still very difficult to estimate the impact of regulations which are in effect different for each owner group and vary substantially across the landscape. Before we attempt to stratify the management treatments across owner groups we have provided a county level case study describing how the Forest and Fish rules impact private and industry owners in particular ***(Estimating the Impact of Fish-Bearing and Headwater Stream Protection Across Large Areas).*** It is generally easier to understand these impacts by taking the analysis one step at a time, first at the stand level (Second Progress Report), then at a larger landscape level such as our case study and finally stratified across all owners and all regions across the state.

While the riparian management impacts are also substantial on the Eastside, the analysis of Forest Health Trend analysis provided in the Second Progress Report suggests that forest health problems eclipse other impacts on the Eastside. However difficult it is to assess the impact of regulations for which the intent is pretty clear, it is that much more difficult to assess the impact of climate change, insects and fire as the impact of a series of stochastic processes. In particular, while the purpose of a management alternative may be to reduce fire risk and restore forest health, fire events will interact with treatment schedules so that one cannot simulate the future of a treatment without considering the dynamic fire response itself, which will be treatment-sensitive to the timing and magnitude of hazard reduction treatment implementation across the landscape. Therefore we have provided a summary of a simulation for the Okanogan National Forest (ONF) to demonstrate how effective certain treatments could be in reducing fire hazard and also how the pace of phasing in these treatments results in very pragmatic limitations on their effectiveness ***(Impacts of Thinning and Implementation Schedules on Fire Hazard Reduction Effectiveness, Carbon Storage, and Economics in the Inland West***). We use this example to show the interaction between treatments and their timing on economics including avoided future costs, carbon and acres burned as example metrics of primary importance. While the ONF has more acres classified as high fire hazard than the private sector, the illustration is still instructive as a demonstration of the degree of complexity needed for an analysis to characterize important dynamic processes imposed by fire regimes and aggravated by climate change.

An obvious criticism of considering only fire is that insect risks while contributing to fire are not driven by fire. Our eastside mortality analysis provided in the Second Progress Report led us to provide potential management alternatives that reduced stand density contributing to both reduce risk of insect attacks and fire. We acknowledged that while available research supports the benefits of reduced densities it falls short of providing enough detail to characterize site specific carrying capacity. Some stands have the potential to carry more density than others. Ongoing research appears to show that carrying capacity is very sensitive to climate and the eastside temperature and vapor pressure deficit over the last few years have been outside the 200 year historic dynamic range. The mortality implications for the more sensitive species such as pine are huge and bring into question whether any of the treatments we have suggested based on previous studies will contribute to forest sustainability if the climate metrics remain outside of the historic dynamic range.

*We have included an update chapter to the Second Progress Report entitled **Eastern Washington Mortality and Climate Change Trends with Implications for Eastern Washington Timber Supply** to at least introduce the issues being raised as a consequence of climate change.*

Increasing the value of biomass in order to pay for the cost of removing small diameter pieces that will reduce fire and insect hazard is motivating the use of much of this material as a bioenergy source. We provide a brief introduction to the problems associated with biofuel processing entitled ***Bio-Energy Development.***

Given these initial steps at characterizing some of the difficulties of getting beyond stand-level management alternatives to stratification of treatment strategies across the broader land base, we then turn to shifting owner management intentions which vary widely by owner and timbershed ***(Private Sector Management Intentions).*** Aggregation of management intensities by landowner type provides the key information on what and how many treatments are expected to be applied in each timbershed. We summarize the change in management intentions from prior studies as it provides rather clear evidence that, as with environmental policy, management intentions have changed substantially since the prior studies were completed in 1992 (Westside) and 1995 (Eastside).

Finally we develop the link between stand level management alternatives and harvest volume forecasts with an economic analysis, not just for the landowner, but also an examination of how forest supplies of wood as raw materials contribute to downstream processing jobs and ultimately to indirect employment and tax impacts that ripple across the economy ***(Impact of Management Treatment Alternatives on Regional Economic Activity)***. This information provides the necessary link between a top down state-level economic analysis (Study 3), and a bottoms-up stand-by-stand timber supply evaluation of impacts. While in a short-term context there will be supply/demand interactions causing prices to rise and fall, we accept the interpretation of economists, that over the longer term, timber prices are residual values determined by national and international markets based on what the final product-market will pay for timber, rather than supply competition at the local level. In that context, if the competition for producing timber is very high, and the price is low, the value of timber may decline but the volume of harvest, linked to investment commitments made decades prior, will be predisposed to not decline. What will change, however, is the value of current investments in future timber crops which will be correlated with the present and anticipated future price and economic return realized from prior timber investments.

Timber has historically been considered a long term investment commitment as returns have generally been deferred longer (40 to 100 years) than for almost all other financial investment alternatives. Recently, higher and more stable returns have been experienced by timber land investors, contributing to many commercial timberland ownership shifts from vertically integrated forest products companies to timber investment management organizations (TIMOs) and real estate investment trusts (REITs). Tax advantages are a contributing factor. The degree to which they will remain long term investors is unclear. Developing ecosystem service markets may also contribute to future changes in ownership strategy.

Finally we summarize with some extensions to the more prevailing driving issues that were articulated in the Second Progress Report ***(Management Treatment Issues Revisited).***

Estimating the Impact of Fish-Bearing and Headwater Stream Protection Across Large Areas

Introduction

The Second Progress Report provided a case study analysis of riparian protection on small owners and an economic analysis of management alternatives at the stand level. One of the critiques of that report suggested that a broader characterization of the problems of estimating the impacts from the Forest and Fish regulations was needed. There are a number of somewhat complicating factors that make estimating the ecological and economic impacts of stream protection rules across a landscape very important, yet difficult to assess at the county or timbershed level.

For example, while the definitions of fish-bearing and non fish-bearing streams may be stable, the application of these definitions to stream miles is a moving target subject to changing interpretations, new stream assessment technology, and ground-truthing. Our knowledge about the stream network, as represented in the hydrography layer in Geographic Information Systems (GIS), is limited by error, resolution, and the dynamic nature of stream systems. Upgrades to the hydrography layer from ground-truthing are not tracked, thus providing uncertainty in the quality of existing stream data. Subsequently, any assessment based on these data should be viewed with caution. Of additional concern, since there are many more miles of headwater streams than fish-bearing streams, the magnitude of management restrictions around these streams can undermine the economics of sustainable forestry, motivating accelerated land conversions with a consequent loss of forests and stream protections. There are also economic disparity and equity issues related to who pays for the public benefits of protective buffers as was noted in the case studies on small owners.

Given these complications we will extend the stand level and small owner case studies provided in the progress report with a spatial analysis of buffer impacts on private lands in Lewis County as a pilot project before extending the analysis to the seven timbersheds in the state. Lewis County provides an attractive sub-sample for previewing the issues for the westside timbersheds as it has a diverse range of ownerships and topography (Map 1: Lewis County location and Map 2: Ownership). The eastern portion of the county includes higher altitudes and mostly public ownership; the western portion contains more industry ownership with a diverse topography; and in the somewhat flatter middle area along the Interstate-5 corridor small private forest landowners are concentrated amidst growing urban areas where land conversion pressures are highest.

Stream Typing: Old vs. New

Washington State's Forests and Fish Rules are based on an evolving system of stream typing that classifies streams into categorical types related to fish usage. Initially created in 1975, this system used six types (1, 2, 3, 4, 5 and 9), with types 1, 2 and 3 being fish-bearing, 4 non-fish-bearing perennial, 5 non fish-bearing seasonal, and 9 unknown or unclassified. With the adoption of the Forest and Fish Rules, stream typing changed to a system of S, F, N, and U (Shoreline, Fish-bearing, Non-fish-bearing, and Unknown), with type N sub-typed as Np for perennial and Ns for seasonal. These stream type changes initially had little impact, as under the Interim Rules there was a direct relationship between the old and new types with old type 1 classified as new type S, 2 and 3 as F, 4 as Np, 5 as Ns and 9 as U.

Stream typing impacts did result from the adoption of the Final Rules, as the new stream types were no longer linear transformations of the old types as they were under the Interim Rules (Table 1). For private lands in western Washington, streams formerly typed as 1, 2 and 3 generally retained their fish-bearing status as new types S and F. Type changes for streams formerly classified as non-fish-bearing (4, 5 and 9) were substantial, with 44.3% of old type 4, 8.7% of old type 5 and 13.2% of old type 9 moving to new types S and F. This transition to fish-bearing status greatly increased the buffer area associated with the stream protection. In addition, 49.5% of the old type 9 streams were reclassified as new type N. These headwater streams may require buffers if they are perennial.

Table 1: Distribution of old stream type length within new stream types for private lands in western Washington from DNR's hydrographic layer

Old	New Steam Type %				
Type	S	F	N	U	Total
1	77.54	20.48	1.97	0.01	100.00
2	13.83	86.17	0.00	0.00	100.00
3	0.58	95.93	3.49	0.00	100.00
4	0.21	44.11	55.66	0.01	100.00
5	0.08	8.58	91.33	0.01	100.00
9	2.28	10.87	49.51	37.34	100.00

In addition to stream typing changes, the new rules specify that the transition from seasonal to perennial non fish-bearing streams (Ns to Np) is at the Perennial Initiation Point (PIP), defined as the base of a catchment area, which is 5 ha (13 ac) in the Sitka Spruce Zone and 21 ha (52 ac) in the remainder of western Washington. PIPs have not been mapped by the Washington Department of Natural Resources (DNR), but they can be estimated using hydrological models in GIS. PIPs and 21 ha (52 ac) catchment areas were determined for Lewis County in southwest Washington. Type N stream segments falling within these catchment areas were typed as Np, with the remaining type N segments typed as Ns. On private lands, this results in a 134% increase in the total area impacted by headwater buffers compared to the old water typing rules. These increases in both fish-bearing and non fish-bearing stream mileage and associated riparian management zones can have a considerable impact on the economic viability of sustainable forest management on private lands.

Economic Impact of Stream Typing Changes

Determining the area of required buffers and the resulting economic impacts is not trivial. For most areas of western Washington ground-truthed stream data are sparse or not available. Since the age class distribution is approximately uniform on private lands in Lewis County and site class is generally high, unrestricted management practices were simulated by a commercial thinning before age 30 with final harvest at age 50. In an earlier Lewis County study (Lippke et al 2000), private final harvest levels of 74 thousand board feet (mbf)/ha (30 mbf/ac) with a stumpage value of $396/mbf and a commercial thinning volume of 25 mbf/ha (10 mbf/ac) at $313/mbf were considered representative. Communication with local experts confirmed that, while markets have fluctuated in recent years, these values provide an adequate representation of current conditions (Stinson 2005).

Lost harvest revenue from riparian buffers on private land is estimated in Table 2 under both new and old stream typing, excluding the cost of leaving 49 trees/ha (20/ac) outside of the more restrictive zones closer to the streambank. Buffer area was determined in ArcGIS using the DNR's hydrographic and site class layers with hydrological modeling using a 10-meter digital elevation model (DEM) to determine PIPs and classify streams as Np or Ns in accordance with the Forests and Fish Rules. The stream typing change increased total buffer area 56% on industry land and 77% for small forest landowners. The split between industry and smaller owners was derived using tax parcel identification (Rogers 2003).

Table 2: Impact of new stream typing rules in Lewis Co.

	New	Old	Change
Small ownership (60,000 ha)			
Buffers (ha)	6,160	3,483	2,677
Buffers (% of total ha)	10.3	5.8	4.5
Rev/yr loss ($mils)	4.6	2.6	2.0
NPV loss ($mils)	92	52	40
Industry (230,000 ha)			
Buffers (ha)	20,052	12,885	7,167
Buffers (% of total ha)	8.7	5.6	3.1
Rev/yr loss ($mils)	14.9	9.6	5.3
NPV loss ($mils)	298	192	106
NPV total ($mils)	390	244	146

For industrial lands, the loss in the net present value (NPV) of future harvests (estimated using a 5% real discount rate) increased from $192 million under the earlier stream typing rules to $298 million under the new rules on 230,000 total ha (569,000 ac). The loss for small ownerships increased from $52 million to $92 million on 60,000 total ha (148,000 ac). The total combined NPV loss increased from $244 million to $390 million.

The percentage of total acreage in no-harvest buffers increased from 5.6% on industry lands to 8.7% under the new stream typing and from 5.8% to 10.3% for small owners. These percentages do not include the impact of leave tree requirements or the diminished economics associated with increased fragmentation and compromised operability for the remaining less restricted portion of the riparian zone. Many owners, especially small owners, may find it no longer economically feasible to harvest smaller slivers of land that are not restricted in buffers but have become difficult to access such that harvesting is cost-prohibitive.

Impact Disparity

While it is noteworthy that the new stream typing rules increased the average impact on smaller owners substantially more than on industry lands, these averages understate the impact to individual owners as was demonstrated in the Second Progress Report. The increase in the average impact is largely related to the fact that small ownerships are concentrated in the lower flat lands that act as the interface between growing urban communities and more rural forests (Rogers 2004).

Impact of Newly Defined Headwater Streams

Acknowledging the uncertainty in the DNR hydrographic layer and stream typing methods, we compared the buffer area corresponding to fish-bearing (F) and non fish-bearing perennial streams (Np). Tables 3 and 4 show total and percentage buffer impacts respectively by these stream types. For Np streams the increase is larger for small owners, 143%, versus 133% for industry lands. However, the buffers for headwater streams are a lower percentage of the total buffer area for small ownerships, reflecting the greater proportion of industry lands and lower frequency of small ownerships at higher elevations where headwater streams are prevalent. Headwater buffers as a percent of total buffers increased from 13% to 17% for small owners compared to an increase from 21% to 32% for industry lands.

Table 3: Buffer impacts by stream type in Lewis Co.

	F	Np
Small ownership		
Buffers (ha)	5,091	1,069
Buffers (% of total ha)	8.52	1.79
Rev/yr ($mils)	3.8	0.8
NPV ($mils)	75.7	15.9
Industry		
Buffers (ha)	13,705	6,347
Buffers (% of total ha)	5.95	2.76
Rev/yr loss($mils)	10.2	4.7
NPV loss ($mils)	203.7	94.3

Table 4: Percentage increase in buffer impact under new stream typing rules by stream type and ownership class.

	% Increase		
	F	Np	Total
Small ownership	67	143	77
Industry	35	133	56
Total	42	134	60

The magnitudes of these impacts are very sensitive to potential errors in the hydrographic layers used to derive estimates of required buffers. While we may know with near certainty the location of large fish bearing streams, our knowledge of the Np streams is much more limited.

Potential Np Buffer Errors

Perhaps the biggest surprise in our analysis is the decline in our confidence in estimates of headwater streams based on concerns over the accuracy in the GIS hydrographic layer available from DNR. Recent studies on sample areas in southwest Washington using LIDAR (LIght Detection And Ranging) to create digital terrain models (DTM) have shown a substantial difference in stream mapping detail. Mouton (2005) provided a detailed comparison of stream networks derived from LIDAR data using hydrologic models in GIS and the DNR hydro layer. In his sample area he found 362 kilometers (km) of stream length using the LIDAR elevation model, which is a 432% increase over the 68 km in the DNR hydrographic layer. The corresponding area increase in buffers was somewhat less mainly because the size of the PIP catchment areas was reduced as a result of the improved site-specific PIP location determination and modeling. Mouton found 860 hectares in buffers using the LIDAR layer versus 240 hectares in the DNR layer, which is a 260% increase. These are substantial differences in buffer requirements with the difference related directly to the adequacy of the hydrographic layer. Since the variation in stream characteristics across the region is very large, it raises questions about the feasibility of estimating the economic impact of non-fish bearing perennial streams. Any scale factor to represent the increased streams identified in a LIDAR sample that might be developed from one or more sample areas will not likely be very representative for other parts of the county or state. However, LIDAR evidence indicates that estimates based on the current

DNR hydrographic layer may be inadequate and likely understate the magnitude of the required buffer area.

This should not be interpreted to mean that owners are not protecting enough buffer area as the buffers are being managed in practice based upon walking the streams for a more reliable representation (ground-truth) than is available in the DNR hydrographic layer. A serious policy problem has surfaced, however, in that the impact of stream buffers is almost certainly much larger than early estimates with consequent increases to impacts on economic viability. Independent survey estimates of unmanaged acres on industry lands at the timbershed level do provide an alternative estimate of areas not being managed. These surveys do not suggest that the unmanaged acreage is larger than shown by the DNR hydrography layer, however this comparison is complicated by other factors such as unstable slopes and other non-riparian related set-asides. In effect we lack sufficient data to determine the adequacy of currently available hydrography data and consequently to accurately determine the magnitude of buffer impacts. The magnitude of our estimated impacts over large landscapes must be viewed with caution.

The Impact on Sustainable Management

Despite these data limitations, the relative magnitude of the economic impacts raises questions about whether continued forest management is sustainable on private ownerships. The NPV loss of not being able to harvest timber in riparian buffers can be as high as $30,000/ha ($12,000/ac) depending on the age class (i.e. the time until the economic rotation age). Based on Table 2, the average NPV loss for small ownerships is about $15,000/buffer ha ($6,000/ac). Even when this loss is allocated over all hectares (not just buffer zones), the average NPV loss for small ownerships is $1,532/ha ($620/ac), which includes $872/ha ($353/ac) under the old stream typing plus $512/ha ($207/ac) for new fish bearing and $158/ha ($64/ac) for net new Np. For industry owners, the average NPV loss is $1,295/ha ($524/ac), which includes $835/ha ($338/ac) under the old stream typing plus $230/ha ($93/ac) for new fish bearing and $235/ha ($95/ac) for net new Np. These results suggest that it is not economically attractive to manage or own forestland in riparian buffers. This further suggests a high motivation for conversion of these lands to non-forest uses, an unintended consequence that ultimately reduces available riparian habitat. Even for larger properties forest management may become economically inferior to other investment alternatives. As noted above, estimated losses may be underestimated because we expect the buffer area will be larger than our current estimates that have been derived from the DNR hydrographic layer (as noted by LIDAR comparisons) and the above loss estimates do not include the cost of leave trees, fragmentation impacts or unstable slope protection.

Impacts Scaled to Western Washington

Table 5 scales up the Lewis County impact as a rough estimate for Western Washington, assuming for demonstration purposes that the ownership distribution of commercial forestland in other counties of Western Washington is proportional to Lewis County. Acknowledging that these estimates are potentially substantial understatements of the full impacts, we note that the NPV loss of private timber in buffers increased from about $2.0 billion under the prior stream typing rules to $3.2 billion under the new system for an additional loss of $1.2 billion.

Table 5: Impact of new stream typing rules scaled to WWA

	New	Old	Change
Small ownership (0.97 mil. ha)			
Buffers (ha)	100,057	56,573	43,484
Rev/yr ($mils)	75	42	32
NPV ($mils)	1,494	845	650
Industry (1.34 mil. ha)			
Buffers (ha)	116,696	74,987	41,709
Rev/yr loss ($mils)	87	56	31
NPV loss ($mils)	1,734	1,115	619
NIPF+Ind. NPV ($mils)	3,229	1,960	1,269

The economic losses are not limited to lost timber revenue. The lost opportunity to process harvested logs means reduced economic activity with direct and indirect job and revenue losses to mills, workers, rural communities, as well as local and state taxing districts. The total economic impact is therefore several times larger than the revenue loss from reduced timber harvests. The harvest loss from the changed stream typing for Western Washington is estimated to be 86 million board feet per year. Using Conway's economic model (Conway 1994) as adapted for use with alternative management scenarios (Lippke et al. 1996), we can estimate the expected impact of the new stream typing rules based on the DNR hydrographic layer to be an additional loss of 3,170 direct and indirect jobs. Accordingly, gross state product would be reduced $139 million and state and local taxes by about $15 million. Labor productivity gains are being analyzed and probably have reduced the jobs impact in recent years.

We expect to estimate these impacts directly for each timbershed and owner group by the end of the study, reducing the uncertainty associated with the degree that Lewis County is a representative sample. We do not expect to reduce the uncertainty related to accuracy of he hydrography layer until better data becomes available.

Management Alternatives

Using the targeting and assessment procedure developed by Gehringer (2005) and the management alternatives examined for small owner alternative plans (Zobrist et al. 2005) in our Second Progress Report (page 22-23) we can provide some insight on the impact of management alternatives for motivating sustainable forest management in riparian areas. The statistical assessment procedure provides an evaluation whether stream buffers managed under different treatments develop similar structure to that of mature, unmanaged forests, which is considered to be the desired future condition (DFC) along streams. We used the assessment procedure to evaluate the percentage of time over a period of interest that a management alternative results in forest structure that is statistically similar to that of mature, unmanaged forests. When using this ecological metric in conjunction with economic viability metrics (Zobrist 2005) we gain insight into both the benefits and costs associated with different management strategies.

Table 6 compares the SEV/ha for a regulatory no-harvest buffer, no buffer at all (i.e. unrestricted commercial management), and a narrower buffer with thinning treatments designed to put riparian buffer areas on a pathway to reach the desired future condition (DFC) of natural mature stands more rapidly and more reliably. Note that while the SEV for the narrower buffer with thinning is lower than the no buffer alternative, it is still positive, indicating that a 5% minimum target rate of return is still achieved (in contrast to the negative SEV for the no touch buffer). It also reaches the statistical criteria for DFC more than twice as frequently as the more costly no-touch buffer. The removal of the excess density found in young commercial stands by thinning treatments improves both the economics of sustainable forestry and the desired ecological condition of the riparian areas.

Table 6: Thinning Alternative

	Soil expectation value ($/ha)	Time in DFC (%)
No Touch Buffer	-531	32
Thin & Narrow Buffer	512	65-70
No Buffer	1,549	<32

Conclusions

In spite of great difficulty in estimating the economic impact of headwater stream management, it would appear that new stream typing rules being applied in Washington State have significant economic impacts that may have the unintended consequence of motivating a change in land use investment away from forestry. However, there are alternative buffer management treatments that appear to substantially lower the cost of stream protection and at least partially restore the motivation to pursue sustainable forest management.

Disproportionate impacts on small ownerships are large, both on average across the owner classes, and even more so for those owners with a higher percentage of acres along streams. Incentives may be required for many to keep their land in forestry. The estimated increase in buffer area related to new stream typing is large (+60%) and may become substantially larger as better hydrographic mapping becomes available through LIDAR and ground surveys. The quality of information available in the DNR hydrographic layer does not appear to be adequate to make good estimates of economic impacts. Investing in LIDAR data and analysis routines, ground-truthed for robust confidence, would improve buffer estimation accuracy and economic impact analysis. Understanding the comparisons of a wider array of management alternatives designed to minimize economic impacts while sustaining healthy riparian environments will be important to refine protection strategies to avoid unintended consequences such as deforestation associated with land-use conversions.

Literature Cited:

Conway, Richard. 1994. The Forest Products Economic Impact Study Current Conditions and Issues. Prepared for WFPA, WADNR, and WADTED by Dick Conway and Associates, Seattle, Washington. 59p.

Gehringer, K.R. 2006. Structure-based nonparametric target definition and assessment procedures with an application to riparian forest management. Forest Ecology and Management Vol 223, March 2005, pages 125-138.

Lippke, B., S. Marshall, M. Ludwig, J. Moffett, D. Fitzpatrick and B.B. Bare. 2000. Lewis County Economic Assessment, for the Lewis County Natural Resources Advisory Committee. CINTRAFOR Special Paper 35, College of Forest Resources, Univ. of Washington, Seattle, WA. 62 p.

Lippke, B.R., J. Sessions, and A.B. Carey. 1996. Economic Analysis of Forest Landscape Management Alternatives: Final report of the working group on the economic analysis of forest landscape management alternatives for the Washington Forest Landscape Management Project. Special Paper 21, CINTRAFOR, College of Forest Resources, Univ. of Washington, Seattle, WA. 157 p.

Mouton, A. 2005. Generating stream maps using LiDAR Derived Digital Elevation Models and 10-m USGS DEM. M.Sc. Thesis, Univ. of Washington, Seattle, WA.

Rogers, L.W. 2003. Determination of the Current State of Geographic Information Systems Data in Washington State Counties. Report prepared for the Washington State Department of Natural Resources under contract. Rural Technology Initiative, College of Forest Resources, University of Washington, Seattle, WA.

Rogers, L. 2004. Map of Known Washington State Non-Industrial Private Forestland Parcels by Elevation Ranges. Rural Technology Initiative, College of Forest Resources, University of Washington, Seattle, WA. Available online at http://www.ruraltech.org/gis/sflowria/maps/ sflodb/NIPF_by_Elevation_Bands_Version_3.jpg

Stinson, S. 2005. Personal communication that captured the consensus of a group of Lewis County family foresters on timber prices.

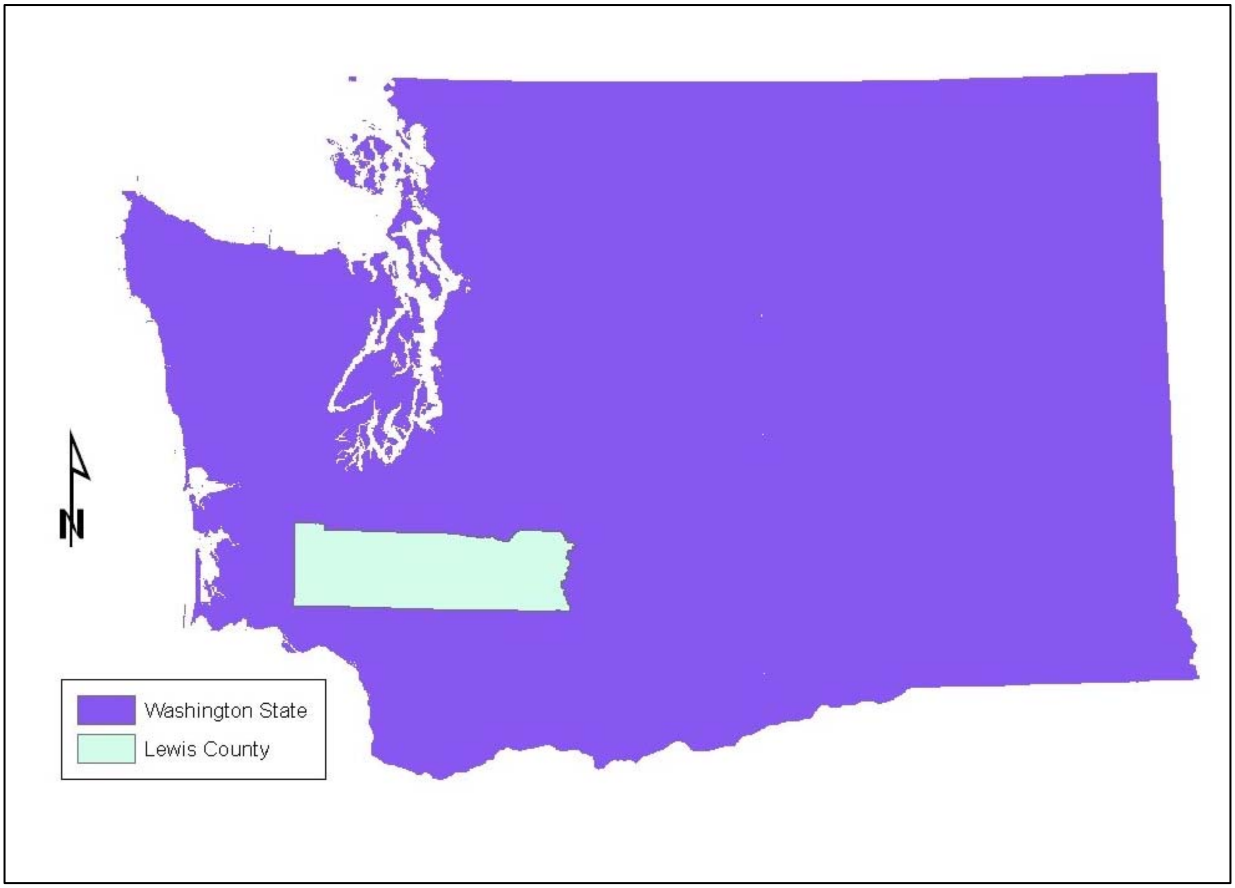
Washington Department of Natural Resources (WADNR). 1999. Forests and Fish Report. Olympia, WA. 177 p.

Zobrist, K.W., K.R. Gehringer, and B.R. Lippke. 2005. A sustainable solution for riparian management. P. 54-62 in Understanding Key Issues of Sustainable Wood Production in the Pacific Northwest, Deal, R.L. and S.M. White, eds. USDA For. Serv. Gen. Tech. Rep. PNW-GTR-626..

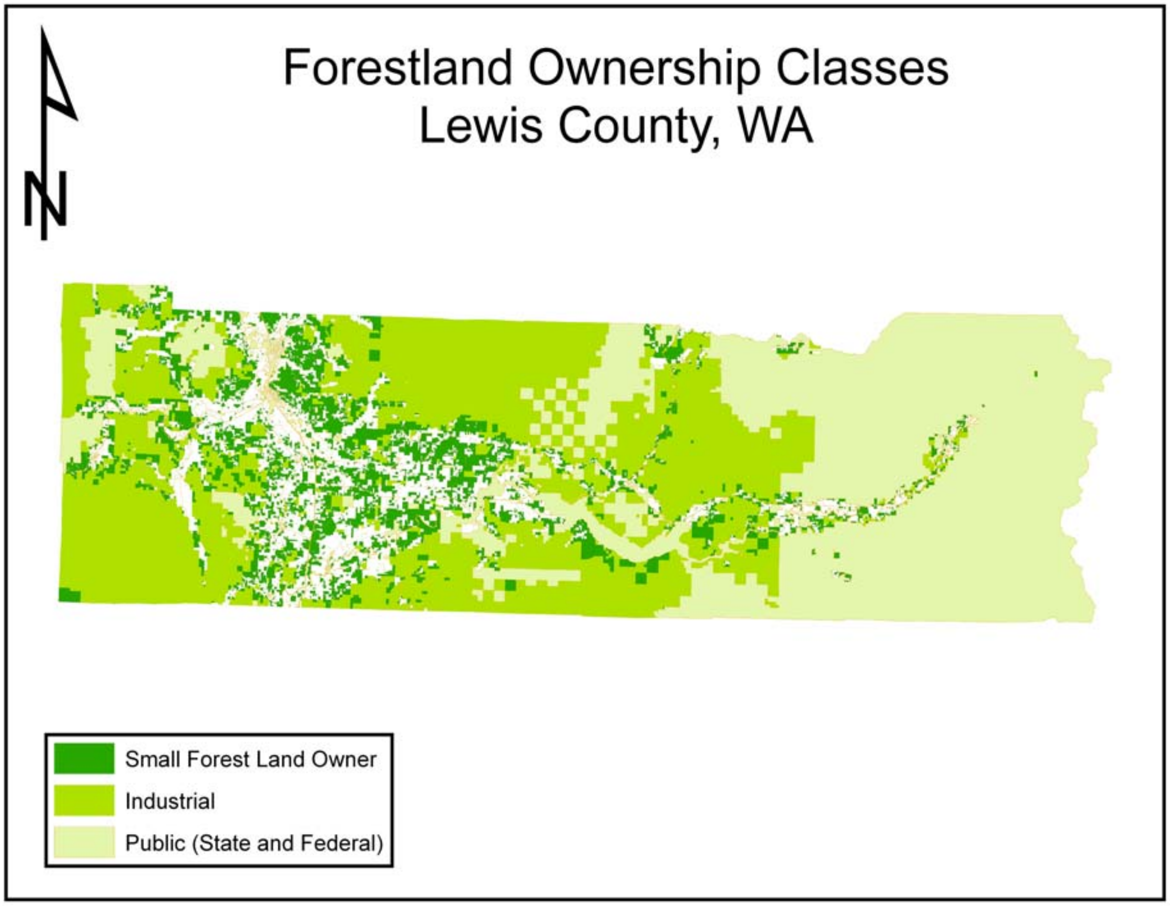
Zobrist, K.W. 2005. Economically Sustainable Working Forests: Financial Analysis Principles and Applications. Northwest Environmental Forum Topic Paper 2. Northwest Environmental Forum, College of Forest Resources, University of Washington, Seattle, WA. 16 p.

[1] Washington Administrative Code (WAC) 222-30-021

Map 1: Headwater Stream Buffers, Lewis County example



Map 2: Lewis County Forest Land Ownership



Impacts of Thinning and Implementation Schedules on Fire Hazard Reduction Effectiveness, Carbon Storage, and Economics in Eastern Washington.

Introduction

Many overstocked forests in the Inland West are experiencing uncharacteristic insect damage and wildfire. The effectiveness of fuel removal treatments to reduce this hazard has been well documented in numerous recent publications (Agee 1993, Graham et al. 2004, Kalabokidis and Omi 1998, Keyes and O'Hara 2002, Omi and Martinson 2002, Peterson et al. 2005, Pollet and Omi 2002, Sandberg et al. 2001). The relative costs and benefits of thinning treatments to reduce wildfire as compared to a no management alternative should include both market economics and the avoided costs of fighting fires, carbon storage, habitat, and other non-market values (Mason et al 2006). An absence of consistent methodologies for assessing these values has constrained institutional adoption, with the adverse impact of defaulting to no action. This increases the fire hazard. We provide here a brief demonstration of an accounting framework that includes the consequences of fire hazard reduction treatments and the timing of their implementation on fires and hence on avoided future costs as well as carbon, one of the more important environmental considerations impacted by fire. A more detailed description is available in an RTI working paper (Lippke et al 2006). Research currently underway by the Consortium for Research on Renewable Industrial Materials (CORRIM 2004) will provide life cycle data on the atmospheric carbon implications of forest resource use in the Inland West. These new data will ultimately support more accurate carbon accounting for Inland West forest biomass and associated fossil fuel offsets.

Methodology

While the process of developing thinning treatments to reduce fire hazard is straight forward, evaluating the effectiveness is much more complex, as fire events will interact with treatment schedules. One cannot simulate the future of a treatment without considering the dynamic fire response, which itself will be treatment-sensitive to the timing and magnitude of hazard reduction treatment implementation across the landscape. Therefore we have provided a summary of a simulation for the Okanogan National Forest (ONF) to demonstrate how effective certain treatments could be in reducing fire hazard and also how the pace of phasing in these treatments results in reduced fire fighting costs, acres burned, revenue and carbon as some of the more important values of interest.

Integrated computer technologies make it possible to simulate forest stand growth starting with tree list inventory measures. Impacts of management treatments or disturbance events can be tracked for any outputs that can be quantitatively associated with changes in the tree list inventory. For this analysis, inventory data from the Current Vegetation Survey were assembled for the Okanogan National Forest (ONF) to demonstrate fuel reductions in an Inland forest landscape with moderate to high fire hazard. Sample plots were analyzed for stand structure characteristics and relative fire hazard (Hardy 2005). A high, moderate, or low fire hazard classification was assigned for each plot based on the Severe Crowning Index assessment from the Fire and Fuels Extension model, FFE (Crookston et al 2002), linked to the Forest Vegetation Simulator, FVS (Dixon et al 2003), within the Landscape Management System, LMS, (McCarter et al 1998). Alternative fuel reduction treatment pathways were simulated to create post-treatment inventory data representative of vegetation conditions at 5-year increments within the 50-year simulation period. A fire disturbance scheduling model (rate of ignition) was developed based upon prior research on unburned refugia patterns. The probability of fire on high fire hazard stands was selected to result in 18% unburned refugia in 50 years, moderate hazard stands at half that rate and low hazard stands did not receive burn simulations. Of the 764,000 acres sampled, almost 80% were initially found to have a moderate or high fire hazard level with 30% at the high level. Fire disturbances were introduced across the virtual landscape based on the rate of burn and evaluation of the stand level fire hazard rating. LMS with FVS-FFE was used to simulate growth, treatments, and fire, and to produce per acre output metrics including acres burned, economics, carbon stored and other ecological metrics.

Thinning Treatments

A range of forest treatment intensities were evaluated. A light intensity treatment simulation removed only trees equal to or less than 9 inches in diameter at breast height **(9 & under).** A more aggressive thinning treatment was designed to reduce forest density while retaining the largest trees and achieving a basal area target of 45 sq. ft. per acre **(BA45).** Simulated harvests of trees 12 inches in diameter at breast height and larger **(12&over)** were developed to provide an upper bound for revenue production. Fire as a likely natural disturbance for a no action scenario **(NA)** was simulated and produced standing dead and dying trees with volumes calibrated from recent fire results. Contrasting scenarios were developed for immediate treatment of all moderate and high hazard acres and treatments phased-in over a 25-year period to demonstrate the impact of not being able to treat all stands simultaneously. The entire simulation period of interest for both scheduling scenarios was 50 years.

Net economic returns were estimated using logging costs and log market values from recent surveys (Mason et al. 2003). The mean net return from the **9&under** thinning was found to be $-316/acre (below cost), for **BA45** mean harvest revenues were found to be $+61/acre (very close to costs), **12&over** thinning produced $1489 of mean net revenue per acre, and **NA** with no harvest produced no revenue. The fire fighting cost for each treatment scenario was estimated to be $1000/acre based on the average fire fighting cost for the ONF for the last decade. A 5% discount rate was used to convert all future anticipated fire fighting cost liability exposures to present value dollars.

Fire Probability Model

The fire probability model allows burn rates to be set each period for each plot dependent on the treatment and fire hazard classification. Prior study results have estimated that unburned pre-settlement refugia, usually found in the forest mosaic on north slopes and in moist areas, accounted for very small percentages of the forest area in some areas to as much as 20% of an entire landscape in other areas (Olson 2000, Camp et al 1996). A 14% burn rate every 5 year period approaches the 20% refugia target in 50 years as shown in Figure 1. However, in conjunction with lower burn rates on the moderate hazard acres and no burn on low hazard acres, 30% of the total forest acres for this simulation remain unburned across the total ONF. While actual fires will be governed by weather conditions and spill over into some lower hazard stands, plots with lower fuel loads have been shown to be unlikely to experience crown fires which is the governing criteria for fire in these simulations (Omni and Martinson 2002).

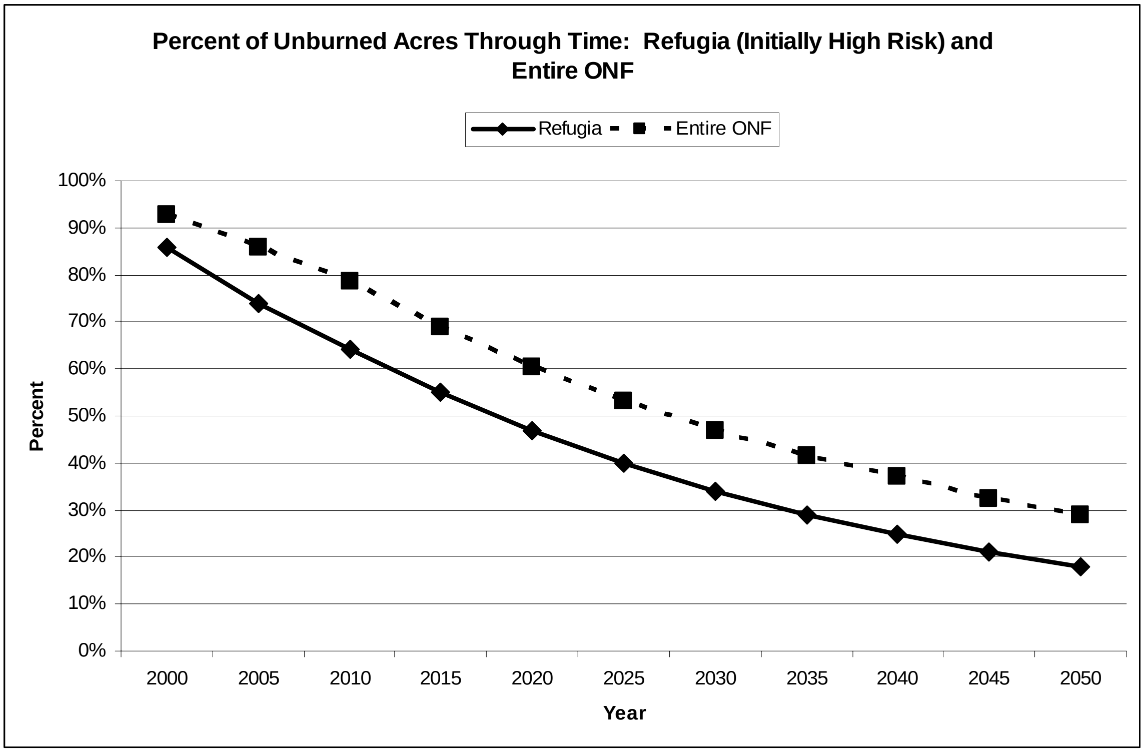


Figure 1. Unburned Okanogan National Forest and High Fire Hazard Refugia through time with no thinning treatments.

Fire Hazard Reduction

The No Action alternative results in a steady rate of fires and new burned acres that maintains 25-30% of the acres in both the low and high hazard category much like the initial condition (Figure 2&3 left). The BA45 treatment eliminates high hazard acres for almost 45 years but re-growth after treatment will transition these acres back into higher hazard status in absence of future treatments to remove the recovering undergrowth. Similarly those acres initially categorized as low hazard move into moderate and high hazard categories as a result of stand growth. Neither the 9&Under or the 12&Over treatment reduce the ladder fuels sufficiently to lower hazard levels substantively.

For the 25 Yr Phase-In period the share of acres in the Low Hazard class after a BA45 treatment remains twice as high as the alternatives for about a 25-year interval (Figure 2&3 right). Some Low Hazard acres are maintained even under the No Action alternative as a direct result of fires reducing the number of High and Moderate hazard acres.

If all high hazard acres could be treated with BA45 immediately, the acres burned each period would fall to low levels for 20 years but without continued treatments the rate of burn would begin to increase again from 20 to 40 years (Figure 4 left). For the 25Yr Phase-In, the rate of burn is cut almost in half from 60,000 acres per year to 30,000 per year (Figure 4 right).

If forests are thinned heavily from below to remove ladder fuels, and understory re-growth is periodically burned or otherwise removed, stands are more likely to grow into sustainable savanna conditions. These stands would be characterized by sparse densities of large overstory conifers with high crown bulk density and thick bark that is resistant to fire damage (Everett, 2005).

Average values, presented for review in this paper, are offered for relative comparisons of landscape trends and treatment performance. Actual planning for comprehensive landscape-level hazard reduction analysis would logically include a mix of customized treatment intensities sensitive to site specific stand conditions and public values at risk.

High Hazard Acres	
Immediate Treatment Schedule	25 Year Phase-In Treatment Schedule

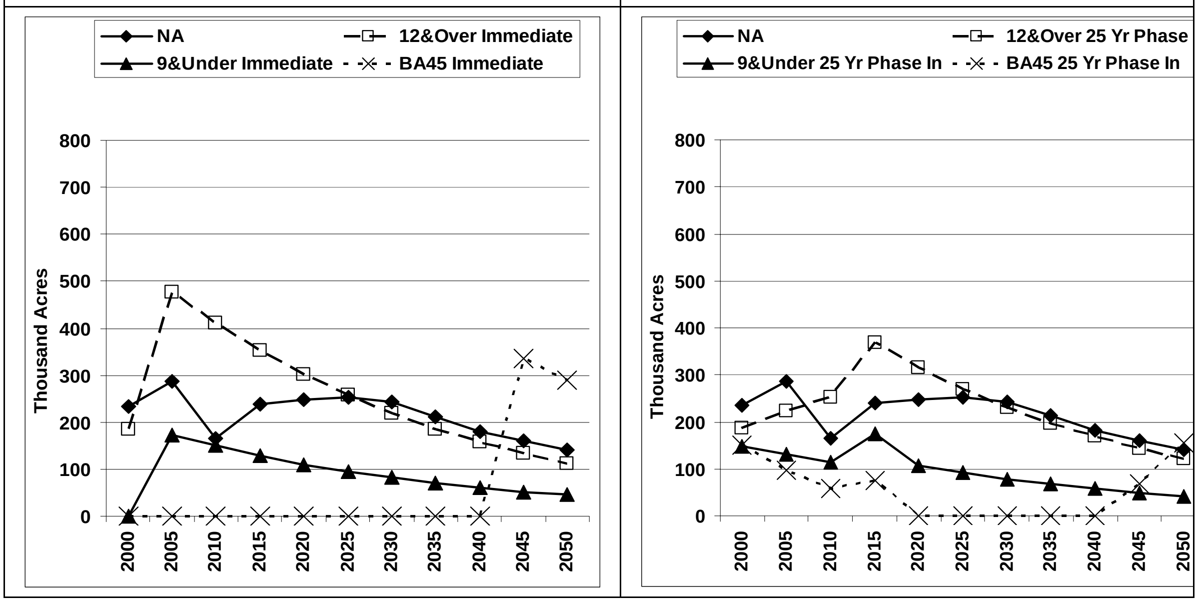


Figure 2. High hazard acres in each 5 year period by landscape scenario.

Low Hazard Acres	
Immediate Treatment Schedule	25 Year Phase-In Treatment Schedule

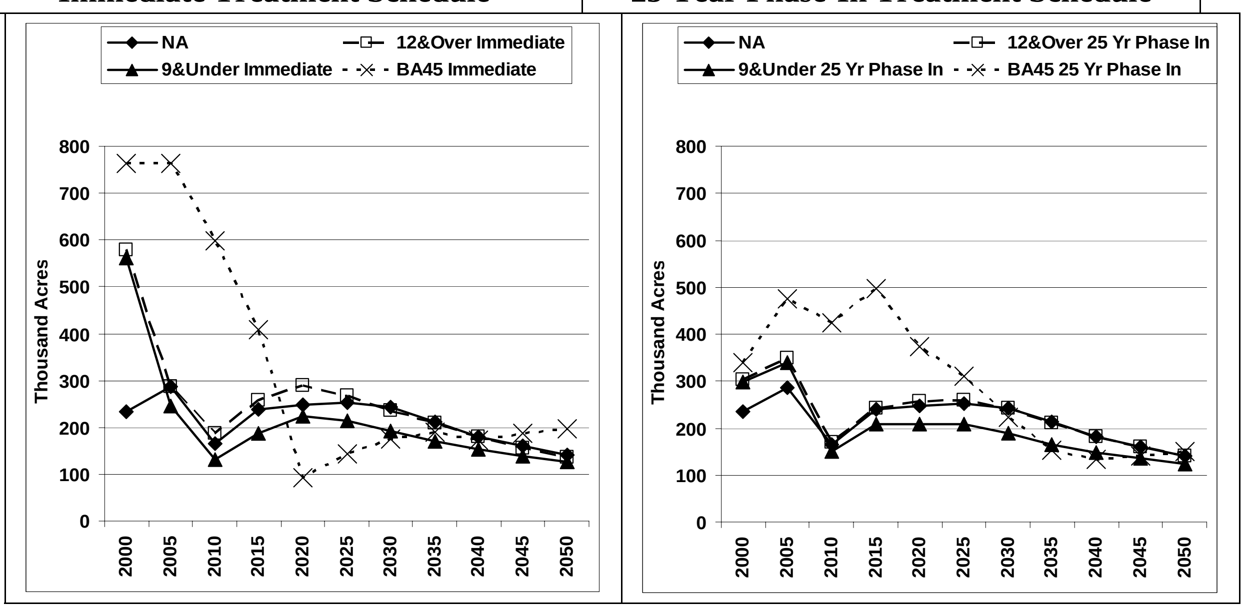


Figure 3. Low hazard acres in each 5 year period by landscape scenario.

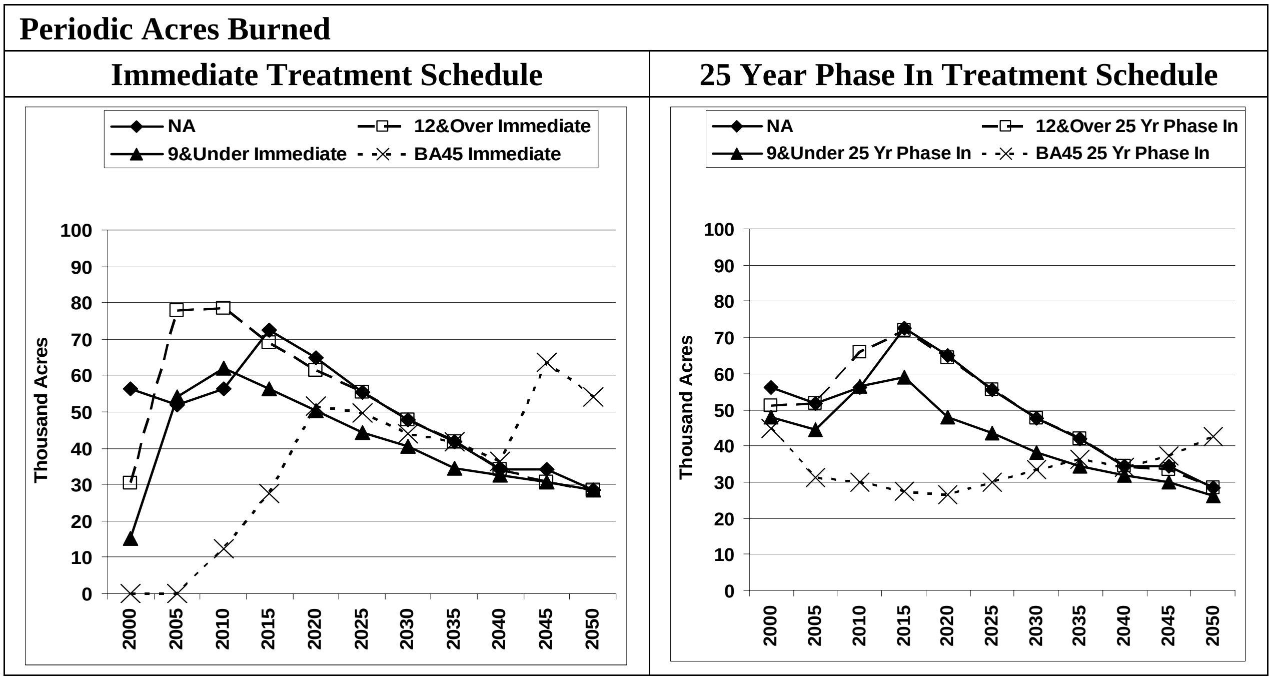


Figure 4. Acres burned in each 5 year period by landscape scenario.

Carbon

Carbon estimates were developed for management alternatives to include forest carbon, products carbon net of emissions from energy, and the carbon displaced by use of wood building products instead of more polluting building product alternatives (Lippke et al 2004). For the No Action simulation, Figure 5 shows increasing carbon stored in the standing forest biomass until 2015 and, coincident with increased fires, decreasing carbon during the latter time periods (2015 – 2050) with nearly 5 million metric tons of carbon released into the atmosphere during the analysis period due to forest fire events. As a benchmark for comparison that is approximately equivalent to the annual carbon emissions from 2.5 million sport utility vehicles (Environmental Protection Agency 2006).

All treatment scenarios remove carbon from the forest, resulting in lower mean carbon in the forest during the early periods (2000 – 2020). However, the BA45 and 9&Under scenarios resulted in more carbon in the forest by 2050 as a result of reduced fire hazard. When the carbon stored in products and avoided emissions are included all treatment scenarios result in less total carbon released to the atmosphere than the No Action scenario (Figure 6). The No Action scenario results in higher burn rates than any of the other treatment scenarios essentially capping the potential for carbon storage in the forest well below that which might be anticipated in the absence of high fire hazard. Wildfire simulations in untreated stands increase carbon emissions relative to treatments that capture more of that carbon in products and fossil fuel use through substitution and displacement channels.

In comparing the treatment scenarios, it is apparent that while the 12&Over treatment moves larger volumes of carbon into long-lived products quickly, it does not reduce fires as effectively as the BA45 treatment. Over the total period BA45 stores about 6.5 million metric tons more than NA while the 12&Over treatment results in 8.5 million metric tons more. Since carbon stored increases with time with fewer fires, BA45 stores 12 million metric tons more carbon than NA by the end of the period.

When comparing treatments to NA in percentage terms the increase in the mean total carbon storage is substantial (26% during the total analysis period, 38% during the later period between 2025 and 2050, and more than 50% by the end of the 50 year period). Figure 6 demonstrates that the high carbon in forest biomass associated with the NA alternative cannot continue to increase. Over time the High and Moderate hazard classes (highest biomass and carbon stores) will experience forest fires with subsequent carbon releases.

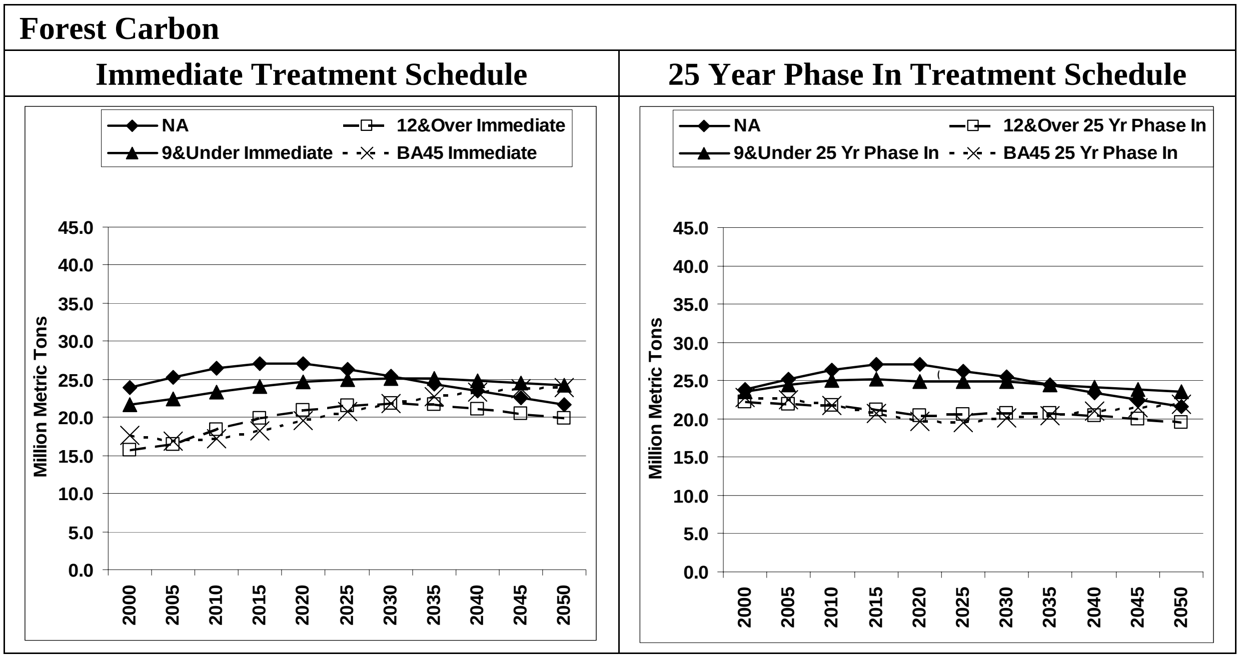


Figure 5. Forest carbon over time by landscape scenario.

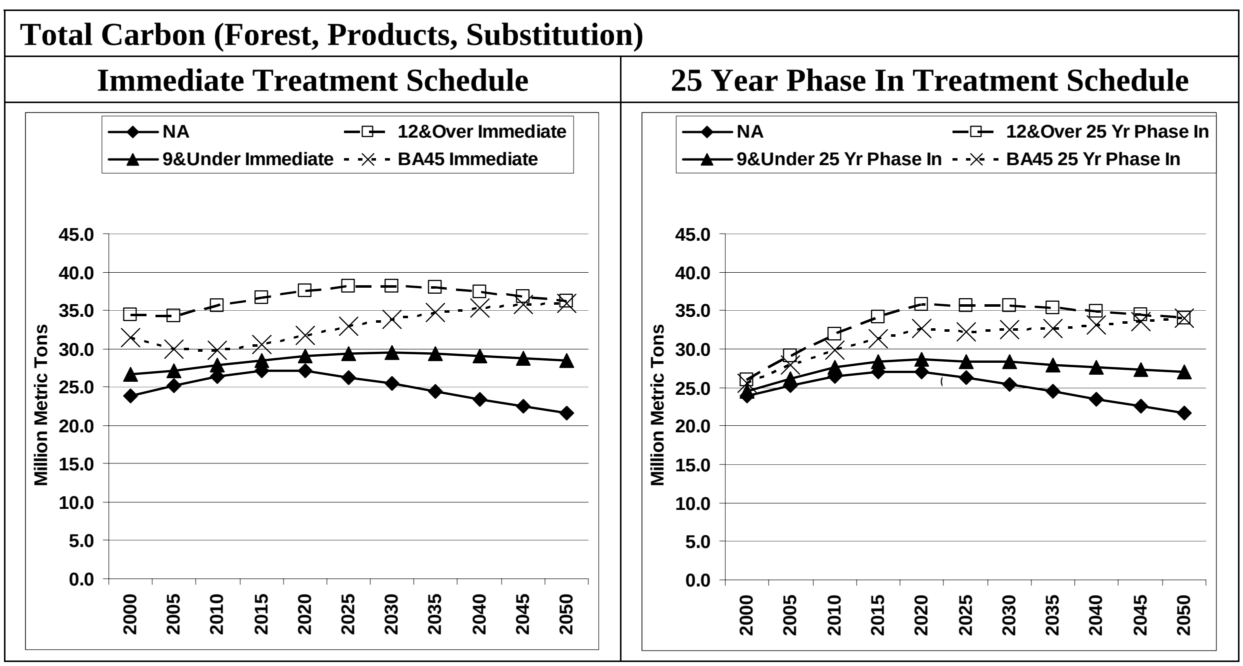


Figure 6. Total carbon (forest, products, substitution) over time by landscape scenario.

The CORRIM analysis on life cycle inventories and assessment (LCI/LCA) for all stages of processing highlights the significance of using life cycle information to better understand where and how carbon is stored (Bowyer et al 2004). These dynamic fire simulations demonstrate the significance of treatments and their timing on fire and consequently on the more complete assessment of carbon pools.

Economics

An analysis of the economic trade-offs between scenarios is summarized in (Table 1). The simulations show that failure to reduce fuel loads (NA scenario) results in a public cost exposure for fire suppression activities through the simulation period of approximately $237 million (net present value) due to estimated recurring fire fighting cost liabilities. Warming weather conditions may elevate hazards and increase wildfire cost exposures further.

Analysis of harvest returns net of fuels treatment costs, as mentioned above, indicates that treatment alternatives will result in net negative or positive revenue depending upon the amount and value of merchantable logs removed in the treatment simulation. The composite economic analyses for the treatment scenarios presented here examined the interaction between reducing firefighting costs by lowering hazard classification and incurring additional treatment costs or generating revenue from log and slash removals. The 12&Over scenarios (Immediate and 25 Yr Phase-In) resulted in the only Total Value positive returns, due to the high value of wood removed. However, the 12&Over treatments were least successful at fire hazard reduction and resulted in the most acres burned. Log revenues removed early in the period were of sufficient magnitude to absorb high fire fighting costs.

Table 1: Summary impacts from 25 Yr Phase-In Treatments

25 Yr Phase-In Treatments:		NA (fire)	9 & Under	12 & Over	BA45
Carbon	Mil. Tonnes	24.9	27.4	33.4	31.4
Burn	000;s acres	544	460	546	374
Fire Cost	$ mils NPV	237	202	237	147
Harvest $	$ mils NPV	0	-100	457	20
Total Value	$ NPV	-237	-302	220	-127

The 9&Under scenarios (Immediate and 25 Yr Phase-In) result in negative treatment values and provide only marginal fire hazard reduction. While the net present value of firefighting costs is reduced compared to NA, the 9&Under scenarios produce the largest overall public cost after treatment expenditures are included ($302 million).

The BA45 scenarios (Immediate and 25 Yr Phase-In) produce marginal but positive average thinning treatment returns of $61/acre. Therefore, differences from NA are almost entirely caused by the reduced fire hazard and subsequent firefighting costs. The BA45 scenarios resulted in significant reduction of net present public cost exposure as compared to NA: nearly $183 million less for BA45 Immediate, and $110 million less for BA45 25 Yr Phase-In. Note that, while the BA45 scenarios appear most successful in achieving the range of management objectives considered, the BA45 scenarios still result in costs greater than revenue. However, the difference between the magnitude of the positive return generated by the 12&Over Immediate (in spite of higher fire fighting expenses) and the BA45 Immediate may indicate that a slight modification in this treatment prescription to increase merchantable timber removals could provide a cost neutral hazard reduction option while still maximizing carbon storage and restoring large diameter fire resistant savannah-like forest conditions as the objective. As with other management objectives, the cost of delaying treatments can be quantified, as total savings are reduced by nearly 40% for BA45 25 Yr Phase-In as compared to the BA45 Immediate treatments.

It is noteworthy that Washington Department of Natural Resources fire suppression costs are approximately $2000 per acre or roughly twice as high as Forest Service costs thereby comparatively increasing the public benefit of hazard reduction treatments on state and private forests (WADNR 2004). If, in addition to fire fighting costs, other avoided costs such as fatalities, facility losses, and regeneration costs are included, the treatment schedule with the least number of acres burned will provide the most favorable economic result

(Mason et al 2006). Emerging carbon markets (credits) could also contribute value to offset fuels removal treatment costs.

Conclusions

The intensity of fuel reduction thinning treatments and their timing are important factors in landscape fire hazard reduction. The No Action alternative results in more acres burned, higher future costs, and less total carbon stored. Phased-in treatment schedules were only able to reduce the acres burned by half. Benefits from thinning may also be relatively short-lived as re-growth results in increased hazard within about 25 years. Periodic re-entries for fuels removals will be required to keep the fire hazard contained.

The accounting required to accurately assess comparative carbon emissions reductions for fire hazard treatments in Inland West forests was demonstrated. In the long-term, maximizing carbon storage in the standing forest biomass will likely be most successfully achieved by the reduction of fire hazard and the number of acres burned. Simulations also demonstrate that while fire reduction treatments remove carbon from the forests, much of the forest carbon removed remains stored in long-lived products while displacing fossil intensive products. When total carbon accounting is considered, the NA scenario results in significantly greater carbon emissions to the atmosphere than all treatment scenarios.

The ability to use emerging forestry modeling capabilities such as FVS and FFE to predict forest vegetation growth, treatment impacts, and relative fire hazard, with any of the tree list analyses modules developed for LMS, such as carbon accounting, provides many advantages. Modeling of forest landscape conditions over time with FVS and LMS creates consistency between multiple modeling and planning scales. In addition to large landscape analysis, FVS and LMS also are designed to support site-specific, individual stand management operational planning. Forest attribute analysis can be customized for local conditions and extended to consider the treatment-associated impacts on stand structure, habitats, forest health, and other public values.

Key points based on ONF simulations:

- No Action results in high fire hazard stands that are not sustainable and can be expected to burn; effectively limiting future growth in standing inventory
    - Fire history shows a low percentage of acres unburned (0-20% refugia)
    - Fire suppression has reduced fires but contributed to overly dense at-risk conditions
    - Fires release about 10 tonnes of carbon per acre
- BA45 fire hazard treatment with 25 Year Phase-In reduces acres burned by 30+%
    - stores 8.5 tonnes per acre more carbon
    - stores 50% more carbon by the end of period (44 vs. 29 tonnes per acre)
- Avoiding the future costs of fire and other non-market values can justify investments in fuel reduction treatments (fire fighting costs of $1000/acre federal or $2000/acre WADNR, restoration costs, facility losses, fatalities, water, smoke, habitat losses, and other non-market values).
    - BA45 on 25 Year Phase-In was $145 per acre less costly than No Action when the present value of avoided future fire fighting costs is considered.
- Without periodic fuels removals post-treatment fire hazard will return in 25-40 years.

References

Agee, J.K. 1993. Fire ecology of Pacific Northwest forests. WA. D.C.: Island Press. 493 p.

Bowyer, J., D. Briggs, B. Lippke, J. Perez-Garcia, J. Wilson. 2004. Life Cycle Environmental Performance of Renewable Materials in Context of Residential Building Construction: Phase I

Research Report. Consortium for Research on Renewable Industrial Materials CORRIM Inc. Seattle WA. 60pp +15 chapter modules of approximately 1000pp. www.corrim.org/reports.

Camp, A., C. Oliver, P. Hessburg, and R. Everett. 1996. Predicting late-successional fire refugia pre-dating European settlement in the Wenatchee Mountains. Forest Ecology and Management 95 (1997): 63-77.

CORRIM. 2004. Phase 1I Research Proposal. http://www.corrim.org/reports/2005/phase_2/index.asp

Crookston, N.L., S.J. Beukema, and C. E. Robinson. 2002. User's guide in the fire and fuels extension to forest vegetation simulator: Chapter 3. (RMRS-GTR-000). Ogden, UT: USDA Forest Service, Rocky Mountain Research Station.

Dixon, G. E. comp. 2003. *Essential FVS: A User's Guide to the Forest Vegetation Simulator.* Internal Rep. Fort Collins, CO: U. S. Dept. of Agriculture, Forest Service, Forest Management Service Center. 193p.

Environmental Protection Agency. 2006. How Clean is the Energy That I Use? Power Profiler. http://www.epa.gov/cleanrgy/powerprofiler.htm (Note: C = 27% of CO_2 by weight).

Everett, R. 2005. Eastside Forests Project Update. Rural Technology Initiative Annual Technical Review Streaming Video. http://www.ruraltech.org/video/2005/annual_review/08_everett/fdeflt.htm

Graham, R.T., A.E. Harvey, T.B. Jain, J.R. Tonn. 1999. The effects of thinning and similar stands treatments on fire behavior in western forests. Gen. Tech. Rep. PNW-GTR-463. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 27 p.

Hardy, C. 2005. Wildland fire hazard and risk: Problems, definitions, and context. Forest ecology and management 211 (2005): 73-82.

Kalabokidis, K.D., P.N. Omi. 1998. Reduction of fire hazard through thinning/residue disposal in the urban interface. International Journal of Wildland Fire 8: 29-35.

Keyes, C.R., K.L. O'Hara. 2002. Quantifying stand targets for silvicultural prevention of crown fires. Western Journal of Applied Forestry 17: 101-109.

Lippke, B., J. Wilson. J. Bowyer, J. Perez-Garcia, J. Bowyer, J. Meil, 2004. CORRIM: Life Cycle Environmental Performance of Renewable Building Materials. *Forest Products Journal*. June 2004. Vol. 54, No. 6 page 17.

Lippke, B., J. Comnick, L. Mason. 2006. Alternative Landscape Fuel Removal Scenarios: Impacts of Treatment Thinning Intensity and Implementation Schedules on Fire, Fire Hazard Reduction Effectiveness, Carbon Storage, and Economics.

Mason, L., K. Ceder, H. Rogers, T. Bloxton, J. Comnick, B.Lippke, J. McCarter, K. Zobrist. 2003. Investigation of Alternative Strategies for Design, Layout and Administration of Fuel Removal Projects. Rural Technology Initiative, College of Forest Resources, University of Washington. Seattle. 78pp plus appendices.

Mason, Larry, B. Lippke, K. Zobrist, T. Bloxton, K. Ceder, J. Comnick, J. McCarter, H. Rogers. 2006. Investment in Fuel Removals to Avoid Fires Result n Substantial Benefits. Journal of Forestry, Jan/Feb. 06, 104,1: p 27-31.

McCarter J., J. Wilson, P. Baker, J. Moffett, and C. Oliver. 1998. Landscape management through integration of existing tools and emerging technologies. *Journal of Forestry* 96: pp.17-23.

Olson, D. 2000. Fire in riparian zones: a comparison of historical fire occurrence in riparian and upslope forests in the Blue Mountains and southern Cascades of Oregon. Seattle, WA: University of Washington 274p. M.S. thesis.

Omni, P.N., & E.J. Martinson. 2002. Effect of fuels treatment on wildfire severity. Joint Fire Sciences Program Report. http://www.warnercnr.colostate.edu/frws/research/westfire/FinalReport.pdf

Peterson, D.L., M.C. Johnson, D. McKenzie, J.K. Agee, T.B. Jain, E.D. Reinhardt. 2005. Forest structure and fire hazard in dry forests of the western United States. Gen. Tech. Rep. GTR-PNW-628. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 30 p.

Perez-Garcia, J., B. Lippke, J. Comnick, and C. Manriquez. 2005. An Assessment of Carbon Pools, Storage, and Wood Products Market Substitution Using Life-Cycle Analysis Results. Wood Fiber Sci. 37 Dec. 2005: p140-148

Pollet, J., P.N. Omi. 2002. Effect of thinning and prescribed burning on crown fire severity in ponderosa pine forests. International Journal of Wildland Fire 11: 1-10.

Reinhardt, E. and N.L. Crookston. (Technical Editors) 2003. The Fire and Fuels Extension to the Forest Vegetation Simulator. Gen. Tech. Rep. RMRS-GTR-116. Ogden, UT: U.S. Dept. of Agriculture. Forest Service. Rocky Mountain Research Station. 209p.

Sandberg, D.V., R.D. Ottmar, G.H. Cushon. 2001. Characterizing fuels in the 21st century. International Journal of Wildland Fire 10: 381-387.

WADNR. 2004. A Desirable Forest Health Program For Washington's Forests: Forest Health Strategy Work Group Report. Washington Dept. of Natural Resources. Dec. 2004.

Implications of Eastern Washington Mortality and Climate Change Trends on Timber Supply

Introduction

Eastern Washington forests are undergoing substantial changes as a result of disturbance agents, including fire and insect outbreaks, which are thought to be acting outside their historic range of variability, particularly for low and mid elevation forests. Of all the affected tree species, insect epidemics in lodgepole and ponderosa pine are creating the highest rates of mortality across the largest number of acres. Because of the magnitude of changes that eastern Washington pine forests are experiencing, specific analysis of forest health trends for these two species were targeted for more detailed study. It appears that climate change is an important contributing factor. We provide a brief summary of ongoing research on the nature of the problem and its implications for long term timber supply.

Mountain Pine Beetle Impacts

Data from the Washington State Department of Natural Resources (DNR) insect and disease aerial survey over eastern Washington are collected by DNR and maintained at the USFS Forest Health Protection branch. Digital maps containing location detail and information on the type, intensity, and extent of forest damage were downloaded from the Forest Health Protection site at http://www.fs.fed.us/r6/nr/fid/as/index.shtml for the years of 1980 to 2005. The data were imported into an ARCGIS 9.0 database and queried to identify all polygons where MPB had attacked either ponderosa pine (PP) or lodgepole pine (LPP) over the 26 year period across all forested land in eastern Washington. Aerial survey data for assessing MPB impact captures predominantly 'red attack', which is the point when the tree's needles turn red in the year following successful MPB attack. Thus the aerial survey estimate of attack in the 1980 aerial survey actually reports the mortality that occurred in 1979 because the survey methodology can only positively identify trees that have been killed the year prior to the aerial survey itself. By adjusting aerial survey data for this time lag, we explored relationships between MPB attack, forest attributes and climate data to elucidate likely causes for elevated mortality levels in low and mid elevation pine species. **Figure 1** shows the per acre tree mortality of ponderosa pine (PP) and lodgepole pine (LPP) for the affected acres across all eastern Washington increasing from 2.2 for 1979-1999 to 8.4 for 2000-2004. Total mortality is increasing even faster as more acres are being affected each year. The mortality increase in 2004 alone shows MPB affected over 415,000 acres resulting in over 4 million dead pine trees in eastern Washington (red attack observed in 2005) out of a total of 7.3 million trees killed by all insects, disease, animals, and weather damage across the entire state.

Aerial data for this most recent 25 year period indicate that approximately 80% of the pine mortality has occurred since the forest inventory on eastside forests was completed in the early to mid 1990's under either the Forest Inventory and Analysis (FIA) or the Current Vegetation Survey (CVS) program. Inventory updates using the modified plot parameters and annual re-survey methods have not captured sufficient data to account for the level and extent of mortality in the ensuing years. In particular, the increase in mortality rates since 2000 has not been captured with ground inventory methods. It is estimated that the mortality in lodgepole occurring on state and private forests since 2000 is 72% of total mortality for the 25 year period. In the same five years, national forests have experienced 70% of their total lodgepole mortality.

In order to determine if an historical analogue exists for the level and extent of mortality observed in the past five years, a review of available insect and disease surveys was completed for eastern Washington. That review suggests that lodgepole and ponderosa pine mortality from mountain pine beetle has historically been less than 50,000 acres of infestation per year for as far back as aerial survey records are available (Figure 2). Ground survey data from an earlier era (1928-1937) suggest that early 20th century mountain pine beetle outbreaks in eastern Washington killed approximately 1$^{\%}$/year of the standing inventory in the affected areas. The disparity between historical outbreak conditions and the current situation suggest that there is no historical analogue to the current outbreak in either mortality rate or acres affected.

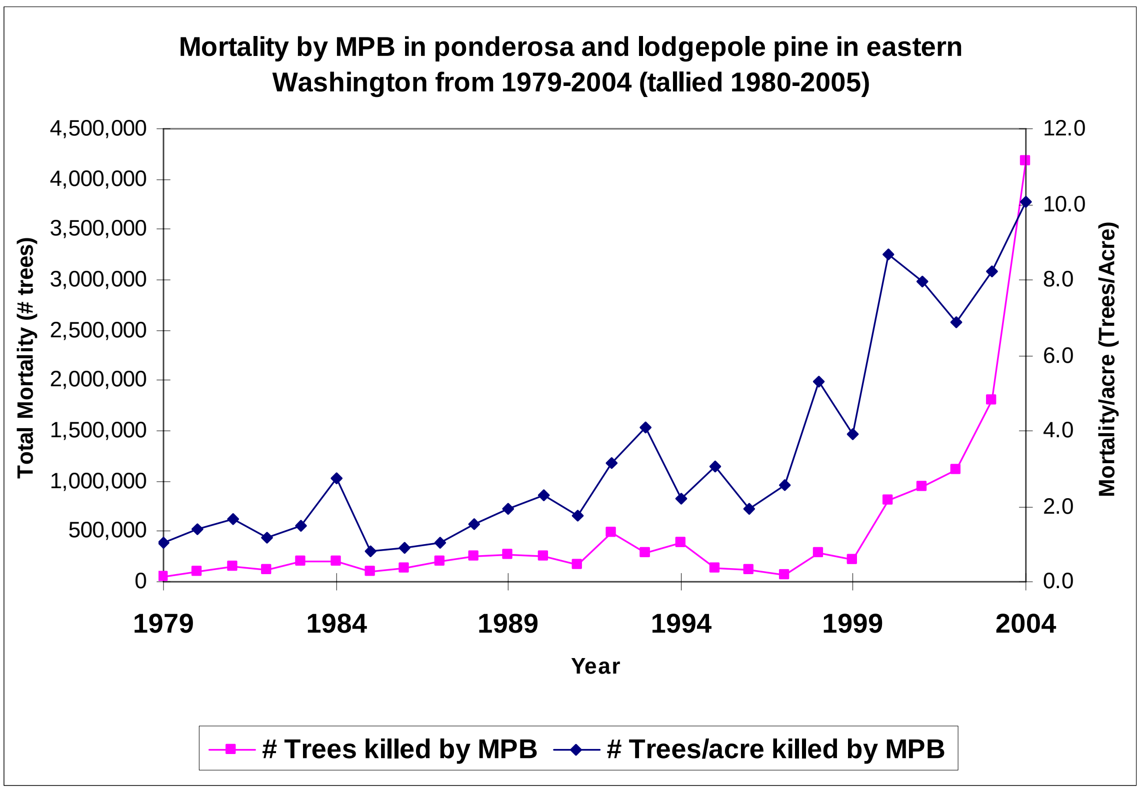


Figure 1: Time series of mortality from MPB in eastern Washington by reporting period.

Linking the Outbreak to Climate Trends

The lack of an historical analogue to the current outbreak suggests that we must rely on knowledge of forest dynamics to predict the likely short and long term consequences of the current outbreak. In the search for probable causes for the spike in mortality and acres hit by MPB, we examined climate trends in both the recent past and as far back as records exist. Using data from the Western Regional Climate Center (http://www.wrcc.dri.edu) average monthly values for temperature and precipitation were determined for the East Cascades (06) and NE Washington climate divisions (09) for the entire period of record (1895-2006) and the subset of records for the 1979-1999 period corresponding to the era of more or less endemic MPB activity reported in the aerial survey, and the 2000-2004 period where MPB mortality is escalating. These data indicate that there is an increase in temperature of 0.4-1.0 degree F in NE Washington and 1.9-2.8 degrees F in the East Cascade region for the June through August period of 2000-2004 relative to the same months of 1979-1999. The substantial increase in summer temperature in the East Cascade region is highly correlated with extensive MPB mortality in the region. A similar jump in average summer temperatures in the early 1980's is correlated with extensive MPB mortality in ponderosa pine forests in NE Washington and the lower foothills of the east Cascades. A five year running average of temperature for these three months was calculated for the entire historical record as shown in Figure 2 with an overlay of pine mortality data for the era where records are available and comparable to the modern record. From Figure 2, it appears that both the increased summer temperatures and the extent of mortality have no historical analogue in the long term record.

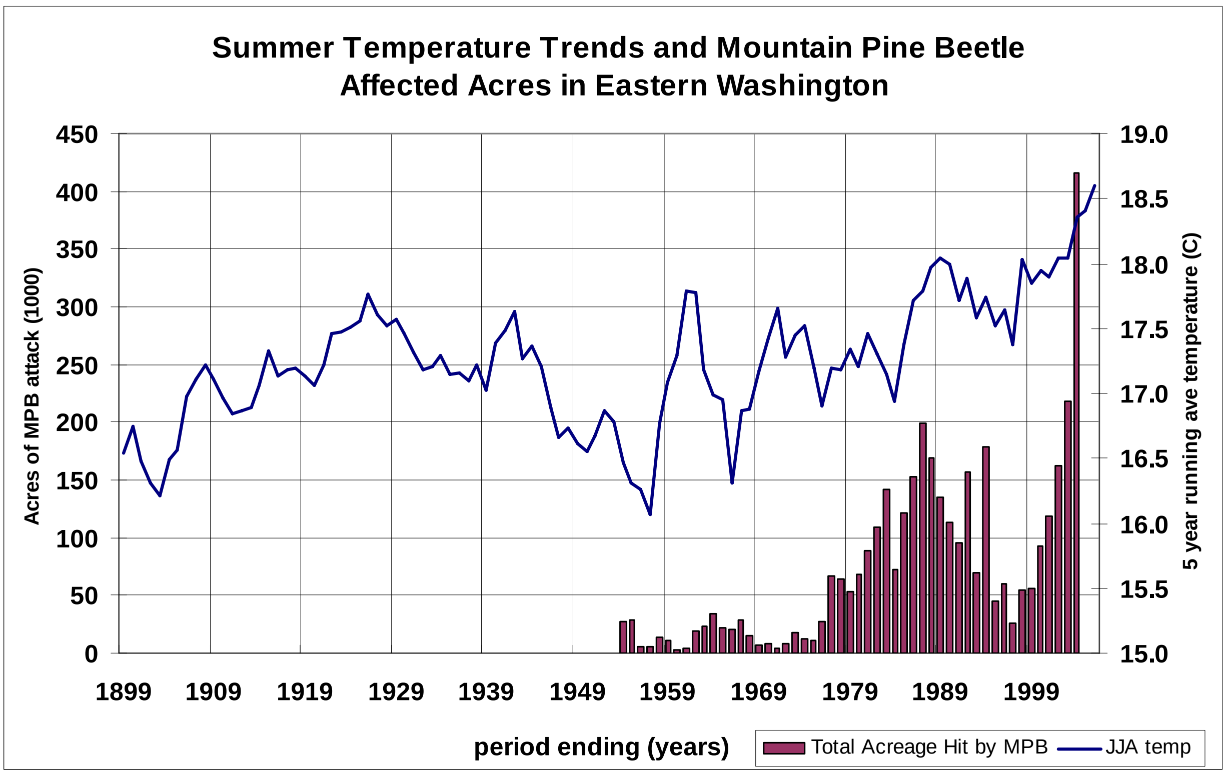


Figure 2: Temperature trends and MPB activity in eastern Washington on PP and LLP forests.

Knowledge of tree physiology suggests that the pine mortality we are witnessing presages an increase in overall mortality impacts that we can expect if temperature trends continue on their current trajectory. Pine's role as 'canary in the coal mine' arises because they are more sensitive than other tree species to shifts in environmental dryness as measured by vapor pressure deficit (VPD) (Delucia et al 2000) which increases exponentially relative to temperature increases (Waring and Running 1998). Pines also tolerate fewer years of stress than more shade tolerant species before succumbing to mortality (Keane et al, 1996). And finally, the average VPD for the growing season months of June, July and August has reached a threshold value at which most tree species begin to exponentially decrease their stomatal conductance and shut down respiration to maintain water status (Waring and Schlesinger 1985). This shut down mechanism poses a significant risk for pines as it coincides with the time period when MPB activity is at its height and the pitching response is required for effective physiological defense.

The dramatic increase in pine mortality we are seeing at the present is concentrated in mid elevation forests dominated by lodgepole pine whereas the MPB outbreak ending in 1988 was largely in low elevation ponderosa pine on state, tribal, and private forests. In both cases the historical record indicates that the outbreaks are correlated to a substantial increase in average summer temperature as well as a large drop in pre-growing season precipitation (**Figure 3**). While it is not yet clear why the shift in the 1980's affected primarily low elevation forests and the current shift in temperature and precipitation are affecting mid and high elevation forests, the trends suggest that stress thresholds related to temperature, vapor pressure deficit, and soil moisture deficits may be breached at different times across the range of elevation bands where pine grows. An understanding of the exact physiological and stand level mechanisms involved has been identified as a research need emerging from the timber supply analysis. What is clear is that these increases in temperature do create conditions that place the Eastside outside the range of historical experience with respect to what we can anticipate in mortality trends and probably for growth of pine species in particular. In comparing the current epidemic with that of the 1980's, the similarities in response to climate-induced stress suggest that it may be only a matter of time before the epidemic spreads to susceptible ponderosa pine stands on state and private lands.

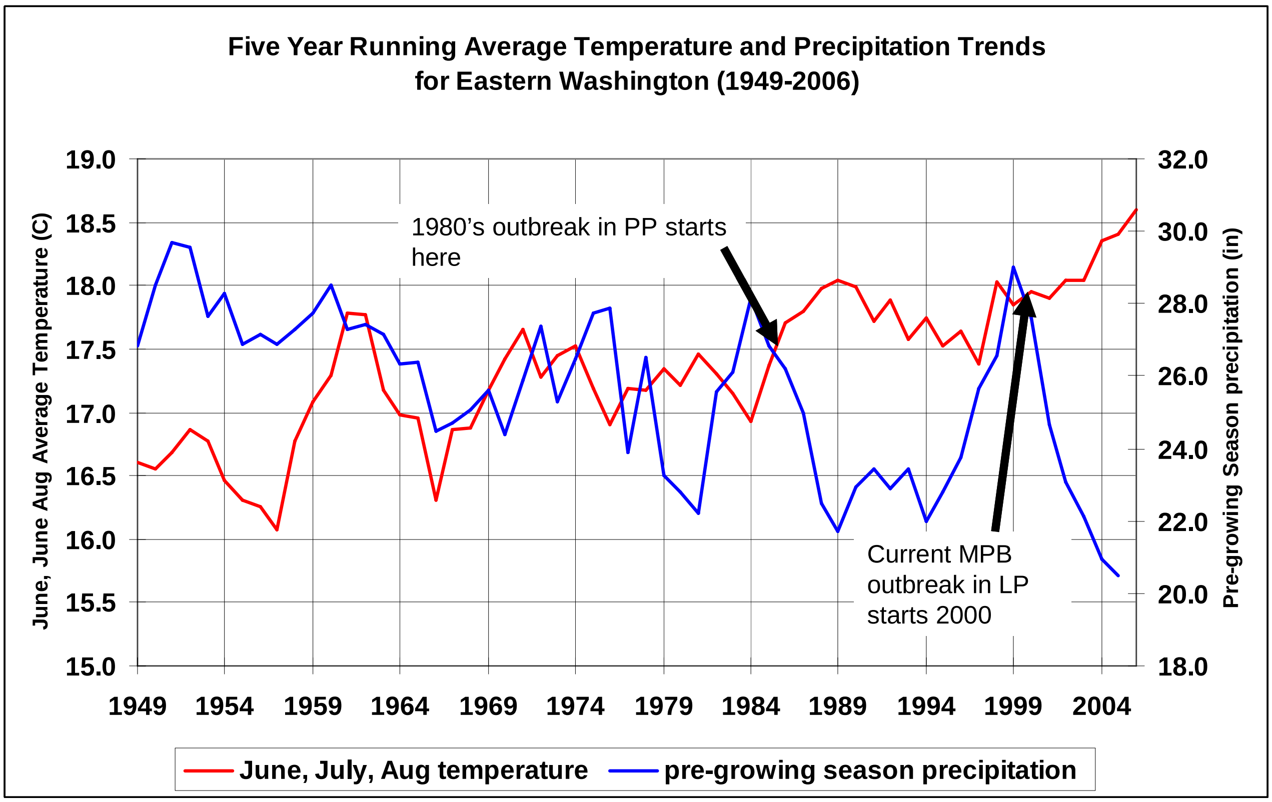


Figure 3: Temperature and Precipitation Trends for eastern Washington

Potential Timber Supply Impacts

This synthesis of elements of tree physiology, temperature and moisture trends, and MPB outbreak conditions suggests that we may be facing the loss of a substantial component of our pine inventory in eastern Washington. As pine forest types are approximately 33% of total inventory (9% lodgepole, 24% ponderosa - **Figure 4**) and pine is found in six other major forest types (Table 1) covering 80% of state and private forest lands in eastern Washington, there is cause for grave concern regarding the potential impacts of this epidemic as it increases its presence on non-federal lands. From 1991, when the most definitive FIA inventory was completed for state and private forest lands in eastern Washington, to 2004, we have lost the equivalent of 3.1 years of average eastside DNR harvest volumes to MPB in lodgepole pine. Fully 23% of lodgepole pine removals on state and private lands since 1991 are attributable to MPB losses, with 15.3% of it (2/3rd) occurring in 2003 and 2004 alone. As has been demonstrated in central British Columbia (Carroll et al 2003), once a MPB epidemic of this magnitude gets established, the MPB population dynamics, which are also enhanced by increasing temperatures, become a driving force that impacts even the healthiest and most resilient forests on the landscape. The synergistic impact of climate-induced tree stress compounds the likelihood of broad scale impacts in all forests, though we do not yet know to what extent.

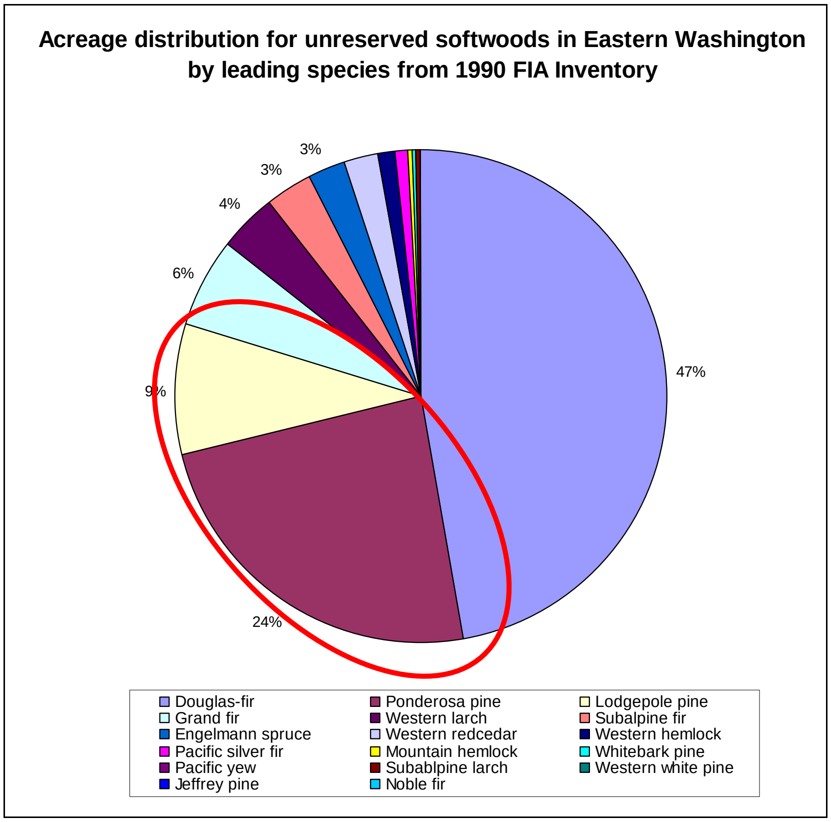


Figure 4: Pine forest types of eastern Washington

Forest Type	Acres with Pine
Ponderosa	1,697,395
Douglas-fir	1,025,719
Lodgepole	287,857
Grand fir	103,140
Larch	70,234
Spruce	41,216
Cedar	18,887
Hardwood types	53,720
All Forest Types	3,298,169

Table 1: Acres by forest type containing a pine component on non-Federal lands in eastern Washington

Mortality data in ponderosa pine extending from 1991 to 2004 combined with harvest data to 2002 and harvest estimates to 2004 indicate that approximately 2.5% of inventory removals are attributable to mortality from MPB (Table 2) and account for a volume loss equivalent to 80% of a single year's harvest off DNR eastside forests.

	Thousand BF	
	lodgepole	ponderosa
1991 Pine Inventory	4,660,725	12,821,899
Pine Harvest 91-02	647,431	1,969,811
MPB mortality 91-04	230,392	61,027
03-04 Estimated harvest/yr	60,089	182,222
2004 Inventory (100% salvage)	4,706,245	13,960,637
% change	1.0%	8.9%
2004 Inventory (No salvage)	4,478,992	13,892,990
% change	-3.9%	8.4%
Removals to harvest	16.5%	18.2%
Removals to MPB	4.9%	0.5%
Total Removals	21.4%	18.7%
% removals attributable to mortality	23.1%	2.5%
mortality as % of yearly DNR harvest	306.5%	81.2%
DNR average harvest rate 91-02 all species	75,159	
# years of DNR harvest lost to MPB	3.1	0.8

Table 2: Inventory, growth, removals, and mortality in pines on non-Federal land in eastern Washington

While the focus of this discussion has been on pine species as the 'canary in the coal mine', climate trends are creating the same gradient of environmental stress for other tree species and forest types as for pines. According to DNR aerial survey data http://www.dnr.wa.gov/htdocs/rp/forhealth/2005highlights/, mortality impacts are not currently as substantial for Douglas-fir as they are for the pines, but there have been 1.5 million acres of spruce budworm attacks since 1999 and Douglas-fir bark beetle has impacted over 500,000 acres in the same time period. More research is required to elucidate the likely impact of climate trends on near and mid term sustainability of Douglas-fir forests, particularly as the elevated mortality trends we are experiencing in pine species combined with insect and disease outbreaks in Douglas-fir would affect 80% of our forest types in eastern Washington.

The recent combination of record breaking temperature and vapor pressure deficit increases combined with near record breaking precipitation shortfalls (0.3 inches off the record breaking low for the 5 year average ending in 1926) has not been witnessed in the historical record. If, as anticipated by global circulation models, these climate variables remain outside of their historic range, we can expect to see a plethora of forest health problems as trees, stands, and entire ecosystems respond to a changing climatic regime. It is likely that stands will continue to experience elevated mortality levels for at least the next few decades as they adapt physiologically to ensure survival and respond as communities to new thresholds in stand carrying capacity.

In the face of such dramatic changes, applying treatments to move stands toward an historical disturbance regime by targeting historical stocking levels, size classes, ages, species mixes, or stand densities may no longer be the best prescription for sustainability. Restoration of a fire resistant pine overstory, which has been considered the desired forest condition for federal lands, may not be possible. It will be necessary to take what we have learned about natural disturbance, climate, tree adaptations to disturbance, and physiology and apply that knowledge in a new framework that explicitly identifies climate as a driving variable in determining better approaches to sustainability of not just timber supply, but also the forested ecosystems of eastern Washington as a whole. The new science that will be required to address these challenges will demand that we integrate climate into current predictive models and link these models across the entire scale from tree to landscape. While the research need is beyond an evaluation of timber supply in eastern Washington, it does indicate areas where yield predictions may falter in capturing a reasonable estimate of future supplies of timber and ecosystem services.

References

Carroll, A. L., S. W. Taylor, et al. (2003). Effects of Climate Change on Range Expansion by the Mountain Pine Beetle in British Columbia. Mountain Pine Beetle Symposium: Challenges and Solutions. J. B. TL Shore, and JE Stone. Kelowna, BC, Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre. Information Report BC-X-399: 298 p.

DeLucia, E. H., H. Maherali, et al. (2000). "Climate-driven changes in biomass allocation in pines." Global Change Biology 6(5): 587-593.

Keane, RE, P Morgan and SW Running, 1996, FIRE-BGC, Res Pap INT-RP-484, USDA FS, RMRS, Ogden, UT, 122 pp.

Waring, R. H. and W. H. Schlesinger (1985). Forest Ecosystems: Concepts and Management. Orlando, FL, Academic Press

Waring, R. H. and S. W. Running (1998). Forest Ecosystems: Analysis at Multiple Scales, San Diego, CA, Academic Press

Bio-Energy Development: Many Questions Remain Unanswered Significant Contributions Could Benefit Washington Rural Economies, Forest Health, and Energy Objectives

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 identified “Clean Energy” as one of its five most important global policy imperatives. The U.S. State Department followed with implementation of the Clean Energy Initiative. Current U.S. energy policy includes legislated incentives and tax credits for renewable energy development. Twenty-two states have adopted Renewable Portfolio Standards that require increases in renewable energy. In November 2006, Washington citizens will vote on Initiative 937. If passed, I-937 will create a Washington Renewable Energy Standard that will require public electric utilities with at least 25,000 customers to obtain 15 percent of electricity from new renewable resources by 2020. It is important to note that the Standard establishes that, “with limited exceptions,” use of fresh water for energy production is not considered renewable.

While hydroelectricity is inexpensive and reliable, most potential sites have already been developed and concerns about fish habitats and water supplies likely preclude any significant expansion of this power source. With no expansion of hydropower expected, energy analysts look to wind, geothermal, solar, and biomass as sources of renewable energy with potential for expanded exploitation. Unlike the massive centralized energy projects of the past, such as large dams and fossil fuel generators, development of renewable energies will likely be smaller in scale and distributed. If fossil fuel reliance is to be substantively reduced in future decades, many types and sizes of renewable energy projects will be needed. Different locations will logically have different energy and resource potentials. Along the Columbia River, there are many developed and significant wind energy sites; in the agricultural areas of eastern Washington, crop residues can be utilized as energy feedstocks; and from the 16 million acres of unreserved Washington forests, woody biomass is an abundant resource that could be used as fuel for a variety of energy applications.

Wood biomass is uniquely versatile in that it can be a source of firm electrical power with steam and heat as a valuable byproduct, or it can be used to produce liquid and gaseous fuels to reduce reliance on fossil fuels for transportation applications. Valuable industrial chemicals can be extracted in the process. Residuals from the manufacture of forest products have proven to be a readily available and cost-effective source of biomass feed stocks. Forest management residues, typically burned in piles after timber harvests, represent another large source of woody biomass that is currently underutilized. Forest thinnings, such as fuel load reductions on Eastside dry land forests, can provide woody biomass for renewable energy feedstocks with an added benefit of reducing the risks and costs associated with recent catastrophic forest fires.

In 2003, combined forest and agricultural biomass contributed 2.9 quadrillion British Thermal Units (BTU) to the nation's energy supply, supplying 3 percent of the total U.S. energy consumption. Biomass accounts for 47 percent of U.S. renewable energy consumption and recently passed hydropower as the nation's largest single source of renewable energy. More than 50 percent of total national biomass-derived energy comes from wood residues and pulping liquors created by the forest products industry[1]. However, the Northwest Power and Conservation Council reported in 2005 that declines in wood products and paper industries are jeopardizing opportunities to exploit low-cost bioresidues useful for expansion of regional cogeneration capacity.

As public interest in renewable energy and pollution avoidance increases, it has become apparent that opportunities to utilize wood biomass provide a parallel opportunity to restore forest health and reduce wildfire hazard in overstocked dry forests east of the Cascade Mountains. During the summer of 2006, more than 360,000 acres of mostly federal forest lands burned in eastern Washington. Fire suppression costs were in the hundreds of millions of dollars, 2 million metric tonnes of carbon were released to the atmosphere in smoke plumes, more than 3 billion board feet of timber were burned, and, without aggressive salvage, an opportunity for biomass-to-energy is lost. In spite of dual state and federal policies to remove forest fuel loads and to promote utilization of biomass for energy, implementation remains slow, complicated, and problematic.[2]

Expansion of small-scale distributed power customized for local resource utilization will require power distribution flexibilities never needed in the past. Institutional hurdles include complex wholesale/retail price, performance, and power distribution and reliability arrangements. While renewable power generated from wood could provide a price hedge and risk mitigation benefit to utilities, short-term price differentials serve as an investment disincentive as do the logistical complexities of multiple small-scale generating facilities. Rapid adjustments from centralized to distributed power distribution arrangements pose complicated logistical challenges to transmission grid capabilities, as does the availability of enough wood to justify power grid contracts.

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[1] R. D. Perlack *et al.*, *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply* (U.S. Department of Energy and U.S. Department of Agriculture, April 2005; available at **feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf**).

[2] For scale purposes, consider that one 25 megawatt (MW) combined heat and energy plant, fueled from forest biomass, requires that 10,000-15,000 acres of fuels reductions be treated each year over a 30-year treatment cycle (total dedicated forest area would equal 300,000 to 450,000 acres).

Further, the maze of production tax credits, green tags, renewable energy credits, low-cost loans, carbon credits, and other complicated financing instruments are politically tenuous and confusing for would-be renewable energy developers. Distributed power development in rural communities, located at the extremes of the transmission grid, should reduce line loss (estimated to average 9 percent of national energy production) and maintenance costs, but no power price premiums reflect this public value. The economic development benefits and tax revenues of wood utilization in depressed rural communities are compelling but are not incorporated into electricity rates.

There is broad confusion amongst the public about how to value and credit the many avoided costs, non-market values, environmental services, and other ancillary benefits associated with distributed power generation from wood waste. For example, reduced pollution from less fossil fuel should mean lower health care, climate change, and clean-up costs. Markets for carbon credits can help but are in early stages of development. The economic and strategic benefits of reduced importation of foreign oil are significant and should be measured as a public benefit of domestic renewable energy development. A broader assessment methodology of avoided costs, jeopardized opportunities, economic impacts, and environmental services associated with wood biomass utilization for renewable energy must reasonably be included when environmental impact assessments are required for forest management and other projects.

Opportunities exist for beneficial development of small-scale wood-to-energy projects in the forest communities of Washington but broadly available information is lacking and many questions are unanswered. Institutional and market arrangements confound renewable energy policy objectives. Political concerns about public forest land management may actually be in contradiction to goals of reducing pollution. A thorough and critical investigation of the complex environmental, institutional, political, and financial challenges associated with development of wood-to-energy resources in Washington state is needed.

Estimates of potentially available woody biomass volumes from forest products manufacture, logging slash, and forest thinnings are being developed as part of the Future of Washington's Forests and Forest Industries Project.

Changing Industrial Forest Management Intensities: Western Washington

Total timber harvest volumes for western Washington declined from 4,646 million board feet (MMBF) in 1990 to 2,667 MMBF in 2002, a two billion board feet (46%) decline[3]. The National Forest share of harvest declined from 11% in 1990 to less than 1% in 2002 as the industry share increased from 64% to 73% (Figure 1) even though the industry harvest level fell from 2,974 MMBF in 1990 to 1,937 MMBF in 2002. The relative share for other ownerships remained stable although harvest volumes dropped for all (Table 1). Industrial forests comprise 40% of non-reserved timberlands in western Washington (68% of all private forestlands) yet are now providing 73% of the total harvest. Industrial forests are more intensively managed to maximize harvest volumes and subsequently dominate the regional yield, however, management intensities have changed substantially since the 1992 timber supply analysis[4].

[3] DNR. 2004. Washington Timber Harvest 2002.
[4] Adams et al. 1992. Future Prospects for Western Washington's Timber Supply.

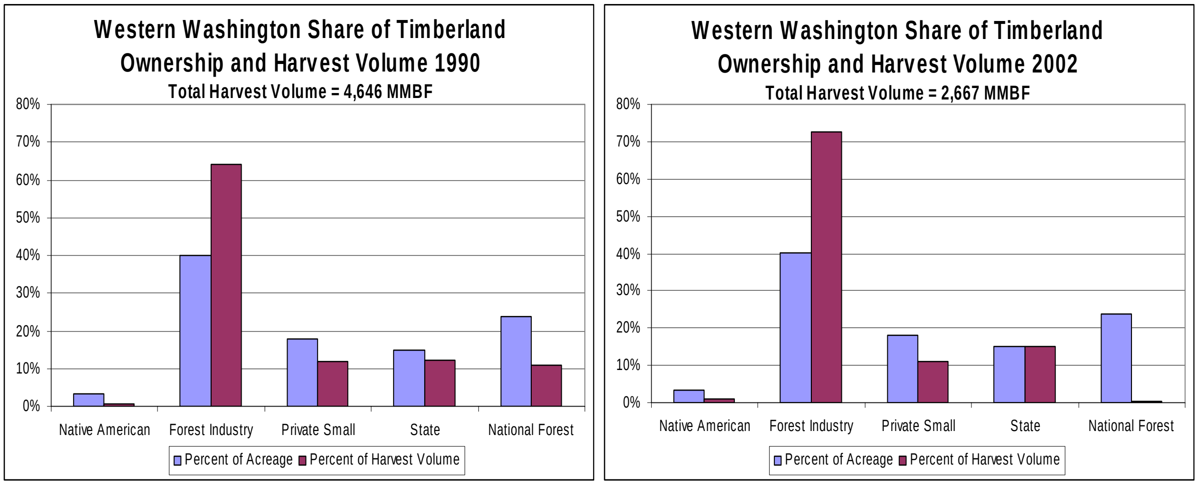


Figure 1: Ownership and Harvest share change from 1990 to 2002

		Ownership Type – *Volumes in Million Board Feet*				
Year	**Native American**	**Forest Industry**	**Private Small**	**State**	**National Forest**	**Total**
1990	**37.6**	**2,974.0**	**557.7**	**573.1**	**504.0**	**4,646.3**
2002	**26.8**	**1,937.0**	**296.8**	**397.8**	**8.3**	**2,666.9**

Table 1: Harvest Volumes for Western Washington by Ownership Type 1990 and 2002

To better understand changes to management approaches on industrial forests, the University of Washington and the Washington Forest Protection Association surveyed timberland companies that manage commercial forestlands within the five timbersheds of western Washington. Forest managers were asked to estimate current and future practices by dominant tree species, site class, and age class. Sixteen responses were received from companies that own more than 10,000 acres and cumulatively manage approximately 3.6 million acres of forestlands in western Washington. Results were weighted by acreage to produce average response data by timbershed. Substantial changes in management intentions from a similar survey in 1990 provide important insights into future prospects for management and harvest.

Respondents indicated that 8.2% of all company lands are covered by roads, rock, wetlands, water, and other areas not capable of growing timber (approximately 300,000 acres). Additional land holdings unavailable for commercial timber management include voluntary reserves at 0.4% (around 14,000 acres) and regulatory reserves at 9.5% of total industrial forests (about 342,000 acres).

There are many changes in management intensions from the prior study. Rotations are shortened by as much as 10 years to final harvest on good sites (minimum 30 years on high productivity sites and maximum 60 years on low sites). Survey respondents report that 64% of forestlands are treated with herbicides to eliminate growth competition from non-commercial vegetation. The 1990 study forecasted no use of herbicides. This change alone probably accounts for much of the shortening of rotations as research plots show that the tree growth in the first 15 years of planting is increased substantially by vegetation control.

While the 1990 management survey anticipated increased planting and elimination of natural regeneration, natural regeneration appears to continue on 12% of western industrial forestlands. Also in contrast to prior practices, fertilization has been all but abandoned in recent years possibly replaced by increases in planting of genetically improved seedlings to accelerate growth.

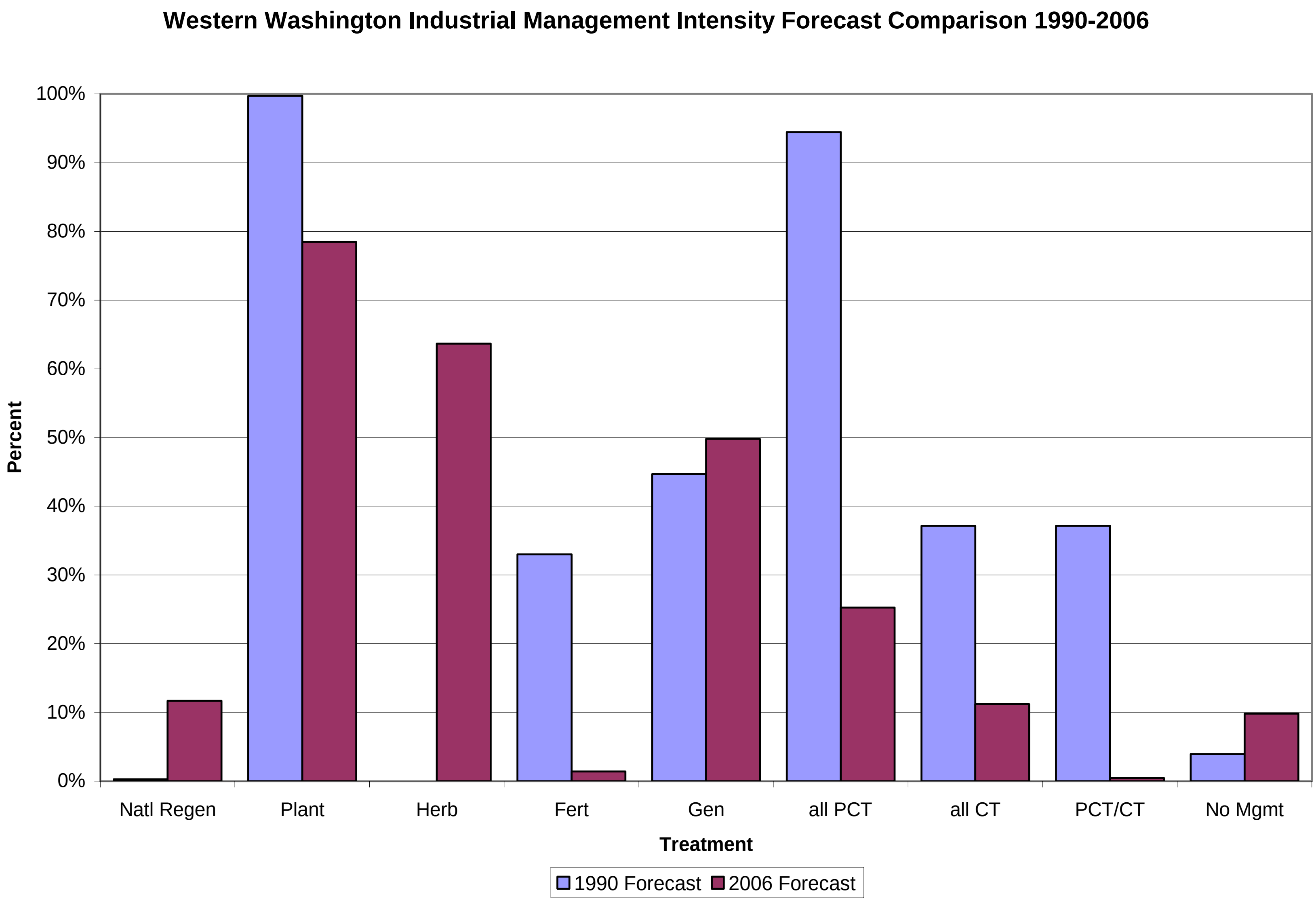
The greatest apparent difference between 1990 expectations and current practices is the dramatic reduction in pre-commercial and commercial thinning. The combined practice of pre-commercial followed by commercial thinning with a delayed final harvest was expected to occur on 37% of industrial forestlands, but respondents now report that this management approach is employed on only 0.5% of forestlands.

A significant impact since the 1990 study has been the increase of acreage set aside for no management. In 1990, the expectation was that 4% of lands would not be managed; however, increases in forest practice restrictions, primarily associated with riparian regulations, have resulted in 10% of industrial forests removed from harvest.

Figure 2 shows the weighted averages for each treatment for all five timbersheds in western Washington measured as a percentage of total industrial forest acres. The differences from 1990 to 2006 (blue bar on left to mahogany bar on right) show a substantial increase in herbicide use and genetically-improved stock with a corresponding decrease in fertilization, pre-commercial and commercial thinning. While Figure 2 displays averaged management intensities for western Washington, it is noteworthy that practices appear to vary considerably by timbershed as shown in Figure 3, which summarizes the variability in current and expected future management by individual timbershed.

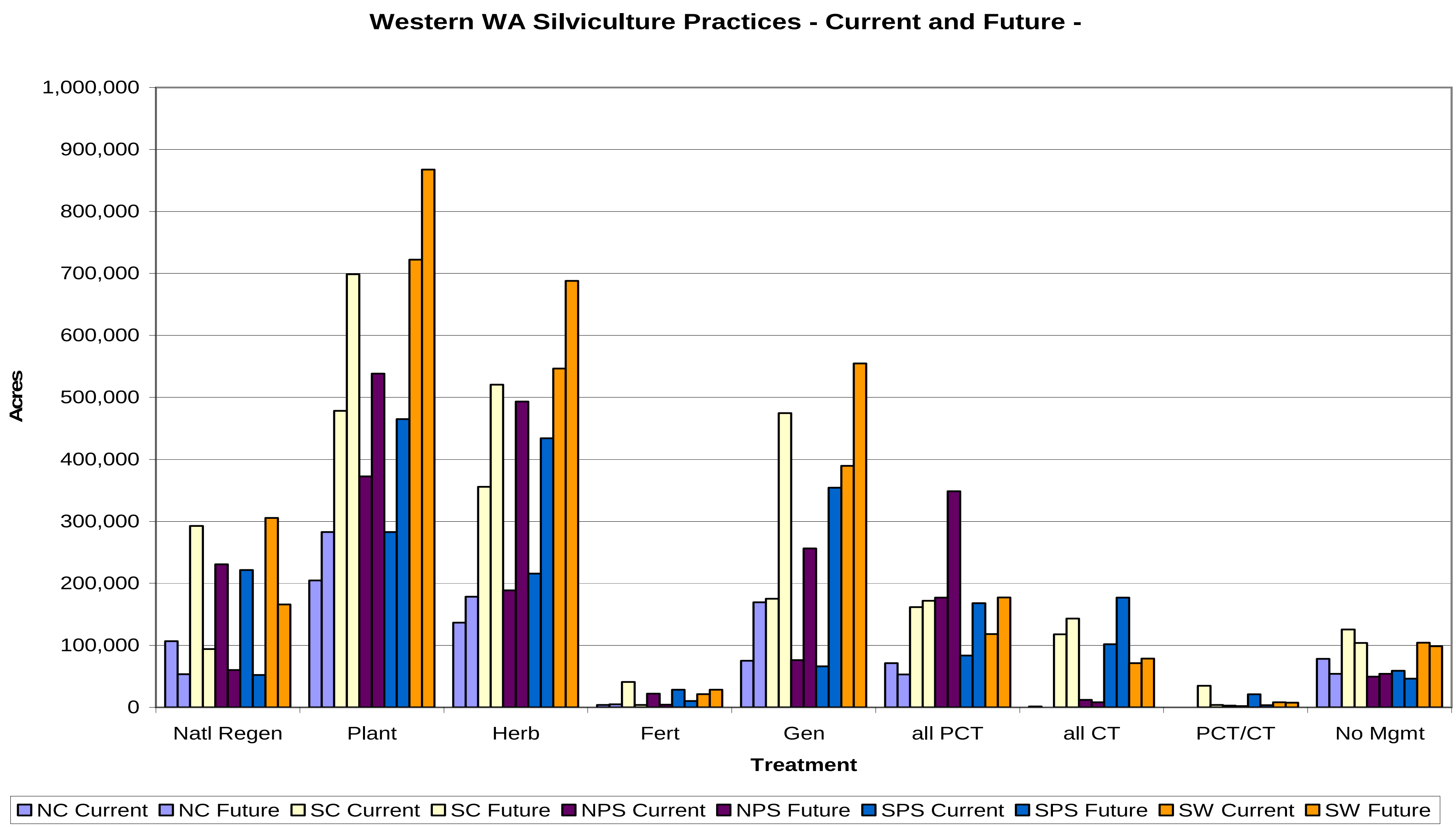
These surveys of management intentions provide the critical assumptions for developing baseline harvest and forest structure projections. We are indebted to the Washington Forest Protection Association and the industrial forestland owners of western Washington for their generous assistance in assembling this data.

Figure 2:



Western Washington Industrial Management Intensity Forecast Comparison 1990-2006
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent
Natl Regen
Plant
Herb
Fert
Gen
all PCT
all CT
PCT/CT
No Mgmt
Treatment
1990 Forecast
2006 Forecast

Figure 3:



NC = North Coast; SC = South Coast; NPS = North Puget Sound; SPS = South Puget Sound; SW = Southwest

Impact of Management Treatment Alternatives on Regional Economic Activity

The links between forest management treatment alternatives and economic activity can be developed through engineering models of the direct economic inputs and outputs for each activity step in growing harvesting and processing wood or by linking the treatments to an existing economic model. Estimates of the current direct inputs and outputs are being collected by surveying foresters, loggers, processing wood and paper mills and secondary manufacturing facilities.

Since surveys of labor intensity by activity sector provide more detail than is available in existing economic models, the current survey data can be used to develop a reasonable first order estimate of the direct economic impacts of different forest management treatment alternatives. For example, if thinning treatments require more labor and produce more chips but less secondary wood products than other activities then adjustments can be applied to these specific sectors that exist in the economic model. The Washington Projection and Simulation Model (WPSM): A Regional Interindustry Econometric Model (Conway 1990) updated to 1994 has been used in prior studies to analyze both direct and indirect downstream economic impacts of changes to the forest sector (Lippke et al 1997, Lippke and Conway 1994). This model has not been updated since 1994 as the classification system for statewide economic sector data collection has since been changed. Useful links for estimating direct and indirect economic activity generated by forestry activities can be created by integrating current survey data collected by the University of Washington into WPSM estimates of jobs and economic activity. Adjustments to the model outputs can be made to reflect productivity changes that have taken place as well as differences associated with management intensity alternatives. Such an updated model can than be linked directly to the treatments used in a timber supply analysis and consequently for providing estimates for indirect activities such as support services that are stimulated in the economic model by different forestry activities.

Economic Model

The basic sector outputs from the model are provided in table 1. The model provides direct and total employment, direct output, gross output and state & local taxes for logging, and sawnwood as two components of primary wood; primary paper, secondary wood and a total impact. Secondary paper is not included nor is wood construction as these are consumer driven activities that are independent of the origin of supply. Our focus is on the impact of supply changes within Washington State i.e. we do not want to infer changes in retailing activity that is not dependent upon local supply.

Table 1. Employment, Economic Output and Tax impacts generated by One Million Board Foot (MMBF/yr) Harvest on Forest Product Sectors (employment in person years, output in millions of 1992 dollars adapted from WPSM 1994).

	Logging	Sawnwood	PrimW(sub)	SecW.	PrimP	Total
Direct employment	1.18	3.47	4.65	2.01	1.03	7.7
Direct output	0.24	0.51	0.75	0.22	0.35	1.32
Total employment	5.17	17.3	22.47	6.93	7.42	36.82
Gross product	0.23	0.76	0.99	0.28	0.34	1.61
St&Loc Taxes	0.02	0.08	0.11	0.03	0.04	0.18

We can develop adjustments to the table for productivity gains, relative output changes and the impact of different treatments that can more directly link to a timber and forest structure supply model. As noted in Lippke et al (1996) a first thinning treatment is much more labor intensive than a final regeneration harvest as a consequence of lower volume and handling many smaller pieces, while a second and third treatment are just slightly more labor intensive due to low volume for each operational setup. Similarly, thinnings with much smaller diameter trees are weighted more heavily to chips for pulp and paper and less heavily to secondary wood uses. While these adjustments are not precise, it is not practical to reconstruct state economic models to accommodate greater detail in one sector. These estimates, based on updates from current survey data, should be sufficient to provide comparative economic assessments in support of policy discussion.

Table 1 differs from survey estimates because the economic data collected statewide is based on data from defined establishments. Survey data has generally shown 2 persons for logging and hauling per MMBF/yr compared to the model estimate of 1.18. There are several reasons for this difference. Many loggers are sole proprietors and therefore are not picked up in establishment data. Independent log haulers are coded under transportation, not logging, and therefore are modeled as an indirect service impact rather than direct employment. Similarly modern mill surveys will show less than the 3.47 person model estimate as they will include some value-added processing that may take place in the sawmill. The establishment data may also include some logging activity when a milling company also buys and harvests timber sales. Similarly forestry is considered as a service to processing operations, an indirect impact, even though it is a primary wood supply activity. Since the number of direct jobs from surveys are upwards of 10-12 persons compared to the model estimate of 7.7/MMBF/yr, the difference is picked up through a higher indirect jobs multiplier that includes forestry jobs, transportation and other services.

Impact of Treatment Differences:

Different treatments produce different log outputs that serve different end uses. By noting how these treatments differences affect the sector level data in the model, a first order estimate of the impact of different treatments can be obtained.

Table 2 summarizes the sector impact responses to different treatments.

The treatment alternatives are:

- Base (short rotation): Regeneration harvest at 50 years after full plantation stocking followed by a pre-commercial thin (PCT) for density and quality control (the dominant historic treatment for western Washington).
- First Thin: Commercial thin at or before age 30, roughly half by ground processor equipment (low slopes) and half by skyline (steep slopes) with costs almost twice the Base.
- Second Thin: Commercial thin at about age 50 with fewer small logs flowing to chips and more large logs.
- Third Thin: Commercial thin at about age 70 with more uniform and larger logs.
- Long Rotation Harvest: Regeneration final harvest of large mostly uniform trees producing more quality wood and less chips.

The sector impacts include:

- Logging: More costly and more jobs from thinning or handling small diameter material
- Primary Wood: Sawnwood plus plywood
- Secondary Wood: Half sensitive to higher quality wood (doors, windows, cut stock, mill work) but including pallets(low quality) and trusses (above average structural quality). Excludes building construction.
- Primary Paper: Pulp and Paper Mills excluding paperboard mills which are largely box converting mills serving local markets. Paper mills receive chip volumes primarily from mill processing residual and smaller diameter logs.

Table 2. Key impact changes to characterize treatment differences on processing costs relative to the base.

	1st thin	2nd thin	3rd thin	base short rot.	long rot. harvest
Logging	1.83	1.13	1.13	1.0	1.0
Sawnwood	1.0	1.0	1.2	1.0	1.4
Secondary Wood	0.5	1.0	1.75	1.0	2.5
Primary Paper	1.6	1.0	.81	1.0	.75

Table 2 incorporates estimates of the difference in these activities for each treatment alternative taken from the Washington Forest Landscape Management Project. They infer that 1st thin logging is 83% more costly per unit of removals than the average due to higher costs including both the cost of handling smaller pieces and less volume per setup. Second and 3rd thin costs are 13% higher per unit volume than the average due to less than average scale volume per setup. And both the base (short rotation) final harvest and a long rotation harvest are near the average cost. The first thin produces 60% more chips for primary paper than the average but a long rotation harvest produces 25% less than the average. Secondary wood processing would be cut in half with the first thinning serving only the low valued operations. However, with more high quality logs after successive thinnings, the potential exists to increase the share of wood going into more labor intensive secondary operations as much as 174% (still less than the full volume even processing the large and best trees retained after thinning). For the high quality logs the primary processing step is assumed to involve somewhat higher costs associated with more special handling of higher valued wood.

Productivity Change

The productivity of primary sawnwood facilities has improved at a trend rate of about 4% per year (34% per decade) driven largely by computer information processing of sawing and sorting technology. Logging productivity changes are more difficult to estimate since many loggers are sole proprietors for which no data is collected. For the data that is available there is little evidence of productivity gains and it is likely that difficult regulatory requirements have offset normal productivity gains. Forestry is handled as an indirect impact in the economic models but the productivity has most likely declined significantly with more difficult environmental planning requirements per unit of harvest. Administration costs on industry lands have been quoted as rising from $12/acre/yr to $17/acrer/yr in just a few years, substantially larger than inflation, evidence of declining productivity. Primary paper productivity has increased more modestly at 2% per year (18% per decade) as mills became very capital intensive as early as the 1980's in response to point source pollution redesigns. Secondary manufacturing includes many operations where there may have been an increase in productivity but also a substantial increase in the share of facilities devoted to higher valued processing with higher labor intensity which at the sector level appears as a decline in output per person.

We have chosen not to include future productivity gains in the labor projections since it is easier to evaluate impacts on a current impact basis and we prefer to display the impact of different treatments directly for a policy perspective rather than to confound the impact with unreliable estimates of productivity in the future.

Since these impacts are sensitive to site productivity they are directly linked to volume outputs not acres and not directly to the log mix which by itself does not include the labor sensitivity involved in treatments.

Restating output value in 2005 dollars, incorporating 2%/yr paper productivity gains (18%), and 4% for sawmill productivity gains (34%), but with no change to logging productivity, and the expansion in the share of logs going to secondary manufacturing offsetting productivity gains per unit volume of input logs, the revised table 1 becomes:

Table 3. Impact of One Million Board Foot Harvest on Forest Product Sectors (employment in person years, output in millions of 2005 dollars).

	Logging	Sawnwood	PrimW(sub)	SecW.	PrimP	Total
Direct employment	1.18	2.3	3.48	2.01	0.85	6.34
Direct output	0.31	0.66	0.98	0.29	0.46	1.72
Total employment	5.17	16.1	21.27	6.93	6.09	34.19
Gross product	0.30	0.99	1.29	0.36	0.44	2.09
St&Loc Taxes	0.03	0.10	0.14	0.04	0.05	0.23

These adjustments assume that the indirect multiplier remains the same in each sector. While one might argue there have been efficiency gains in the multiplier chain lowering the multiplier there are also known increases in outsourcing of services which offsets some of the direct job productivity gain with indirect job increases.

The final step needed to align these job and regional economic impacts with each of the management treatments used in the supply analysis for projecting future harvesting activity involves using table 2 to adjust the average contributions noted in table 3, sector by sector. Since the tables are constructed as a response per unit of harvest removal, the total impacts for any specific treatment can be summed across the sectors. Adjusting these job sensitivities per volume of wood input for different treatments produces tables 4-8, one for each treatment. These tables can be used with the corresponding treatments in the timber supply and forest structure analysis.

Table 4-8 Treatments for first, second & 3rd thinnings, a base short rotation & a long rotation (employment in person years, output in millions of 2005 dollars).

Table 4: First thin	**Logging**	**Sawnwood**	**Primary Wood SubT**	**Secondary Wood**	**Primary Paper**	**Total**
Direct Emp	2.16	2.30	4.46	1.01	1.36	6.82
Total Emp	9.46	16.10	25.56	3.47	9.74	38.77
Ratio: Dir/Tot	4.38	7.00	5.73	3.45	7.16	5.68
Direct Output	0.57	0.66	1.23	0.14	0.73	2.10
Gross Product	0.55	0.99	1.52	0.18	0.70	2.42
St&Loc Tax	0.05	0.10	0.16	0.03	0.08	0.26
Table 5: 2nd thin						
Direct Emp	1.33	2.30	3.63	2.01	0.85	6.49
Total Emp	5.84	16.10	21.94	6.93	6.09	34.96
Ratio: Dir/Tot	4.38	7.00	6.04	3.45	7.16	5.38
Direct Output	0.35	0.66	1.01	0.29	0.46	1.76
Gross Product	0.34	0.99	1.33	0.36	0.44	2.13
St&Loc Tax	0.03	0.10	0.13	0.04	0.05	0.22
Table 6: 3rd thin						
Direct Emp	1.33	2.76	4.09	3.52	0.69	8.30
Total Emp	5.84	19.32	25.16	12.13	4.93	42.22
Ratio: Dir/Tot	4.38	7.00	6.15	3.45	7.16	5.09
Direct Output	0.35	0.79	1.14	0.51	0.36	2.01
Gross Product	0.34	1.18	1.52	0.64	0.36	2.52
St&Loc Tax	0.03	0.13	0.16	0.07	0.04	0.26
Table 7: Base (CC) Economic Rotation						
Direct Emp	1.18	2.30	3.48	2.01	0.85	6.34
Total Emp	5.17	16.10	21.27	6.93	6.09	34.29
Ratio: Dir/Tot	4.38	7.00	6.11	3.45	7.16	5.41
Direct Output	0.31	0.66	0.98	0.29	0.46	1.72
Gross Product	0.30	0.99	1.29	0.36	0.44	2.09
St&Loc Tax	0.03	0.10	0.13	0.04	0.05	0.22
Table 8: Long Rotation						
Direct Emp	1.18	3.22	4.40	5.03	0.64	10.06
Total Emp	5.17	22.54	27.71	17.33	4.57	49.60
Ratio: Dir/Tot	4.38	7.00	6.30	3.45	7.16	4.93
Direct Output	0.31	0.92	1.24	0.72	0.34	2.30
Gross Product	0.30	1.38	1.68	0.91	0.26	2.85
St&Loc Tax	0.03	0.14	0.17	0.10	0.03	0.30

Summary

While a long rotation increases the local job impact per unit of removals by as much as 44% it should be noted that this impact is very far in the future and subject to substantial structural changes including productivity gains prior to the activity. Thinnings, such as the first thin, increase the job impact a modest 13% since the increased logging labor is largely offset by secondary labor declines but the impact is near term and can increase economic activity early in the projection period. Since different management treatments are practiced in different timbersheds we can expect somewhat different job impacts in each local region even before accounting for whether the local region has all of the infrastructure required to take full advantage of available wood supplies.

The economic impacts derived from linking forest treatments to processing provides economic measures of importance to a local region that go beyond the analysis of sustainable economics for the landowner. While such down stream economic impacts depend upon the forest management being economically sustainable, they are also sensitive to other policy impacts that can affect management treatments with impacts to available raw material volumes and types.

Inferences about policies that might cause differences in treatments are likely to be most sensitive to the differences between treatments which are better understood and can be more easily updated by processing surveys. The results, therefore, should be useful for better understanding of policy impacts that alter treatments. We will be evaluating processing surveys over the next few months and hope to be able to provide updated information on direct job activity levels associated with different treatments but not the indirect multipliers.

Management Treatment Issues Summary

The sections above suggest some modification to the issues summary in the second project report.

1. Impact of Shorter Rotations: see 2nd Progress Report July 2006
2. Biodiversity Pathway Support for Older Forest Habitat: see 2nd Progress Report July 2006
3. Reliance on No-Action Alternatives: see 2nd Progress Report July 2006
4. Regulatory Effectiveness: see 2nd Progress Report July 2006

5 revised. Forest Health and Climate Change

In the second progress report it was noted that 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. We posed the questions: should more be done sooner? The Federal Forests are a large contributor to the problem. Can more cooperation accelerate a federal response? We also noted that other 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?

Research currently underway suggests the links between climate change and the current forest health problem may be so strong that basing predictions on past relationships may need to be rethought. The eastside temperature is above its very long term average and vapor pressure deficit (moisture) is below its very long term average. Beatle attacks and pine mortality are correlated with these conditions at lower levels than present conditions and if current research holds up it may suggest that the pine, making up 40% of these forests, cannot survive if the climate remains outside of its historic range. This calls into question the very treatment strategies that have been developed to restore the pine overstory that historically was fire resistant. Pine overstories may not be sustainable under current conditions. Other inland species may also be threatened. It is two years since the Forest Health Working Group Report was published and while none of the solution oriented recommendations have yet been acted upon, pine mortality has increased dramatically. Should the priority for research, technology transfer and outreach be raised? Can we learn more from others?

6. revised. Declining Private Eastside Harvest

There will likely be a decline in private harvest on the Eastside in the near future given the high private (and tribal) 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, particularly on Federal land, to reduce fire hazards with some volume being merchantable as potential offset to declining harvest and some more suitable for biofuel use. There are also growing opportunities for salvage. It appears from the FIA inventory data that DNR should also be able to increase its harvest and health restoration activities although this needs to be verified using DNR’s own inventory data. Are there steps that may contribute to solving both the declining harvest problem and the mortality and high fire hazard problem?

Increased use of biofuels as a renewable resource is viewed as a essential part of biomass removal efforts. There are many different methods for using biomass as a biofuel or in products that substitute for fossil fuels yet we are not aware of studies that demonstrate either best methods for producing biofuels or identification of obstacles that need to be removed. Is there a need for more information to support biofuel processing investments?

8. new. Declining Infrastructure

With the anticipated decline in eastside harvest, there appears already to be a further erosion in the infrastructure, with several existing mills planned for closure. The result will be longer hauls, less competitive bidding for timber, and lower returns for timber investments, just the opposite of desirable conditions to sustain the acres in forestry. What does it take to keep enough mills open to sustain forest management? The professional skills needed to replace the exodus of current workers has been noted as in critical decline. What is needed to provide enough skilled natural resource professionals?

Study 2: Competitive Position

John Perez-Garcia, Hideaki Kubota, Adam Lewis

A Global Overview: Who Produces, Who Consumes?

Forest products are produced and consumed principally in North America, Europe and Asia.

The U.S. is the world's leading producer and consumer of forest products. It accounts for 25% of total industrial wood production, 24% of paper and paperboard production, consumes 31% of world pulp and 30% of paper and paperboard (FAO statistics for 2004.)

Continued growth in the U.S. economy, particularly the housing sector, including new housing starts, repair and maintenance of existing residential structures, has increased demand. It is estimated demand for lumber will increase by 1.4% per year over the next several decades.

Japan and China are the principal producers and consumers in Asia. Malaysia and Indonesia have sizeable forest resources and have managed them to successfully develop forest products industries. Their development was significantly impacted by the financial market crisis in 1997.

Europe is mostly self contained. Its production satisfies its consumptive needs. In 2004 it accounted for 21 percent of global industrial wood production, 24 percent of world pulp production and 29 percent of paper and paper board production. It has significant trade flows to U.S. and Asia. Sweden, Finland, Germany and France produce excess amounts of products. Russia is an important future producer. In 1997, production level was 40 percent of peak levels. Today it is 55 percent of peak levels. Certification in Europe initiated in 1997 and continues to be an important issue.

Latin America has sizable resources but lacks the investments and infrastructure to develop them. Most forest products are derived from managed forests. Brazil, Chile and other southern countries have sizable plantation areas. In 2004 the region produced 11 percent of the global industrial wood and 8 percent of the pulp. Wood pulp exports amounted to 16 percent of global exports. Brazil is home to some large scale and highly efficient pulp operations. Chile's forest sector has developed through expansion of privately owned forest plantations. A few large vertically integrated companies manufacture the majority of Chile's forest products.

New Zealand and Australia are the major producers and consumers of forest products in Oceania.

In Africa, South Africa is the significant producer and exporter of forest products.

While the U.S. has less forestland than Canada, Russia and Brazil, its large market has encouraged investments in management and capital that have resulted in its forests being among the most productive in the world.

What Does Washington Produce?

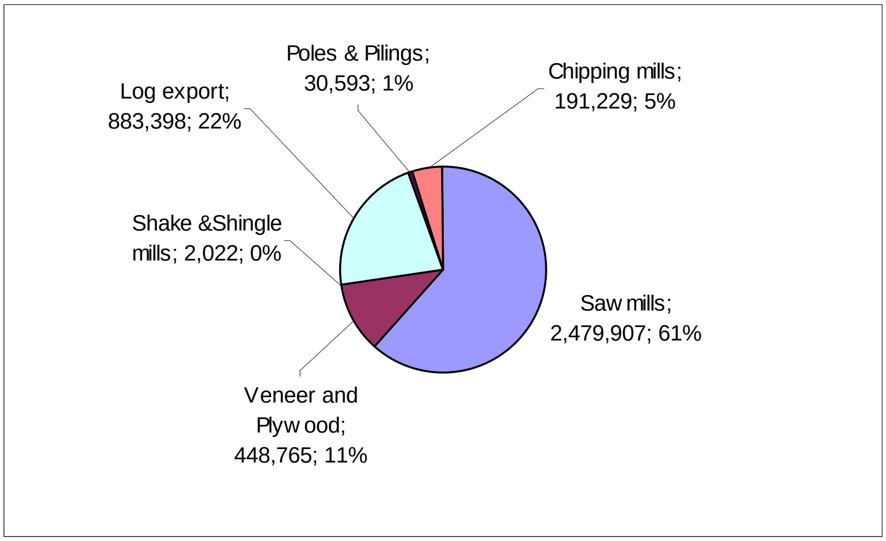


Figure 1. Washington's forest sector use of industrial roundwood in 2002
Source: WADNR 2002 Mill Survey

The major direct user of roundwood is the lumber sector. The pulp and paper manufacturers are the second largest users utilizing sawmill, veneers and plywood residuals as well as chips from chipping mills. These major consumers of logs are followed by exporters of logs, veneer and plywood manufacturers and chipping mills (Figure 1).

There have been significant declines in log exports. During the 1990's there were three events that affected U.S. log exports: high log prices, the Asian collapse of financial markets, and the strong U.S. economy relative to the rest of the world. The strong U.S. economic performance strengthened the U.S. dollar during this period, which favored imports over exports during this period.

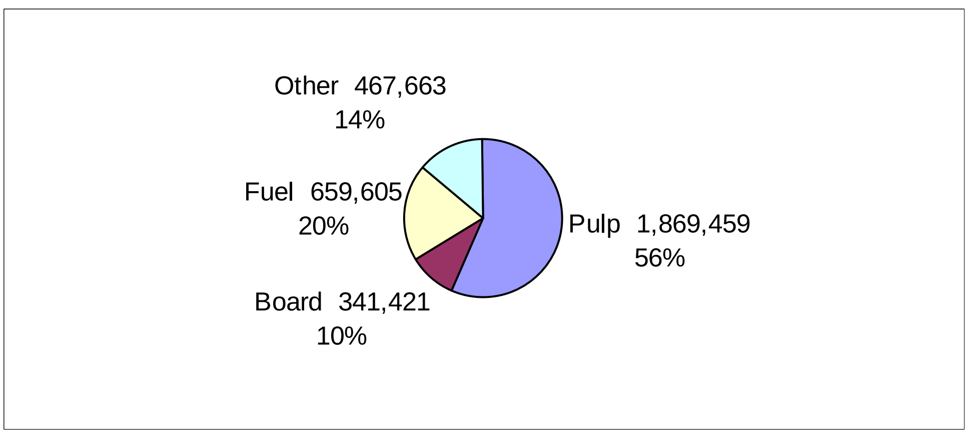


Figure 2. Sawmill production of residuals and their end use in 2002
Source: WADNR 2002 Mill Survey

Around ½ of the roundwood volume used by the sawmilling sector finds other uses. About 1.9 million tons are used by the pulp mills. Sawmills produce residuals that also are used as fuel and in fiberboard.

Washington's forest industries are likely to continue to service lumber, plywood, newsprint and some value-added markets such as trusses, cabinet or furniture stock. OSB may not a viable option since it requires a large resource base of both softwood and hardwood resources.

Washington can compete only in niche market for doors, cabinets and furniture. Other countries, particularly China, have abundant low-cost labor that is used in mass-produced chairs, doors, furniture and cabinets.

Exchange rates are an important factor determining the competitiveness of these industries. Real devaluation of Indonesia and Malaysian currencies relative to the U. S. dollar have diverted world import demand from U.S. forest products toward Indonesian and Malaysian products as long as production levels were not dependant on imported inputs which now cost more. In the case of China, it has allowed them to import cheap raw materials to sell into U.S. markets at U.S. prices. The weakening of currencies in countries that imported U.S. products provides an incentive to purchase from others whose currencies did not appreciate as much as the dollar.

Who Are Our Competitors?

Within North America, our neighboring state of Oregon competes for resources and markets. More broadly, the U.S. South region is a major competitor to PNW mills. Canadian mills also compete with Washington mills in softwood lumber markets.

North American and European production shares have grown at the expense of Asian market shares in softwood lumber during the 1990s. Two factors have contributed to this growth: (1) the decline in Russian production and (2) the substitution of logs for lumber imports by Japan. While the decline in Russian production might have represented an opportunity for Washington mills to increase exports to Asia, this event occurred during a period of harvest constraints that led to the second factor. As a consequence Washington's export sector has declined allowing resources to be used by the sawmilling sector to meet rising domestic demand.

As Russia recovers, it has overtaken the U.S. as the principal supplier of softwood logs to Japan. Canadian log trade volumes to Japan have recently increased (See Figure 3).

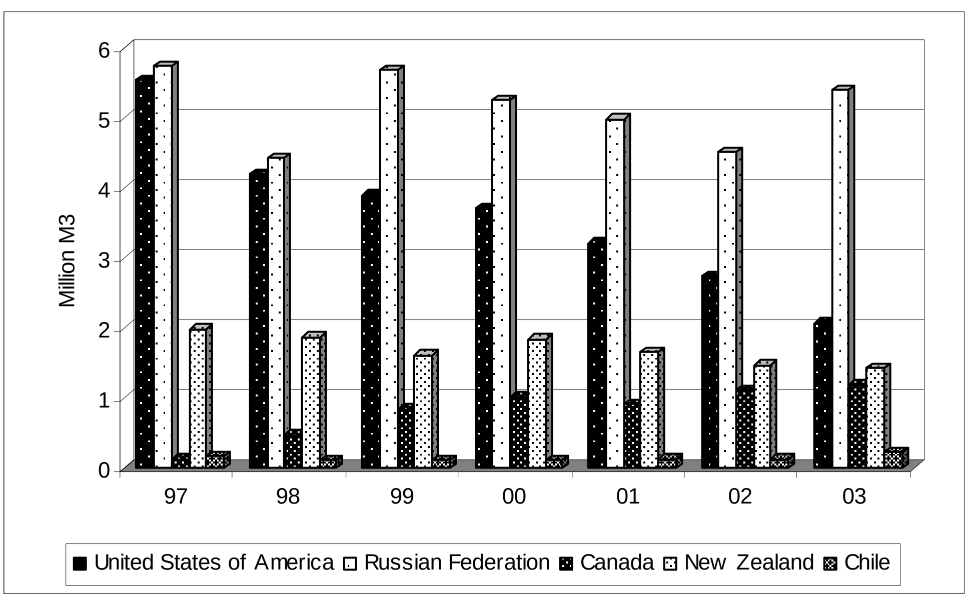


Figure 3. Softwood log imports by Japan. Source: FAOSTAT

The economic malaise that has affected Japan for over 15 years has consequences on Washington lumber producers servicing U. S. markets. As Japan's economy continued to stumble, Canadian lumber export volumes decreased. Lost market share in Japan translates into more Canadian volume available to flow into the U.S. domestic market.

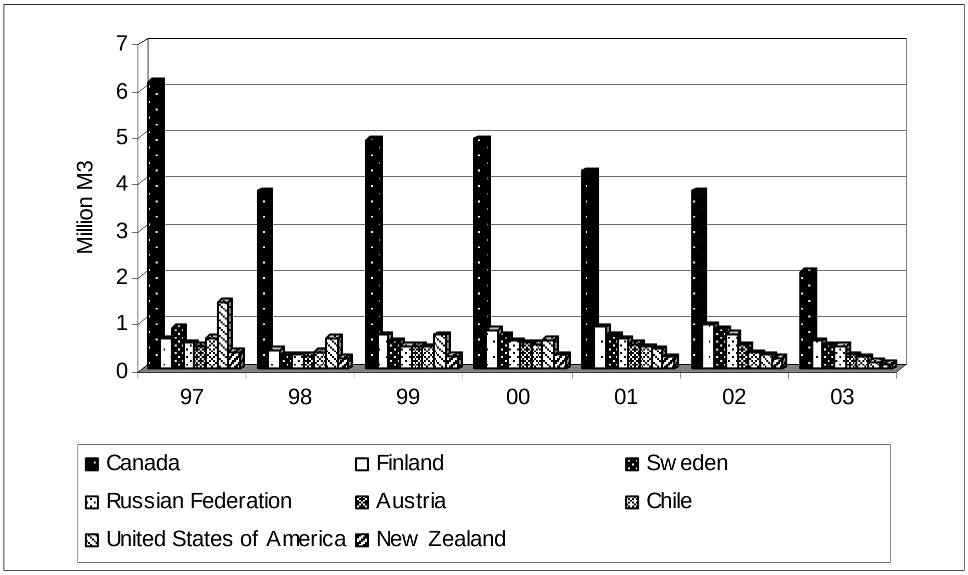


Figure 4. Softwood lumber imports by Japan. Source: FAOSTAT

Newsprint production in Washington amounts to over 75% of total production. A large volume of this production is exported to Japan. In addition, other U.S. producers of newsprint export significant amounts to Mexico. China, the # 2 destination for U.S. newsprint exports has essentially disappeared according to FAO statistics (Figure 5).

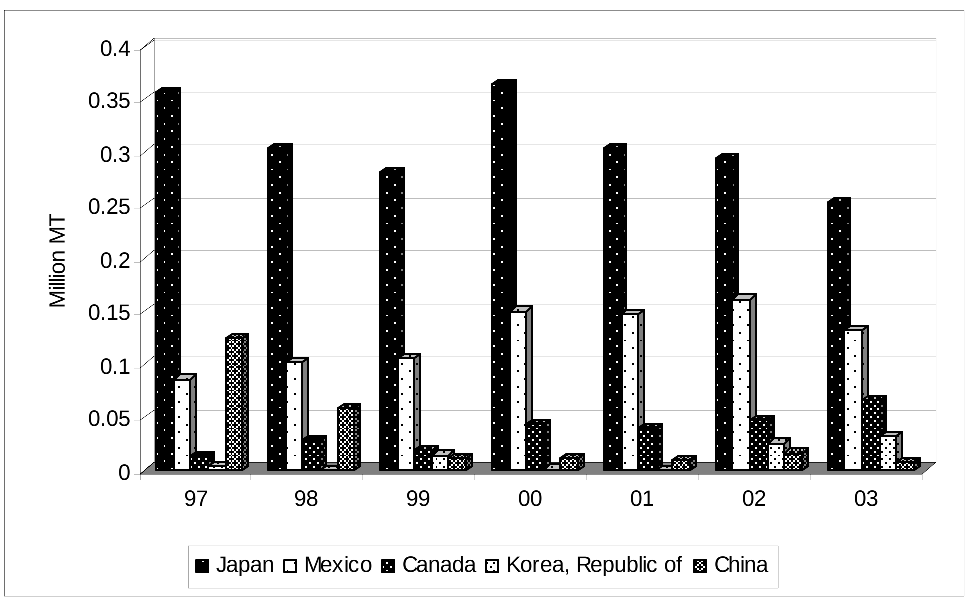


Figure 5. Newsprint exports by U.S. Source: FAOSTAT

China's market for newsprint has changed over the past several years, reducing its imports primarily from Canada (Figure 6).

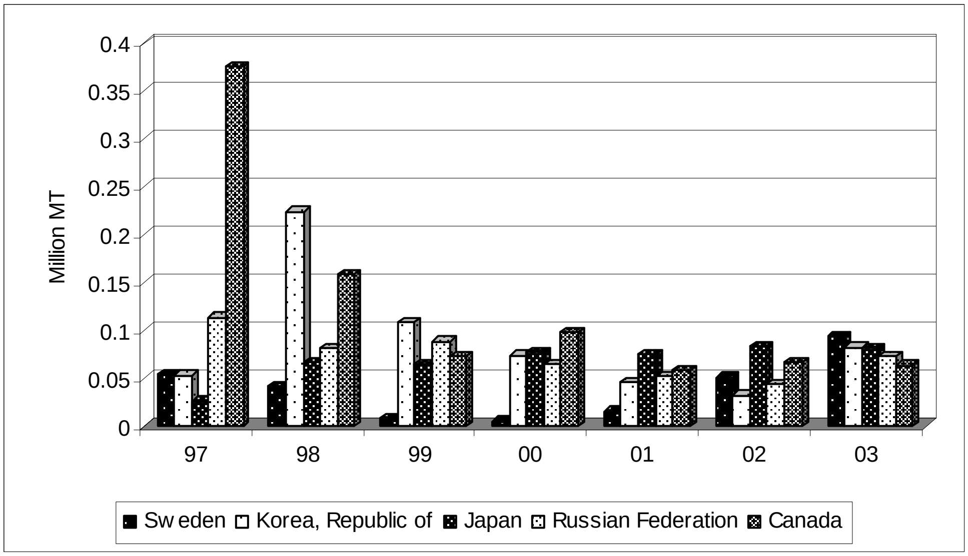


Figure 6. Newsprint imports by China. Source: FAOSTAT

Plywood and veneer production utilized over 10% of the industrial roundwood consumed in Washington. In the U.S., plywood and veneer export markets included Canada, Mexico and China (Figure 7). Both the Canadian and Chinese markets have grown since 2001, while the Mexican market has shrunk. U.S. market share in Mexico has declined primarily due to increased imports from Chile and Brazil (Figure 8).

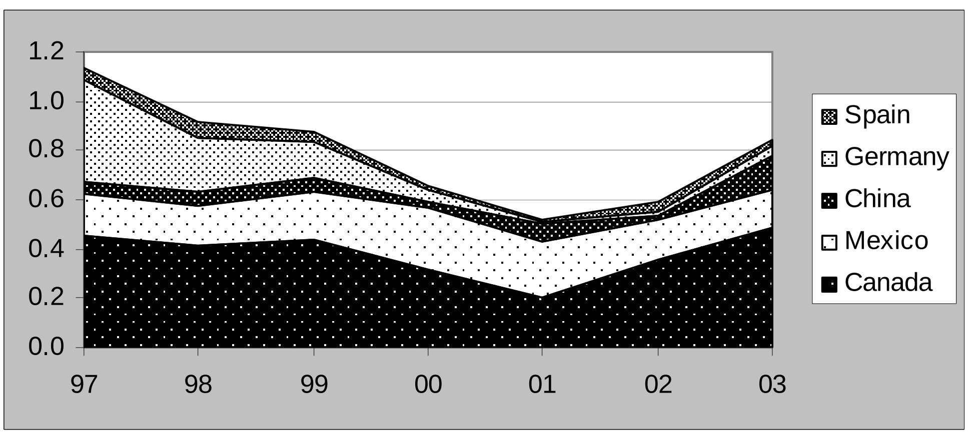


Figure 7. Plywood and veneer sheet exports by U.S. Source: FAOSTAT

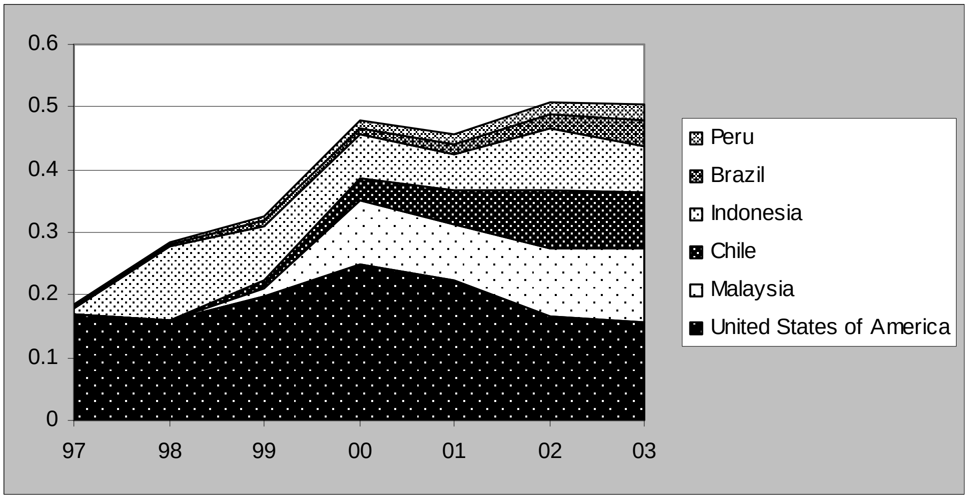


Figure 8. Plywood and veneer sheet imports by Mexico. Source: FAOSTAT

Study 3: Economic Contribution

Ivan Eastin, Indroneil Ganguly, Daisuke Sasatani and Bruce Lippke

Study Summary

Investment by value-adding wood industries is critical to sustaining forestland ownership. An increasingly complex array of forest owners and investors suggests a business climate that views forests as a financial, rather than an industrial, asset. However, maintaining the ecological, environmental and economic health of the forests in Washington requires a vibrant and competitive forest products industry. The lack of a diversified and competitive forest products industry to process the logs, small diameter timber and thinnings removed from the forest undermines the ability to manage forests in Washington in a sustainable manner and reduces the range of management options available to forest managers in the state. The lack of competitive markets for intermediate forest products derived from forest management operations undermines the economic rationale of forest management, adversely affects forest health and ultimately results in increased fire risks. At the same time, the forestry and forest products industries make significant contributions to the economy of Washington State, particularly in rural, timber dependent communities.

The preliminary analysis of the economic data suggests that the forestry and wood products manufacturing sectors have played an increasingly important role in the economy of Washington state since 2001. Not only did this sector provide over 45,000 jobs in 2005 but it also generated approximately $16 billion in gross business revenue, paid out over $2 billion in wages and over $100 million in tax receipts. As a result, the forestry and wood products sector of the state economy employed 1.43% of the workers in the private sector in Washington, accounted for 1.8% of the total wages paid within the private sector and generated 3.2% of the gross business income within the private sector.

The sawmill industry in Washington state suffered through a tough period between 1987 and 1993, much of which can be attributed to the 1990-1991 recession and the loss of federal timber as a result of the listing of the spotted owl as an endangered species in 1989. Between 1987 and 1993 softwood lumber production in Washington decreased by 23.5% as 45 sawmills closed and almost 1,400 jobs were lost. Industry consolidation ensued throughout much of the past decade and by 2005 the number of sawmills had declined from 217 (in 1994) to 128. Much of this decline in sawmills can be attributed to the closure of older, inefficient sawmills that relied on the large, old-growth logs coming from the federal forests. Despite the huge drop in sawmills, employment in the sawmill sector actually increased from 7,721 to 8,565 between 1994 and 2005 as larger more efficient sawmills were built to replace the older mills being closed.

The plywood industry in Washington, previously one of the largest in the U.S., has been in decline since 1962. The number of plywood mills has dropped from 35 to 8 during this period although plywood production has only declined from 1.8 billion square feet (3/8 inch basis) to 1.1 billion square feet (3/8 inch basis). As in the sawmill industry, the closure of smaller, inefficient mills has been offset to a degree by the establishment of larger, more efficient plywood mills. Annual production per mill in 1962 was just 52 million square feet whereas this has jumped to 137 million square feet in 2005. It is important to note that as the end-use market transitions from plywood to OSB, there are no OSB mills located in the state of Washington. The challenge for the structural panel industry is to successfully make the transition from plywood to OSB.

The Washington pulp and paper sector is the second largest following wood products manufacturing. In addition to its importance within the economy, this sector also plays an important demand role within the forest products industry. Pulp and paper companies are important consumers of lower quality pulp logs as well as providing a demand for by-products from other forest products industries such as sawdust and planer shavings from the sawmill industry. Given the cost structure of the sawmill industry, lumber manufacturers often break even at best with their lumber production and it is the sales of their by-products

that provide them with an operating profit. Thus this industry segment is particularly important to the health of the sawmill and logging sectors. From a strategic industry perspective, it is extremely important that this industry remain healthy and viable within the state of Washington.

The regional inter-industry econometric model called the Washington Projection and Simulation Model (WPSM) has been used to estimate that in 1992 there were 7.7 direct jobs and 32.3 indirect jobs linked to each million board feet of timber harvest in Washington. In 1994, it was further estimated that 29.7 Washington jobs would be lost for every $1 million in tax increases to replace lost trust revenue from reduction in timber harvests from the state forestlands. Further public benefits derived from DNR timber sales through the generation of state and local, and federal tax revenues were calculated to be 11% and 19% of the Gross State Product, respectively in 1996.

Introduction

The forest products industry in Washington state, while facing challenging times, is one of the most dynamic in the US, Figure 3.1. Production statistics from the softwood lumber and plywood industries show that Washington ranked second and fourth in terms of the volume of softwood lumber and plywood produced in 2005. The fact that Washington is the second largest softwood lumber producer yet the fact that employment in this sector is ranked 8th suggests that the softwood lumber industry has an above average level of productivity.

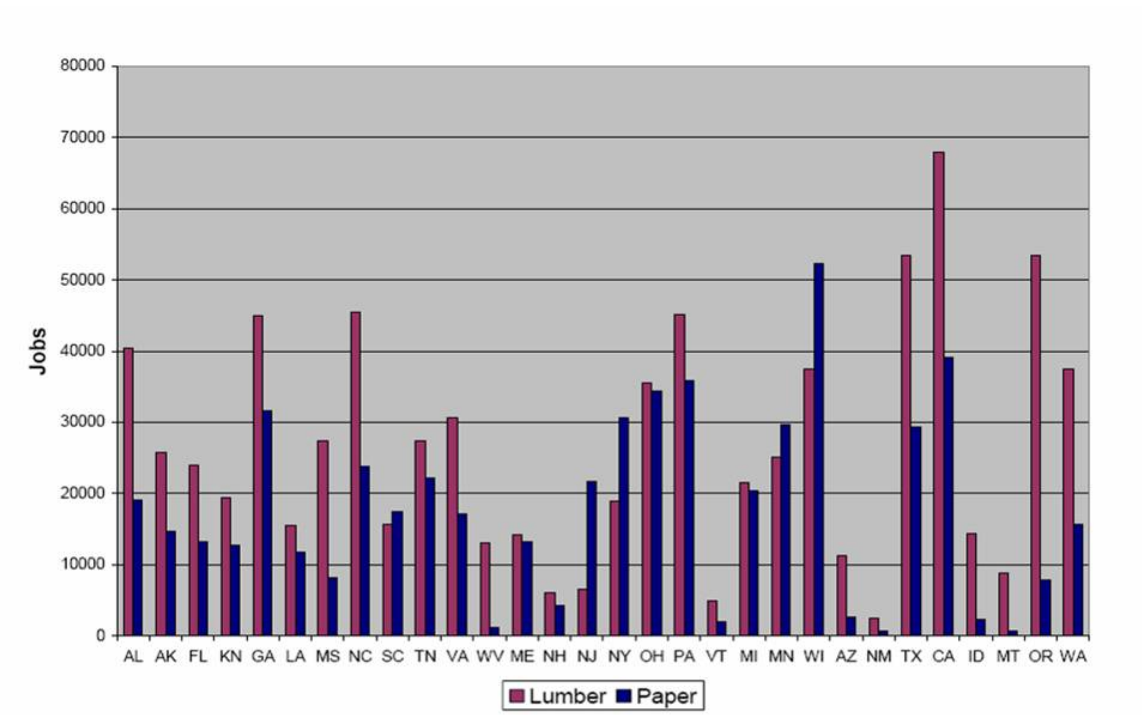


Figure 3.1. Employment in the forest and paper industries in the US.
Source: AF&PA 2005; Evans 2006.

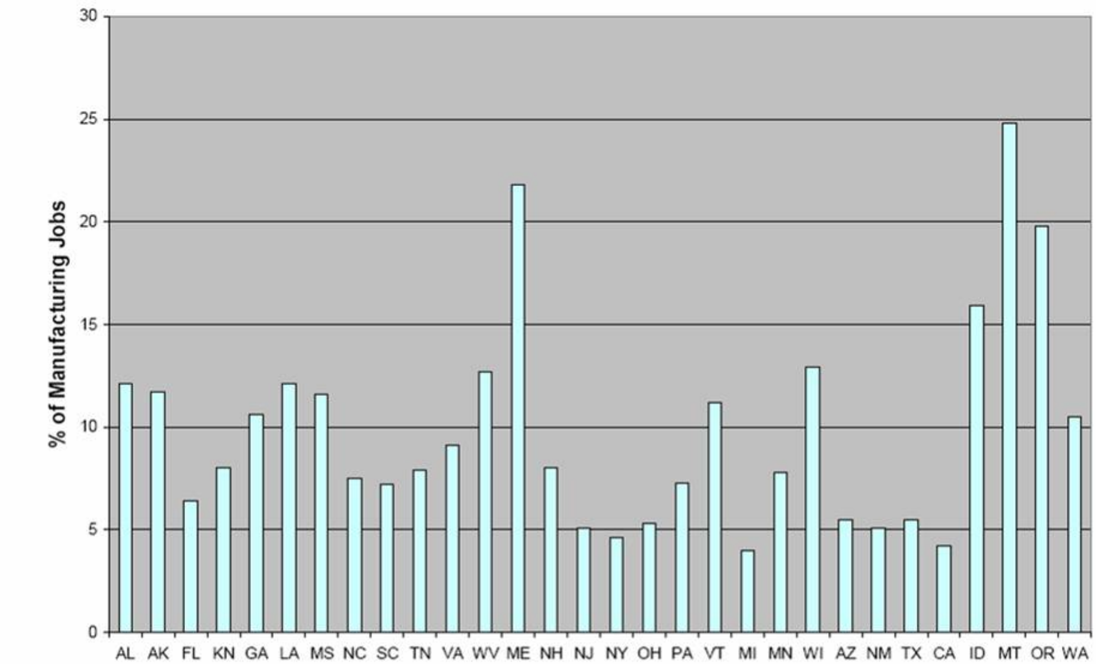


Figure 3.2. Employment in the forest and paper industries as a percentage of manufacturing jobs.
Source: AF&PA 2005; Evans 2006.

The employment data presented in Figure 3.2 show that employment in the forest and paper industries represents 11% of all manufacturing jobs in the state, suggesting that the forest products industry plays an important role within the diversified economy of the state. This is of particular relevance since many of these jobs are located in rural, timber dependent communities where family wage jobs are difficult to come by. For example, the 2005 employment and wage data shows that jobs in the lumber manufacturing and paper manufacturing industries provide an annual average wage of $45,703 and $60,421, respectively. Indeed, even the logging industry provides an average annual wage of $40,208. In addition, the indirect economic impacts of these jobs in the forest sector play an important role in the economies of rural timber dependent communities.

Figure 3.3 shows capital investment in wood products manufacturing as a function of value of wood products shipments. Forest products manufacturers in Washington have one of the highest levels of capital investment trailing only Wisconsin. More important, the level of capital investment is well above the average of 3% of annual sales (as indicated by the slope of the line in Figure 3.3). Equally important, from an industry perspective, is the fact that Washington timber lands have the highest per acre yield of any state in the country, Figure 3.4. At the same time, a study by the Oak Ridge National Laboratory suggests that Washington also has a ready availability of cost competitive forest residues that could provide raw material inputs for a wide range of forest products including particleboard, medium density fiberboard and oriented strandboard as well as providing the raw material for biomass refinery or bioenergy facilities (Figure 3.5).

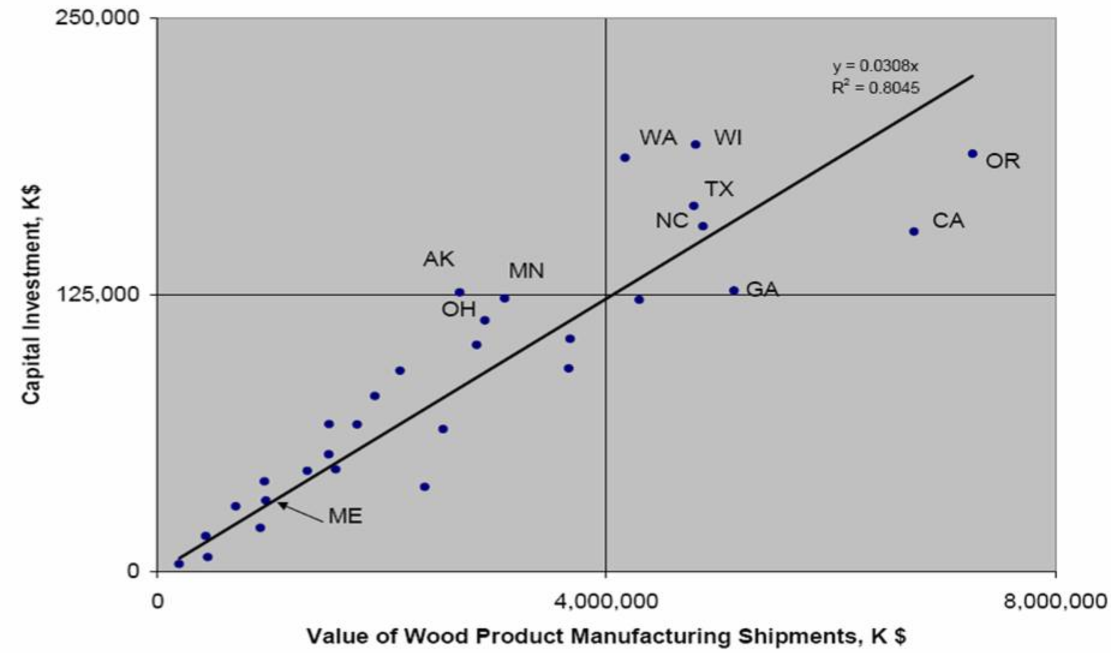


Figure 3.3. Capital investment versus the value of wood product shipments.
Source: AF&PA 2005; Evans 2006.

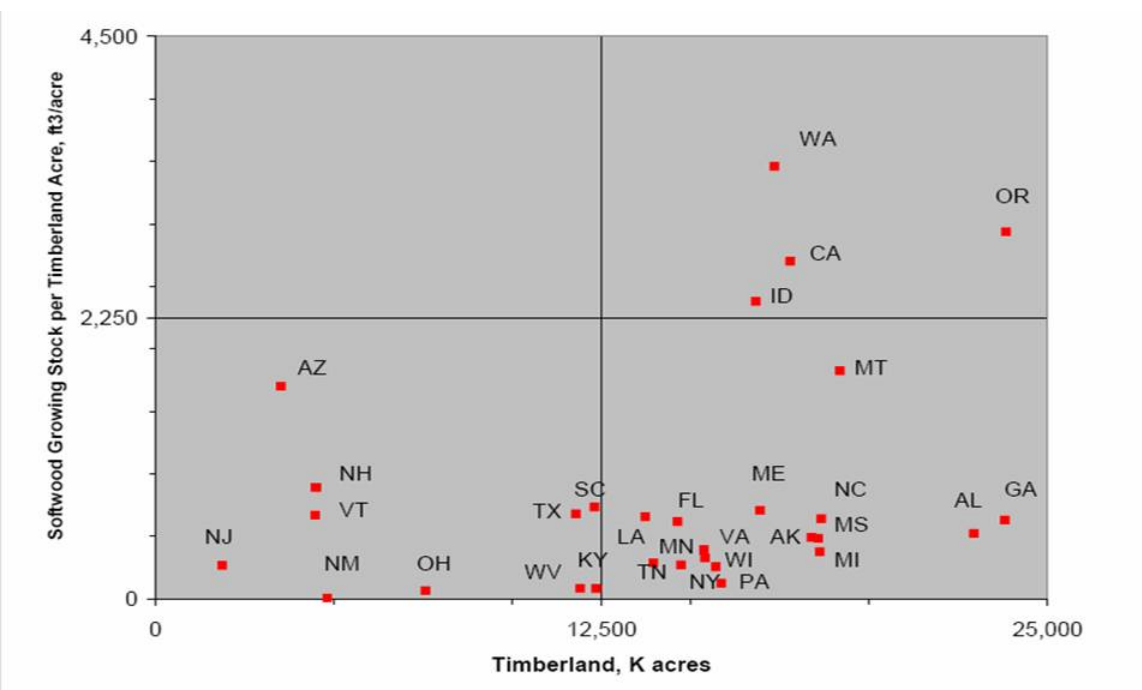


Figure 3.4. Intensity of softwood growing stock relative to timber area.
Source: AF&PA 2005; Evans 2006.

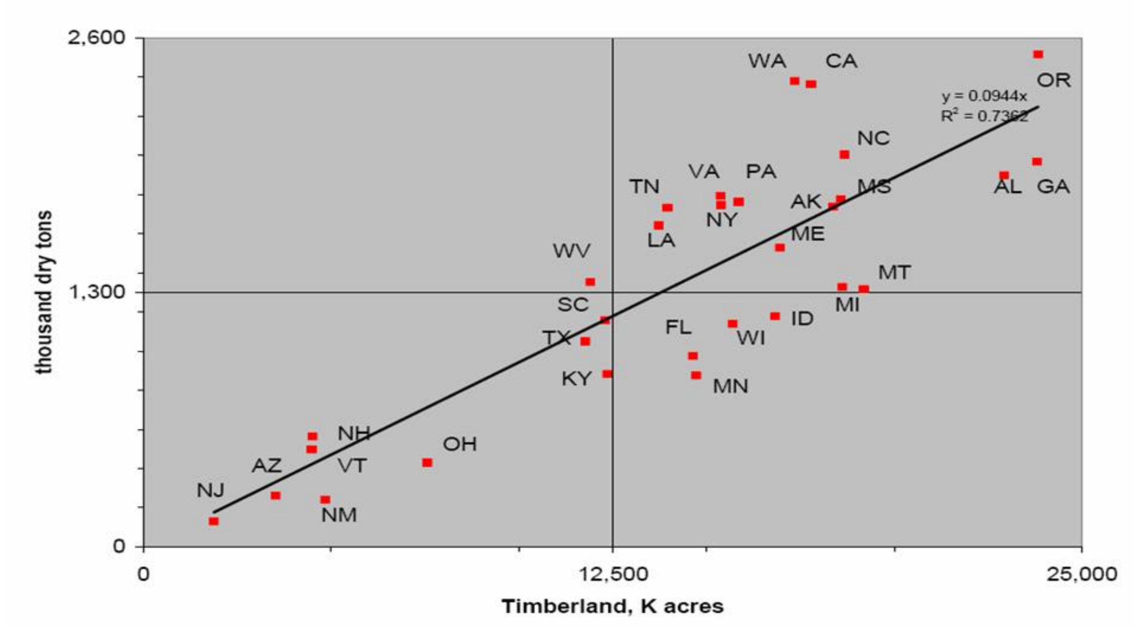


Figure 3.5. Estimates (1999) of forest residues available for less than $50/BDT.
Source: Oak Ridge National Laboratory 2000; Evans 2006.

Study Objectives

Given the critical role of a healthy and diversified forest products industry to the state economy, the Washington state Legislature commissioned a study to evaluate the contribution of the forestry and forest products industries to the economy of Washington State. The objectives of this study include:

- Describe the role of forestry ownerships and forest products industries in the economy of Washington.
- Analyze the economic contribution of the forest products industry on a regional basis (including timber-dependent communities).
- Describe changes over time in key drivers at both the state and regional level.
- Project the contribution of forestry and logging, primary manufacturing, and secondary manufacturing.
- Analyze regional economic and productivity trends across stages of processing.
- Assess economic impacts (gross business revenue, income, direct and indirect jobs, and taxes) related to forest sector activity.
- Identify factors and policies that constrain investment within the industry.

Preliminary Results

Data Inconsistencies

The task of estimating the economic contribution of the forestry and forest products sectors to the economy of the State of Washington is complicated by the transition in the way that much of the industry census data is classified. Between 1997 and 2002, the methodology for classifying industries was changed from the Standard Industrial Classification System (SIC) to the North American Industry Classification System (NAICS). However, the transition between the two classification systems changed the way that industries are aggregated and classified and resulted in a discontinuity in the industry data (Figure 3.6). The data presented in Figure 3.6 clearly show that the change in classification systems can have a significant impact on the employment data. For example, whereas there is fairly good consistency in the logging employment data reported by each classification system, the sawmill employment data reported using the NAICS classification system consistently and significantly under-report employment levels within this industry. As a result, it was determined that the economic analysis for this study would be confined to the time period 1990-2005 using only the NAICS data. Further, limited data availability for taxes and gross business revenue at the state level restricted the analysis to the time period 1994-2005.

Of greater concern is the fact that there is much ambiguity in the way that specific industry groupings are assembled that limits the ability to gain a clear understanding of the economic performance and competitive ability of a specific industry group. For example, using the six digit level of definition within the NAICS system (the greatest detail provided), provides information on the sawmill industry (NAICS code: 321113). However, using this classification would suggest that there were 128 sawmills operating in Washington in 2005. Clearly this is a huge overestimate. A review of the industry definition for NAICS code soon demonstrates the problem of using the NAICS system to gain an understanding of a specific industry. The definition for the NAICS code 321113 (sawmills) provides the following:

> *This U.S. industry comprises establishments primarily engaged in sawing dimension lumber, boards, beams, timbers, poles, ties, shingles, shakes, siding, and wood chips from logs or bolts. Sawmills may plane the rough lumber that they make with a planing machine to achieve smoothness and uniformity of size. Source: http://www.census.gov/epcd/naics02/def/ND321113.HTM#N321113*

Obviously this industry grouping includes much more than just sawmills and using the data provided for this industry sector would provide hugely misleading results. Given the importance of understanding the economic performance and competitiveness of specific industry sectors, it was determined that a census of the major industries should be conducted to facilitate a better understanding of the factors that influence the business environment and competitiveness. The industries that would be surveyed include: logging, sawmills, pulp and paper mills, plywood mills and engineered wood products mills. The surveys have been sent and we expect that the preliminary results will be available by the middle of November, 2006.

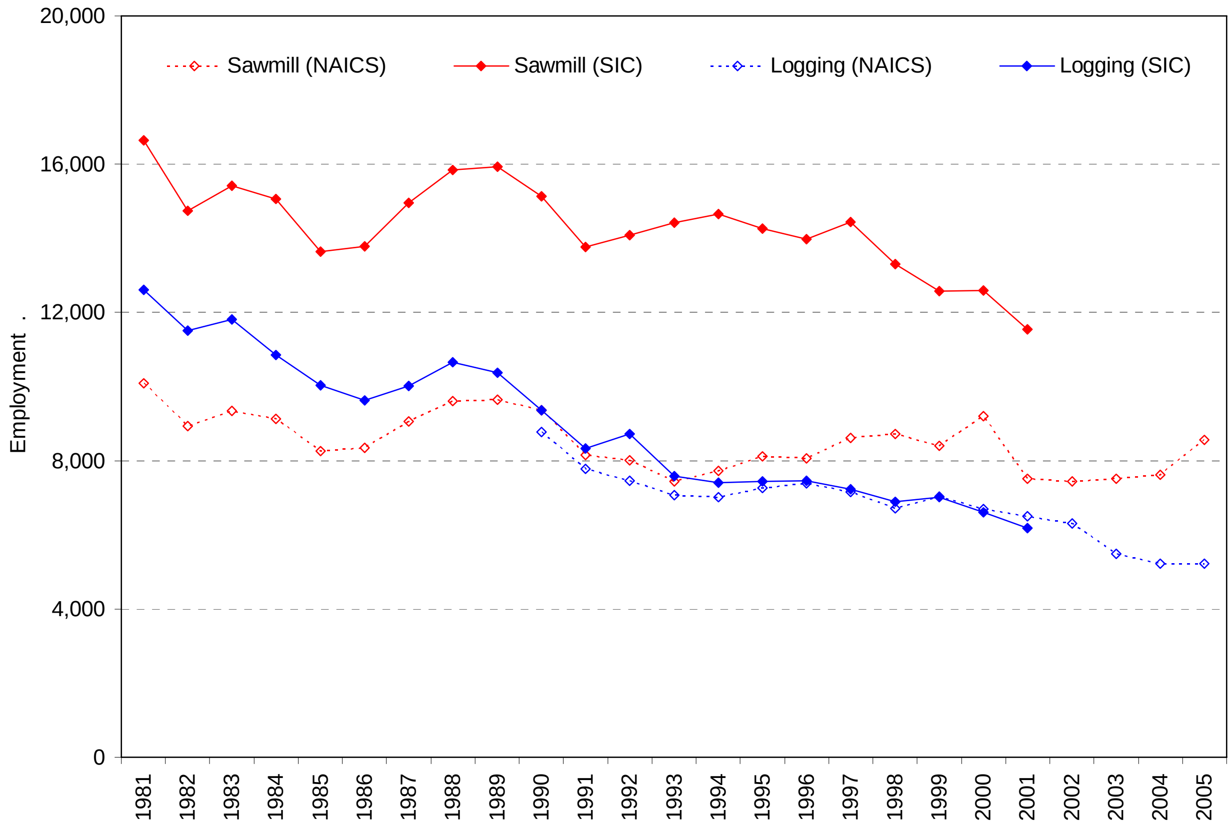


Figure 3.6. A comparison of the differences in the employment levels for the sawmill and logging industries as reported under the SIC and NAICS classification systems.
Source: WA State Employment Security Department website 2006.

Economic Contribution of the Forestry and Forest Products Sectors at the State Level

The preliminary analysis of the economic data suggest that the forestry and wood products manufacturing sectors have played an increasingly important role in the economy of Washington state since 2001 following several years of sub-par performance (Figure 3.7). Not only did this sector provide over 45,000 jobs in 2005 but it also generated almost $16 billion in gross business revenue, paid out over $2 billion in wages and over $100 million in tax receipts. As a result, the forestry and wood products sector of the state economy employed 1.43% of the workers in the private sector in Washington, accounted for 1.8% of the total wages paid within the private sector and generated 3.2% of the gross business income within the private sector (Table 3.1). While employment within the sector has declined since 1990, it increased by 6.1% between 2002 and 2005. In contrast, gross business income within the sector increased slightly over the 1994-2005 period. An important aspect of this sector is that many of the jobs are located in rural, timber dependent communities where job opportunities are often lacking.

In contrast to the modest performance of the forestry and forest products sector (GBI increased by just 4.2%) between 1994-2005, the overall state economy increased by an impressive 42.2% over the same period. As a result, the contribution of the forestry and forest product sector to the state economy declined from 4.3% in 1994 to 3.2% in 2005 (Table 3.2). Over the same period, employment in the forestry and forest products sector declined by 13.5%, while the state economy experienced a 29% increase in employment.

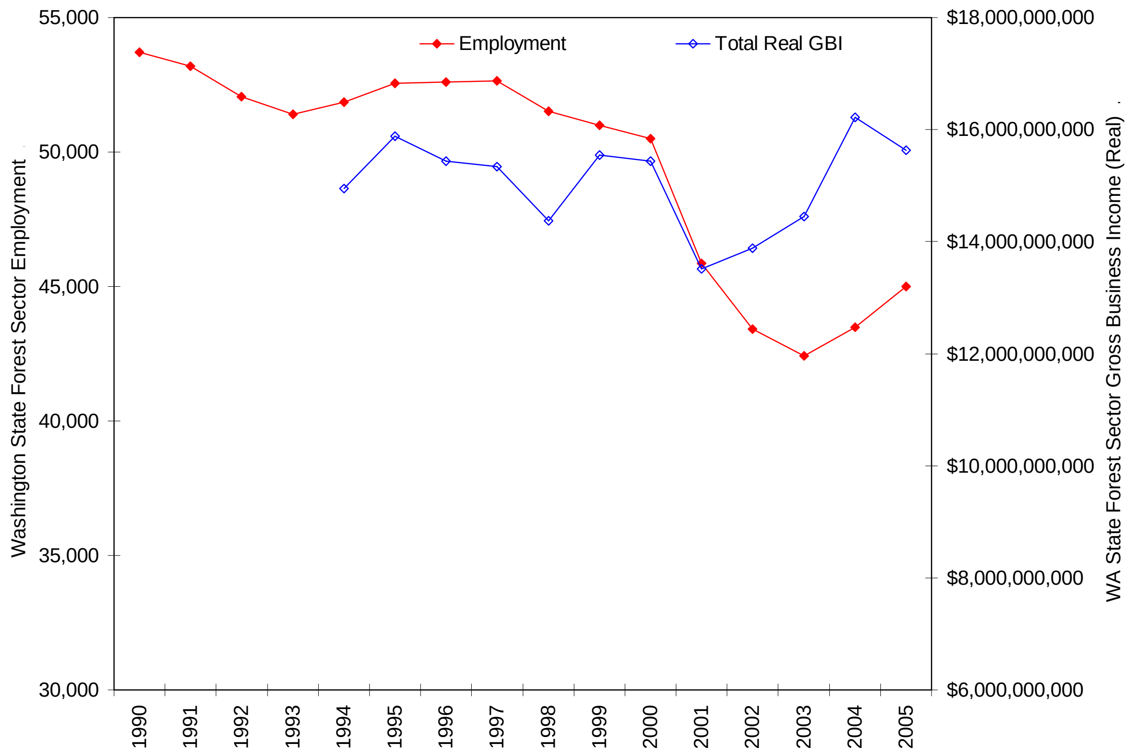


Figure3.7. Employment and real gross business income (GBI) in the WA state forest sector, 1990-2005.
Source: WA State Employment Security Department website 2006; WA State Department of Revenue website 2006.

Table 3.1. Direct economic contributions of the forestry and wood products sector to WA state economy.

	Gross Business Income (Nominal)	Gross Business Income (Real)	Wages Paid (Nominal)	Wages Paid (Real)	TaxesPaid (Nominal)	TaxesPaid (Real)
1994	$12,030,699,633	$14,947,903,371	$1,675,753,809	$2,082,090,550	$89,223,231	$110,858,078
1995	$13,042,168,977	$15,879,682,539	$1,753,282,959	$2,134,735,169	$91,049,216	$110,858,297
1996	$12,922,764,764	$15,441,583,072	$1,799,483,153	$2,150,226,295	$87,818,767	$104,935,810
1997	$13,047,855,668	$15,335,818,369	$1,873,857,914	$2,202,441,945	$89,483,765	$105,174,889
1998	$12,363,538,918	$14,372,139,812	$1,895,060,605	$2,202,935,272	$87,422,495	$101,625,298
1999	$13,571,292,892	$15,551,075,340	$1,945,678,882	$2,229,514,839	$91,667,349	$105,039,797
2000	$13,769,266,067	$15,441,543,431	$1,959,602,334	$2,197,596,037	$94,165,788	$105,602,223
2001	$12,341,930,360	$13,516,594,695	$1,848,160,209	$2,024,062,019	$86,211,453	$94,416,776
2002	$12,896,262,652	$13,881,303,571	$1,791,346,125	$1,928,172,528	$83,017,405	$89,358,431
2003	$13,696,657,217	$14,449,100,452	$1,820,956,326	$1,920,992,871	$86,932,149	$91,707,877
2004	$15,783,200,083	$16,223,860,652	$1,918,991,078	$1,972,568,534	$97,973,692	$100,709,078
2005	$15,630,467,572	$15,630,467,572	$2,010,155,372	$2,010,155,372	$101,751,871	$101,751,871

Source: WA State Employment Security Department website 2006; WA State Department of Revenue website 2006.

Table 3.2. Employment and number of firms in the forestry and wood products sector.

	Forest Sector GBI (Real)	Total WA GBI (Real)	Forest Sector GBI Ratio	Employment	Number of Firms
1994	$14,947,903,371	$349,601,389,919	4.28%	51,857	4,622
1995	$15,879,682,539	$360,464,968,619	4.41%	52,553	4,599
1996	$15,441,583,072	$381,592,784,453	4.05%	52,609	4,219
1997	$15,335,818,369	$413,590,868,751	3.71%	52,644	3,974
1998	$14,372,139,812	$419,184,411,238	3.43%	51,517	3,798
1999	$15,551,075,340	$442,146,067,234	3.52%	50,990	3,692
2000	$15,441,543,431	$463,747,739,788	3.33%	50,488	3,583
2001	$13,516,594,695	$449,723,973,211	3.01%	45,867	3,452
2002	$13,881,303,571	$426,219,152,407	3.26%	43,411	3,585
2003	$14,449,100,452	$434,108,062,031	3.33%	42,413	3,458
2004	$16,223,860,652	$469,551,457,414	3.46%	43,477	3,636
2005	$15,630,467,572	$497,169,968,927	3.14%	45,010	3,673

Source: WA State Employment Security Department website 2006; WA State Department of Revenue website 2006.

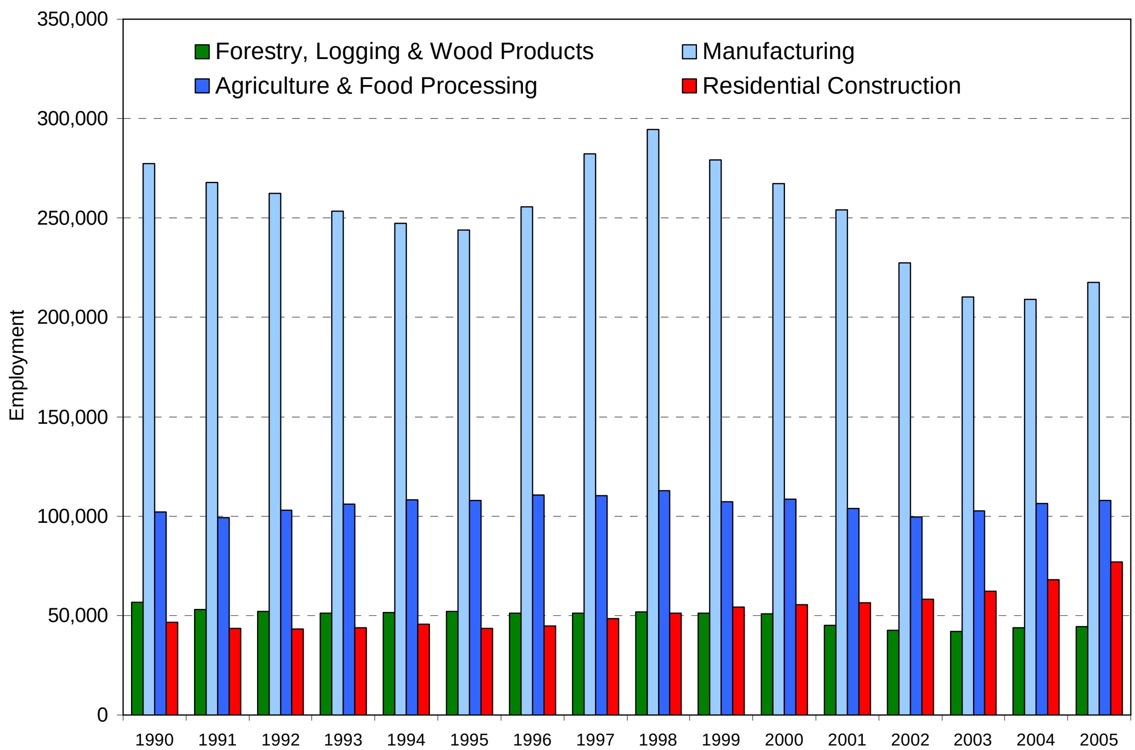


Figure 3.8. Comparative employment between major industries (*see appendix for industry classifications*).
Source: WA State Employment Security Department website 2006.

Compared to other industry sectors, the forestry and forest products sector has been relatively stable (Figure 3.8). For example, employment in the manufacturing sector declined by 12% between 1994 and 2005 while it dropped by 13.5% in the forestry and forest products sector. Employment in the agricultural sector remained relatively stable over the period while employment in residential construction sector jumped by 69%. Thus the forestry and forest products sector has remained a stable component of the State's economy, although there have been important changes within specific sub-sectors.

The forestry and forest products industry is composed of four main sectors: forestry and logging, wood manufacturing, paper manufacturing and furniture manufacturing. The largest sector by employment is wood manufacturing with 42% of the industry employment followed by paper manufacturing (27%), furniture manufacturing (17%) and forestry and logging (13%). Evaluating the industry sectors on the basis of gross business income, the largest sector remains wood manufacturing with a 50% share followed by paper manufacturing (30%), forestry and logging (13%) and furniture manufacturing (6%).

Despite a 15 year decline in employment, the forestry and logging sector saw a dramatic increase in gross business revenue between 2001 and 2004 before declining in 2005 (Figure 3.9). Employment has followed harvest levels to a surprising degree as illustrated in Figure 3.10, suggesting a close linkage between the two. Productivity within the logging sector has continued declining over the past decade.

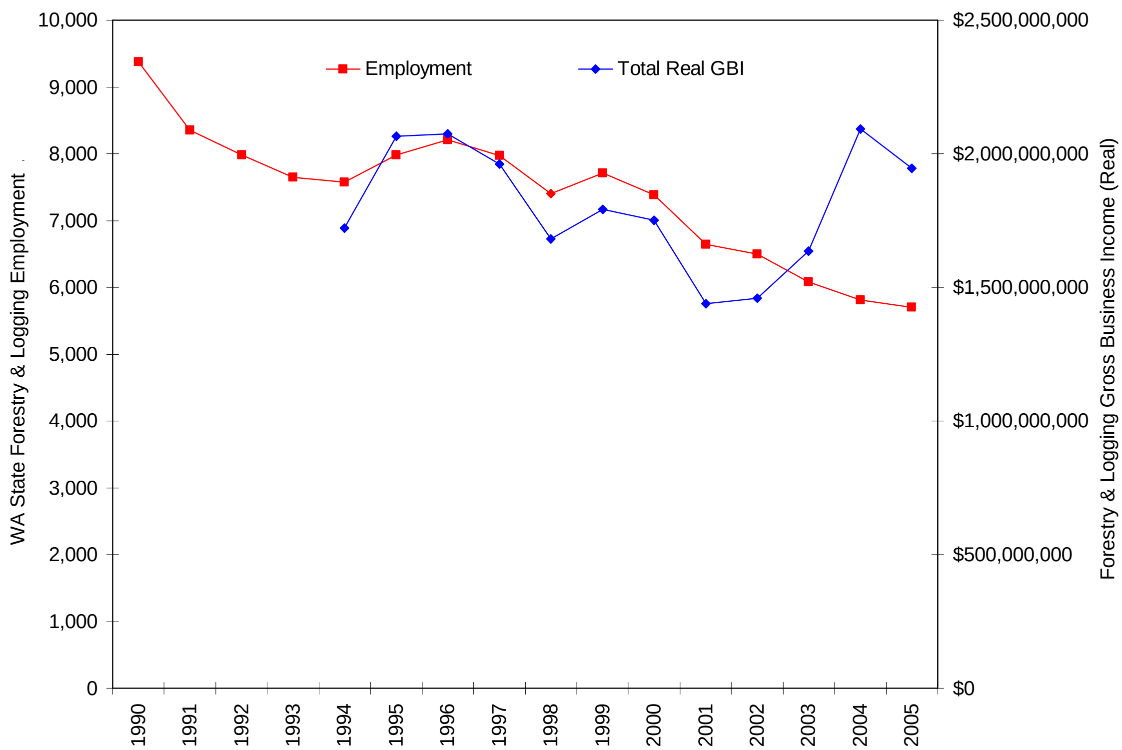


Figure 3.9. Employment and real GBI in the forestry and logging sector, 1990-2005.
Source: WA State Employment Security Department website 2006; WA State Department of Revenue website 2006.

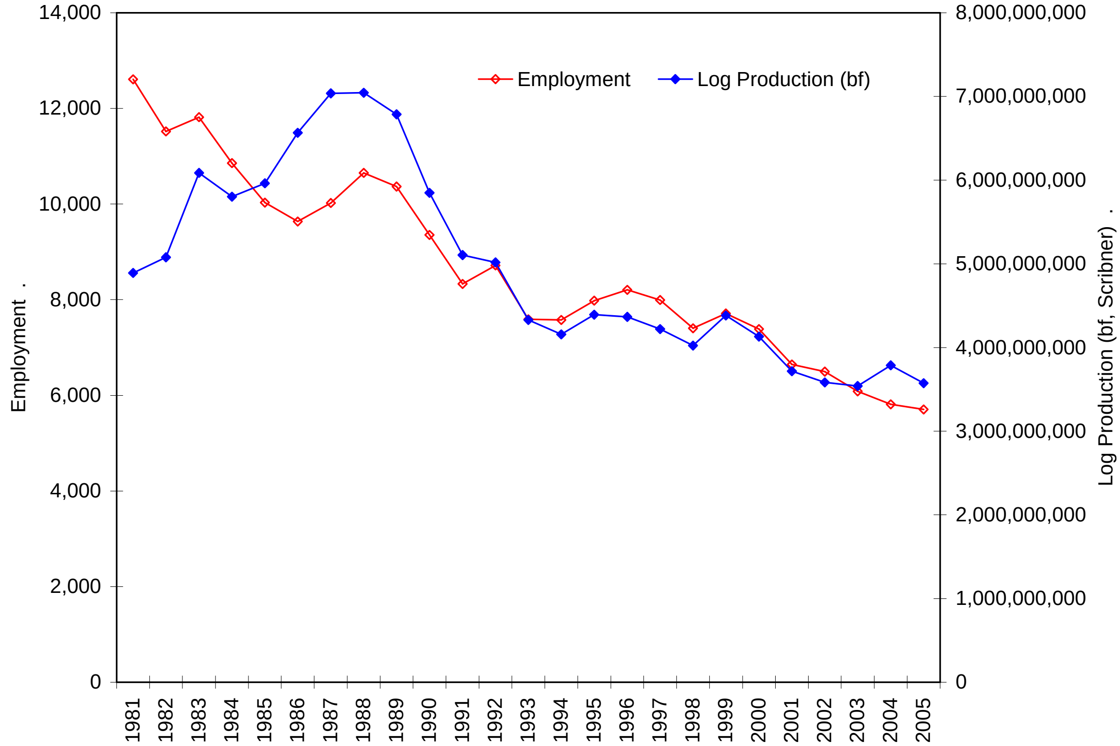


Figure 3.10. Employment and timber harvest in the logging sector, 1981-2005.
Source: WA State Employment Security Department website 2006; WA State Department of Revenue website 2006.

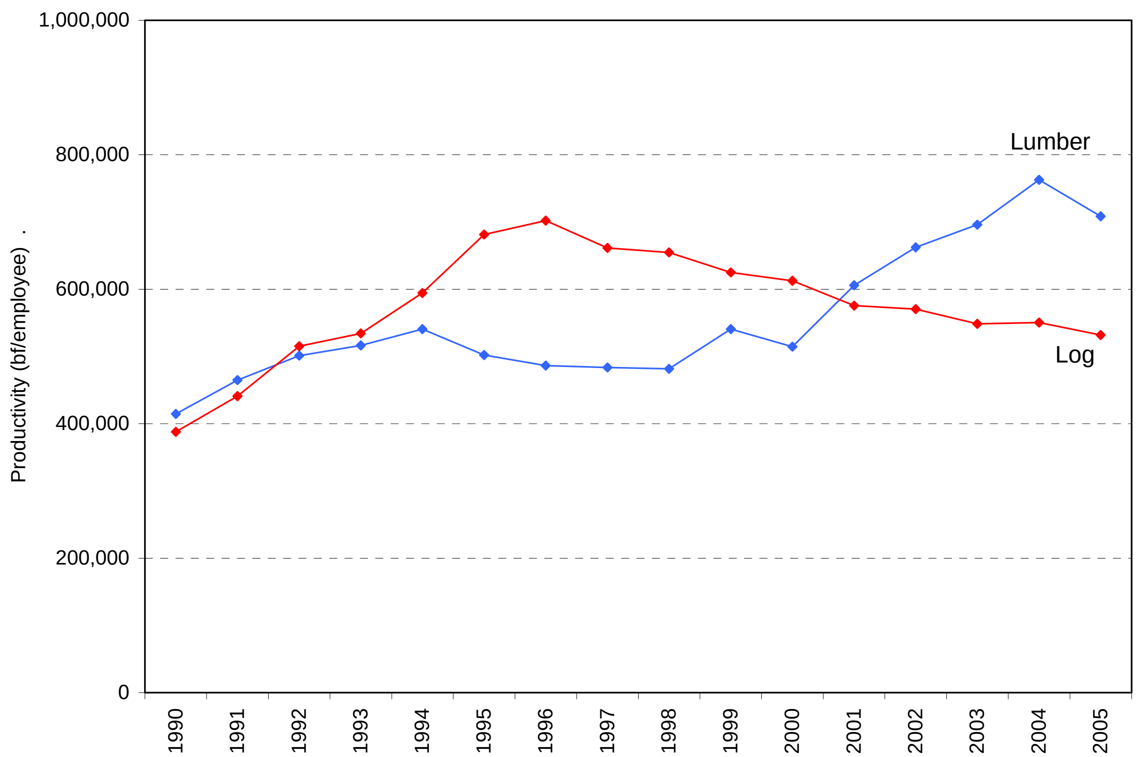


Figure 3.11. Worker productivity in the logging and sawmills sectors, 1990-2005.
Source: WA State Employment Security Department website 2006; WA State Department of Revenue website 2006.

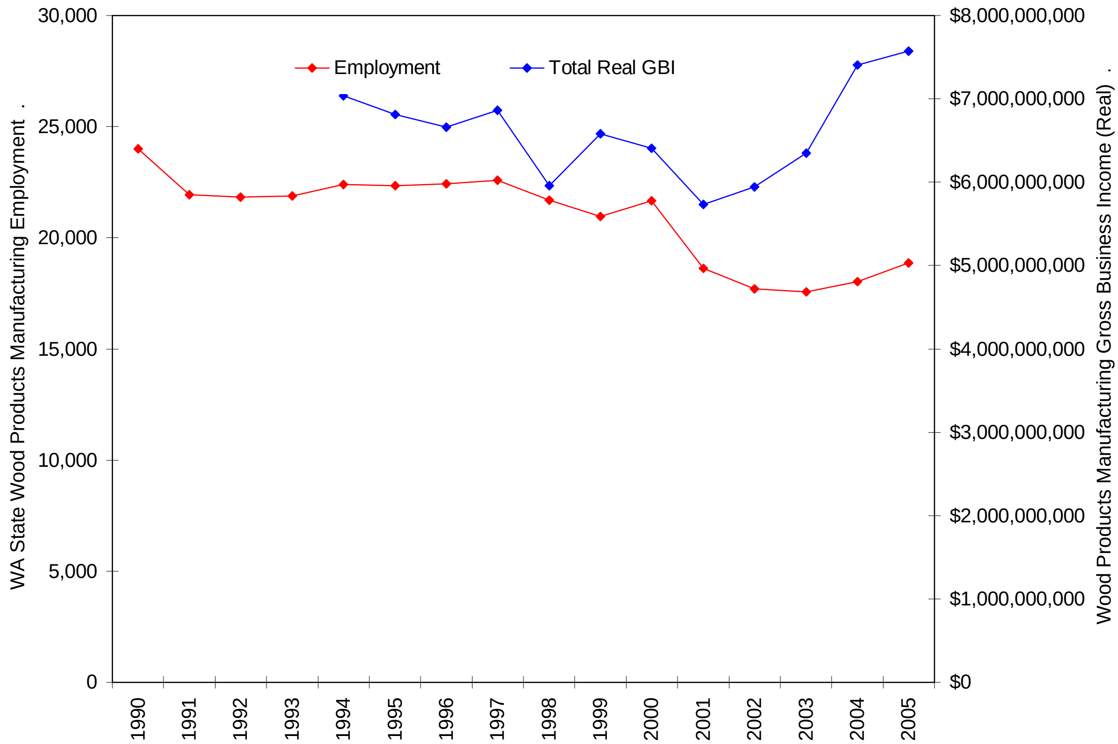


Figure 3.12. Employment and real GBI in the wood manufacturing sector, 1990-2005.
Source: WA State Employment Security Department website 2006; WA State Department of Revenue website 2006.

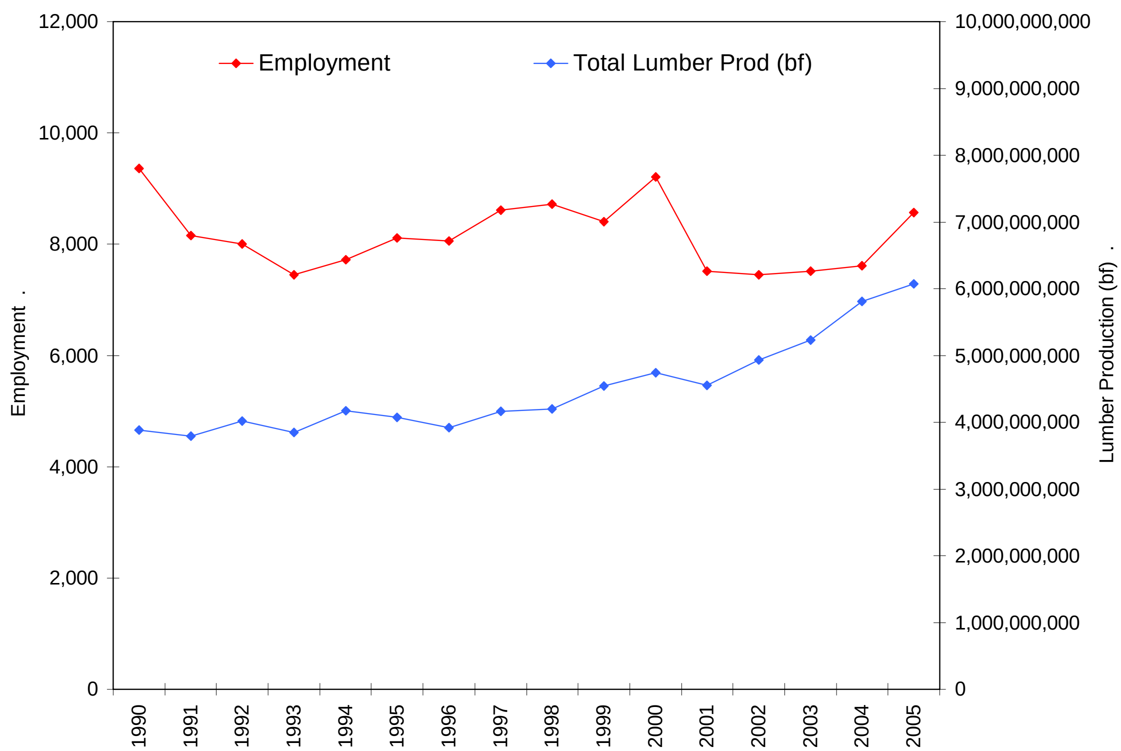


Figure 3.13. Employment and lumber production in the sawmill sector, 1990-2005.
Source: WA State Employment Security Department website 2006; WWPA Yearbook various years.

The largest sector within the forestry and forest products industry is the wood manufacturing sector, both in terms of employment and gross business income. While employment has declined substantially (15.8%) over the period 1994-2005, GBI has increased, particularly during the period 2001-2005 when it increased by 32%, Figure 3.12. Much of this increase can be attributed to the strong performance of the lumber manufacturing sub-sector, Figure 3.13. Strong housing starts over the period 2000-2005 as well as record demand for softwood lumber provided high lumber prices and help to increase gross business income for sawmills. A combination of lower housing starts and increased lumber imports from Canada (as a result of the new Softwood Lumber Agreement) has weakened softwood lumber prices throughout much of 2006 and will adversely affect the financial performance of the industry in 2006 (Figure 3.14). A flood of Canadian lumber arrived into the US between the signing of the new softwood lumber agreement and its implementation a month later. This lumber glut, while short-term, had a chilling effect on lumber prices.

The softwood lumber industry in the western US has increased production since the mid 1990's and represents approximately 50% of domestic softwood lumber production, Figure 3.15. However, with US production increasing by approximately 0.8% annually, and domestic consumption of softwood lumber increasing by 2.7% annually, the US will increasingly rely on imports to fill the supply gap (Figure 3.16).

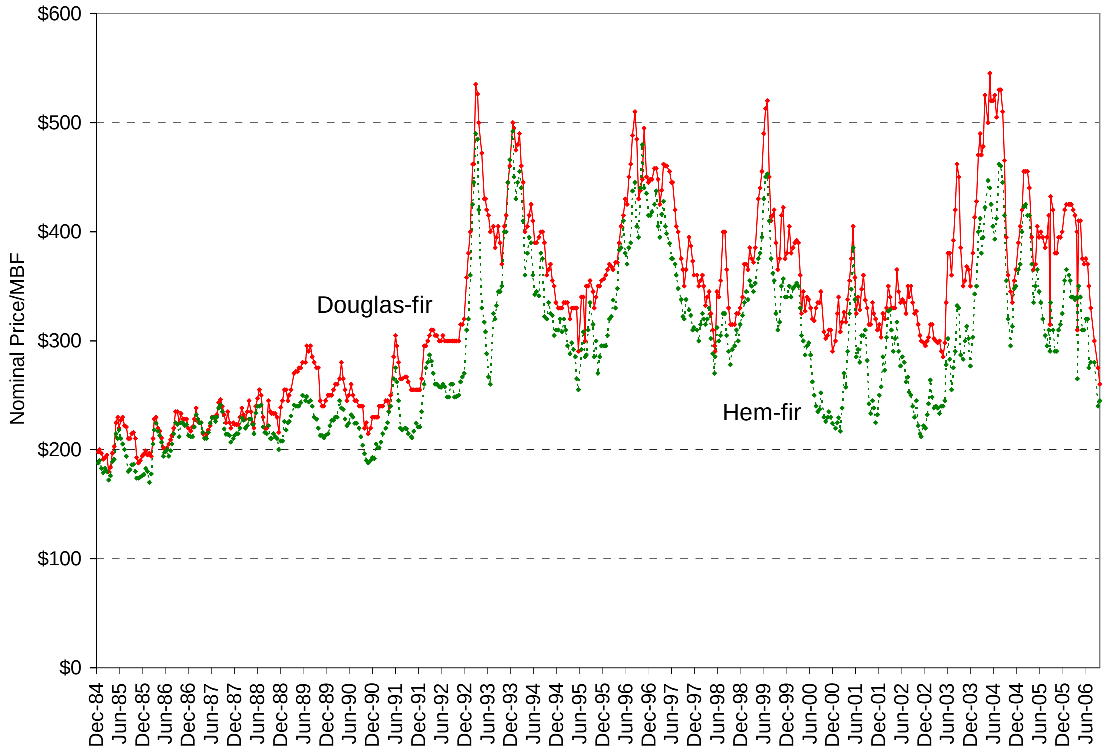


Figure 3.14. Nominal prices for Douglas-fir and hemlock dimension lumber (2x4, Std&Btr, KD, RL).
Source: Random Lengths, various.

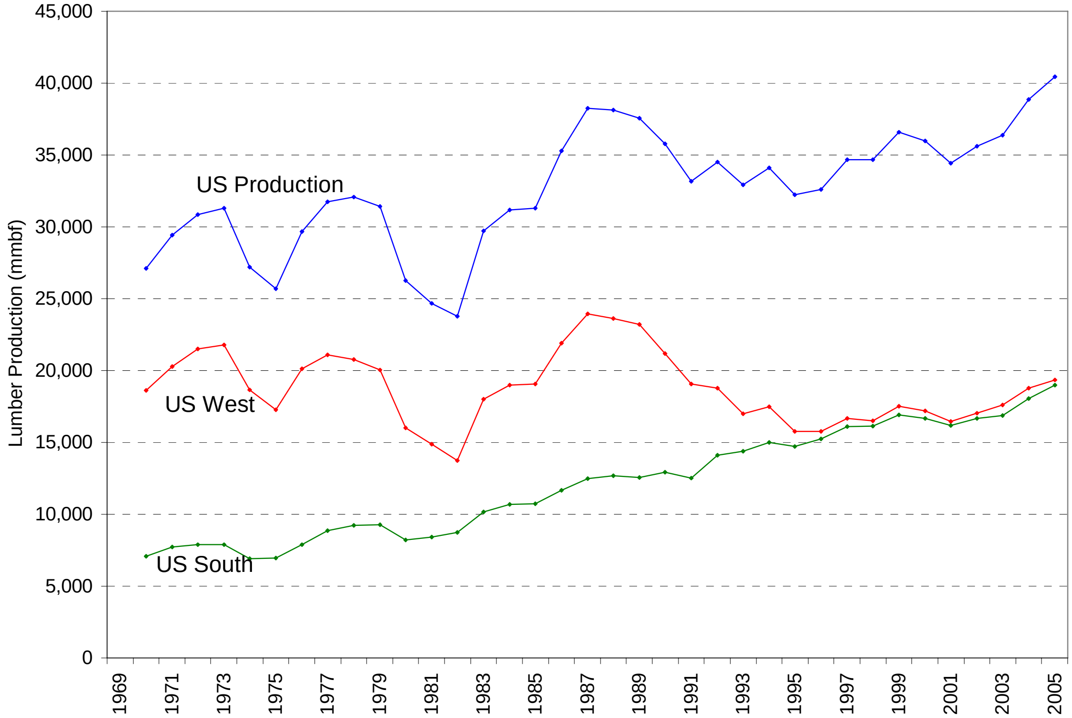


Figure 3.15. Softwood lumber production by geographic region.
Source: WWPA Yearbook various years.

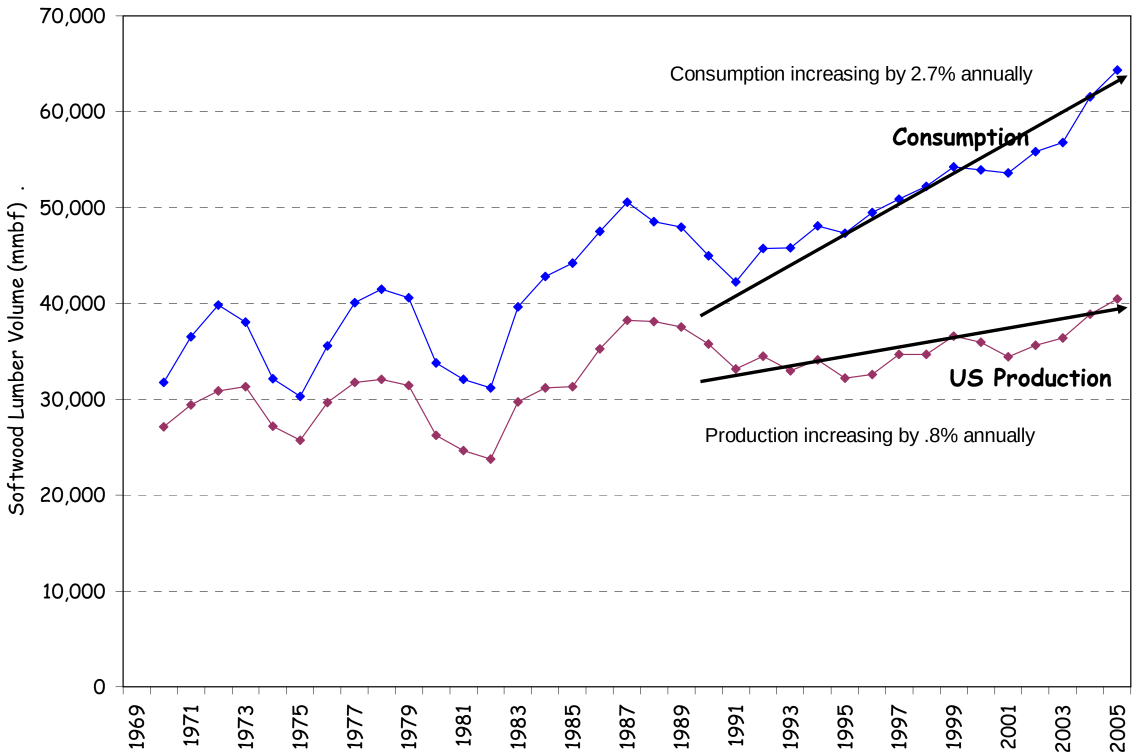


Figure 3.16. Consumption is increasing faster than is domestic production
Source: WWPA Yearbook various years.

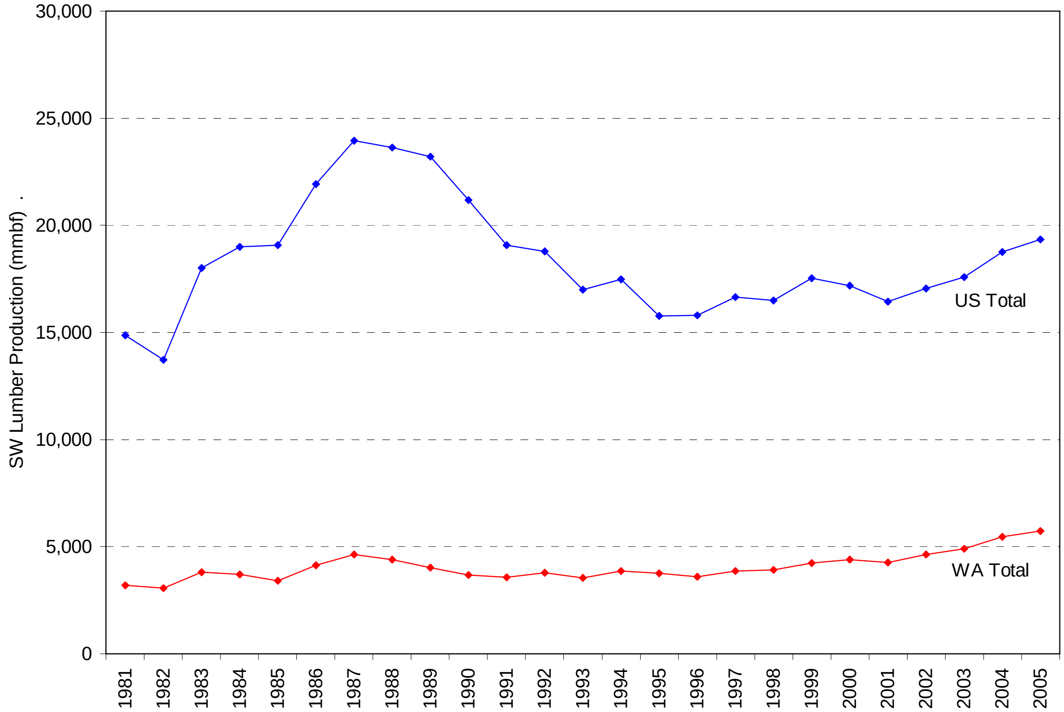


Figure 3.17. Softwood lumber production in Washington state, 1981-2005.
Source: WWPA Yearbook various years.

The sawmill industry in Washington state suffered through a tough period between 1987 and 1993, much of which can be attributed to a drop in demand cause by a recession during 1990-1991 and the loss of federal timber as a result of the decision to list the spotted owl as an endangered species in 1989. Between 1987 and 1993 softwood lumber production in Washington decreased by 23.5% as 45 sawmills closed and almost 1,400 jobs were lost (Figure 3.17 and Table 3.3) Industry consolidation continued throughout the next decade and by 2005 the number of sawmills had declined from 217 (in 1994) to 128. Much of this decline in sawmills can be attributed to the closure of older, inefficient sawmills that relied on the large, old-growth logs coming from the federal forests. Despite the huge drop in sawmills, employment in the sawmill sector actually increased from 7,721 to 8,565 between 1994 and 2005 as larger more efficient sawmills were built to replace the older mills being closed.

This can be clearly seen in the productivity numbers presented in Table 3.3. During the period 1994-2005, the number of workers per sawmill increased from 35.6 to 66.9 (an 88% increase). During the same period, the volume of lumber produced per sawmill increased from 18 million board feet to 45 million board feet (a 150% increase) and lumber production per employee increased from 500,000 board feet to 670,000 board feet (a 33% increase). These numbers suggest that not only were mills getting bigger but the industry was also investing in new processing technologies that improved lumber yields and increased production efficiency. This investment is clearly reflected in the information presented in Figure 3.3 and Figure 3.18.

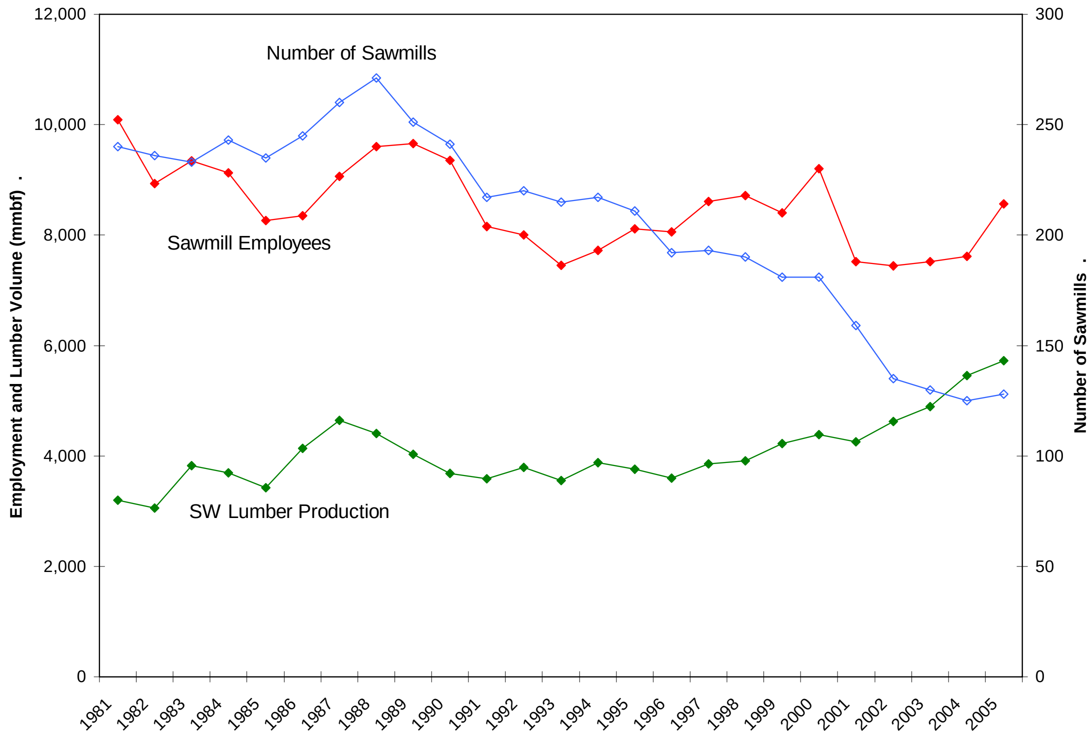


Figure 3.18. Demographic changes within the Washington sawmill industry, 1981-2005.
Source: WA State Employment Security Department website 2006; WWPA Yearbook various years.

Table 3.3. Summary statistics for Washington sawmills, 1981-2005.

	WA Prod (bf)	WA Sawmills	WA Employment	Production (bf)/Mill	Employment/Mill	Production (bf)/Employee
1981	3,200,000,000	240	10,083	13,333,333	42.01	317,354
1982	3,059,000,000	236	8,928	12,961,864	37.83	342,630
1983	3,821,000,000	233	9,346	16,399,142	40.11	408,837
1984	3,697,000,000	243	9,122	15,213,992	37.54	405,290
1985	3,419,000,000	235	8,268	14,548,936	35.18	413,512
1986	4,132,000,000	245	8,352	16,865,306	34.09	494,707
1987	4,645,000,000	260	9,059	17,865,385	34.84	512,758
1988	4,408,000,000	271	9,604	16,265,683	35.44	458,969
1989	4,024,000,000	251	9,651	16,031,873	38.45	416,961
1990	3,678,000,000	241	9,356	15,261,411	38.82	393,117
1991	3,581,000,000	217	8,152	16,502,304	37.57	439,279
1992	3,794,000,000	220	8,006	17,245,455	36.39	473,895
1993	3,555,000,000	215	7,451	16,534,884	34.66	477,117
1994	3,876,000,000	217	7,721	17,861,751	35.58	502,008
1995	3,764,000,000	211	8,109	17,838,863	38.43	464,176
1996	3,596,000,000	192	8,061	18,729,167	41.98	446,098
1997	3,851,000,000	193	8,612	19,953,368	44.62	447,167
1998	3,913,000,000	190	8,718	20,594,737	45.88	448,841
1999	4,224,000,000	181	8,403	23,337,017	46.43	502,678
2000	4,384,000,000	181	9,206	24,220,994	50.86	476,211
2001	4,257,000,000	159	7,515	26,773,585	47.26	566,467
2002	4,625,000,000	135	7,446	34,259,259	55.16	621,139
2003	4,898,000,000	130	7,519	37,676,923	57.84	651,416
2004	5,455,000,000	125	7,613	43,640,000	60.90	716,538
2005	5,729,000,000	128	8,565	44,757,813	66.91	668,885

Source: WWPA Yearbook various years.

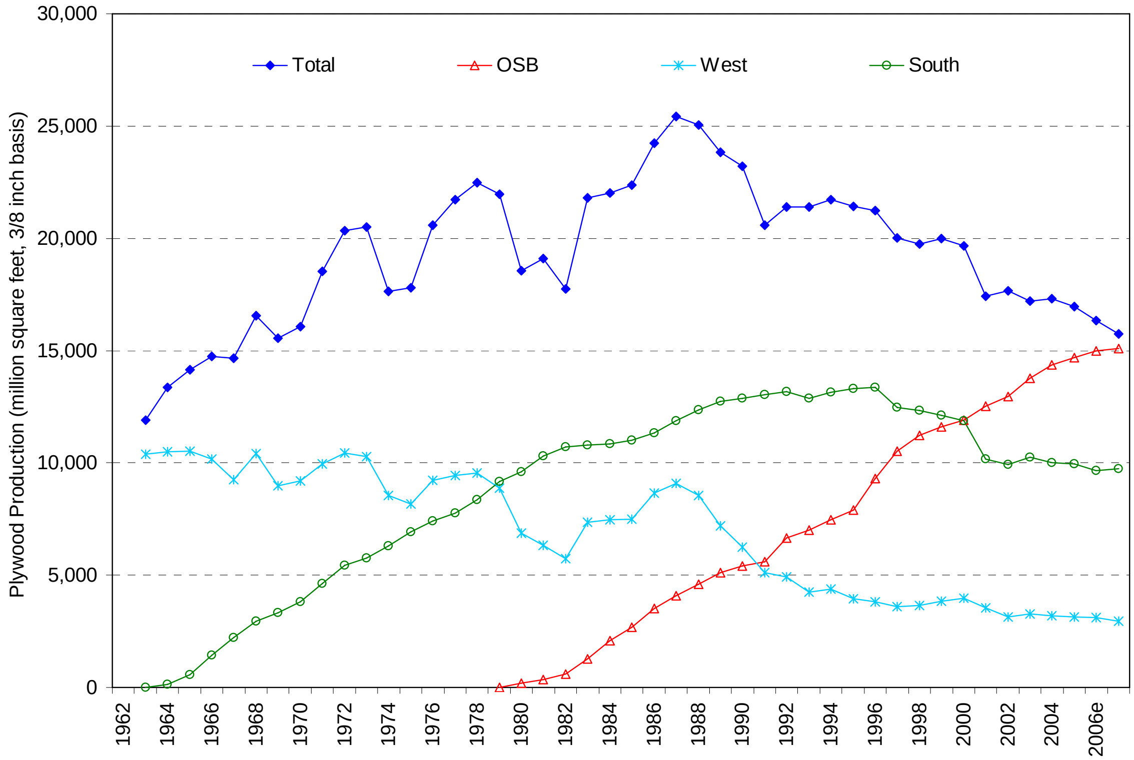


Figure 3.19. Plywood production in the US, by region.
Source: APA Annual Yearbook, various years.

Under the NAICS classification system, the softwood plywood industry includes both plywood manufacturers and veneer manufacturers. The commercial softwood plywood industry really began in Washington and Oregon at the turn of the 20th century as manufacturers took advantage of the large high quality Douglas-fir and white pine logs. However, following the introduction of lower cost southern pine plywood in the early 1960's, the demand for western plywood began a decline that continues to today, Figure 3.19 and 3.20. In fact, to a large degree both western and southern plywood are being replaced by lower cost oriented strand board (OSB). It is important to note that as the end-use market transitions from plywood to OSB, there are no OSB mills located in the state of Washington.

The plywood industry in Washington, previously one of the largest in the US, has been in decline since 1962, Figure 3.20. The number of plywood mills has dropped from 35 to 8 during this period although plywood production has only declined from 1.8 billion square feet (3/8 inch basis) to 1.1 billion square feet (3/8 inch basis). As seen in the sawmill industry, the closure of smaller, inefficient mills has been offset to a degree by the establishment of larger, more efficient plywood mills. Annual production per mill in 1962 was just 52 million square feet whereas this has jumped to 137 million square feet in 2005 (Figure 3.21). The challenge for the structural panel industry is to successfully make the transition from plywood to OSB.

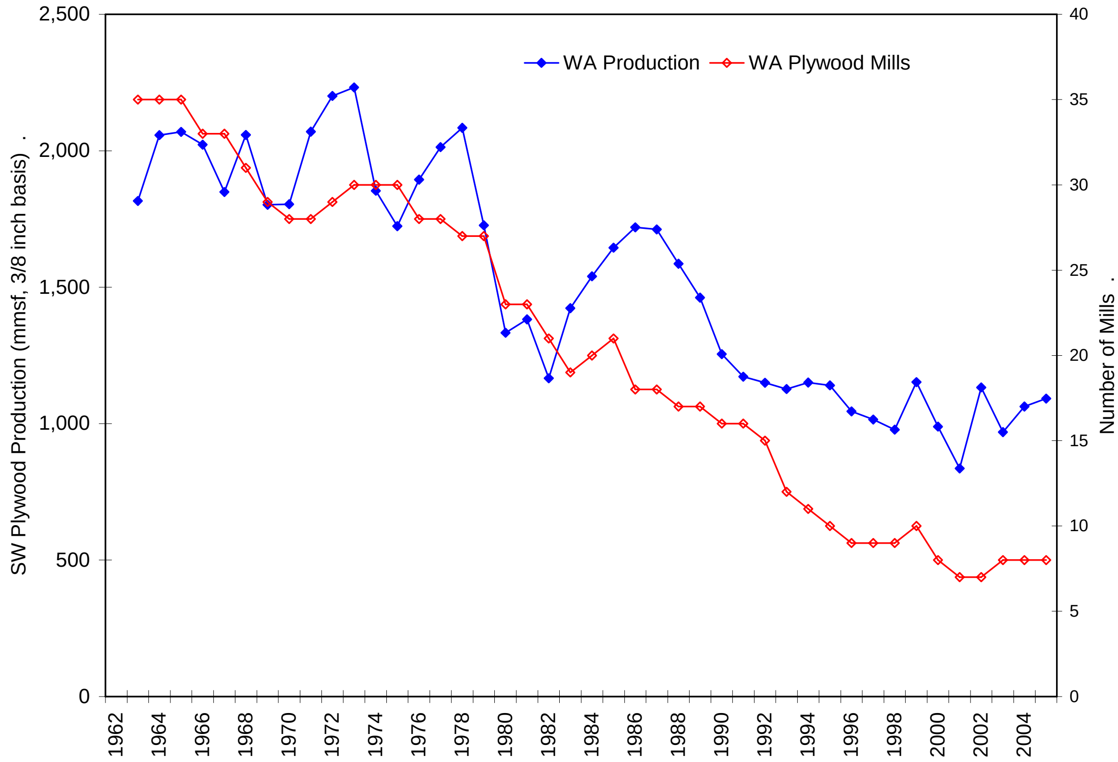


Figure 3.20. Demographic changes within the Washington plywood industry, 1962-2005.
Source: APA Annual Yearbook, various years.

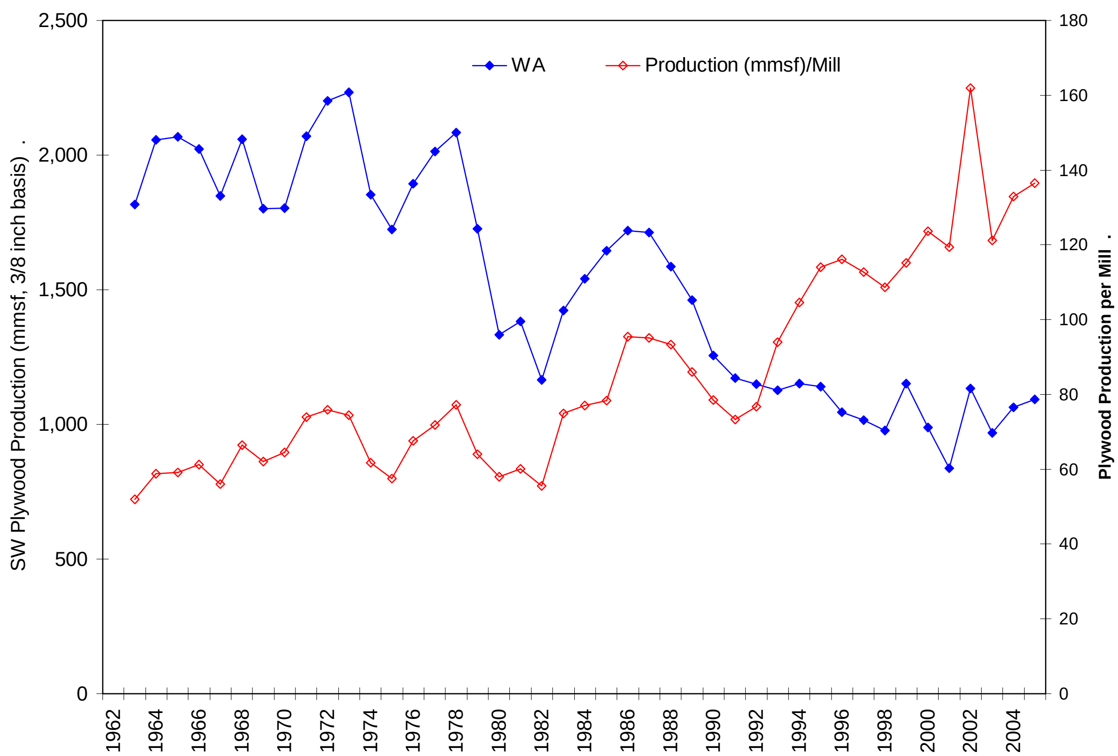


Figure 3.21. Plywood production and production per mill, 1962-2005.
Source: APA Annual Yearbook, various years.

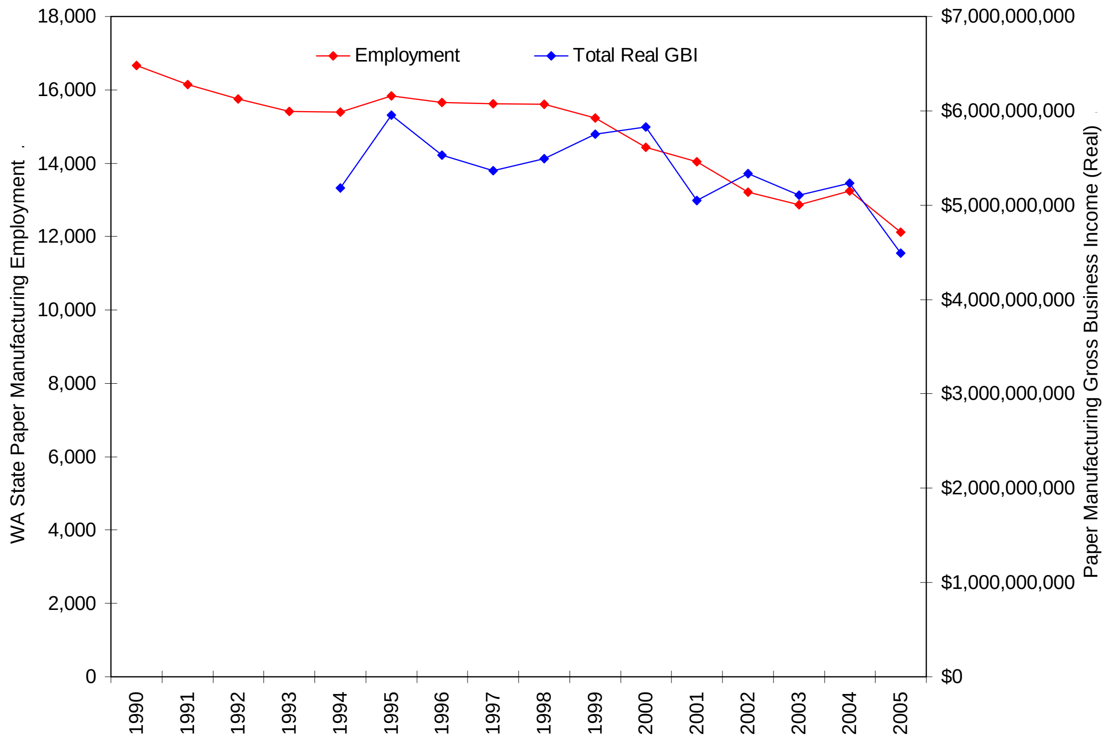


Figure 3.22. Employment and real GBI in the pulp and paper manufacturing sector, 1990-2005.
Source: WA State Employment Security Department website 2006; WA State Department of Revenue website 2006.

The Washington pulp and paper sector is the second largest following wood products manufacturing. In addition to its importance within the economy, this sector also plays an important demand role within the forest products industry. Pulp and paper companies are important consumers of lower quality pulp logs as well as providing a demand for by-products from other forest products industries such as sawdust and planer shavings from the sawmill industry. Given the cost structure of the sawmill industry, lumber manufacturers often break even at best with their lumber production and it is the sales of their by-products that provide them with an operating profit. Thus this industry segment is particularly important to the health of the sawmill and logging sectors. From a strategic industry perspective, it is extremely important that this industry remain healthy and viable within the state of Washington.

Since 1990 there has been a contraction in the number of pulp and paper mills (NAICS: 322) and employment within the sector. Between 1990 and 2005, the number of pulp and paper mills has declined from 106 to 93, although specific numbers for pulp mills and paperboard mills are not available due to confidentiality concerns. Across the entire pulp and paper sector employment has declined from 16,663 in 190 to 12,117 in 2005. Similarly, the real gross business income for the sector has declined slightly from $5.2 billion to $4.5 billion over the same time period.

In contrast to the trends observed in many industry sectors, the wooden furniture industry is doing well. Being primarily a consumer oriented industry, it competes in a different market than do most of the other forest products sectors in Washington. Between 1994 and 2005, the industry has experienced solid growth in employment, gross business income and the number of firms operating in the industry. Gross business income increased from $516 million to $899 million during this period while employment jumped from 5,400 to 7,600 although the number of wooden furniture manufacturers decreased slightly from 536 to 531.

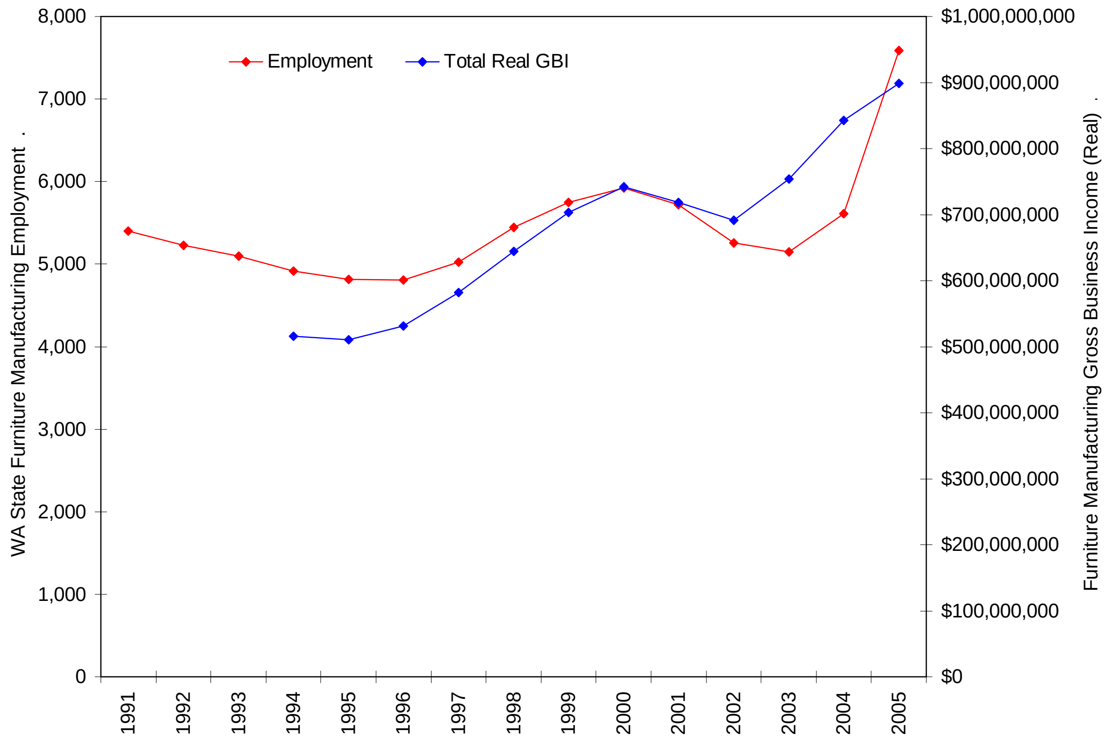


Figure 3.23. Employment and real GBI in the wood furniture manufacturing sector, 1990-2005.
Source: WA State Employment Security Department website 2006; WA State Department of Revenue website 2006.

Economic Contribution of the Forestry and Forest Products Sector at the Timbershed Level

Another important consideration regarding the economic importance of the forestry and forest products industries in Washington is their contribution to local economies. Whereas business data is theoretically available at the county level, oftentimes confidentiality concerns preclude the reporting of this data. In addition, the effort to link the economic analysis with the timber supply analysis suggests that it would be useful for the economic data to be aggregated in such a way that the results can be reported to coincide with the timbersheds developed for use in the timber supply study. As a result, the second phase of the economic analysis will look at the economic contribution of the forestry and forest products industries within the timbersheds defined by the timber supply study.

The regional groupings of counties employed in this study are as follows:

North Coast Clallam and Jefferson	***North Puget Sound*** King, Snohomish, Island, San Juan, Skagit and Whatcom
South Coast Grays Harbor and Pacific	***East Cascade*** Okanogan, Chelan, Douglas, Kittitas, Yakima and Klickitat
Southwest Lewis, Wahkiakum, Cowlitz, Clark and Skamania	***Inland Empire*** Ferry, Stevens, Pend Oreille, Lincoln, Spokane, Grant, Adams, Whitman, Benton, Franklin, Walla Walla, Columbia, Garfield and Asotin
South Puget Sound Kitsap, Pierce, Thurston and Mason	

Methodology for Estimating Gross Business Income within the Timbersheds

In order to develop the economic information for this component of the economic analysis, it required aggregating the county level economic data for the counties included in each timbershed. However, the Washington State Department of Revenue does not collect gross business information for specific industries at the county level, only at the state level. While there are a number of reasons for this, it required that we develop a methodology to estimate gross business income within each timbershed. Two proxies that are correlated with gross business income are total wages and total employment within the industry sectors of interest. However, since both measures are highly correlated, we employed both measures in a regression to determine which provided the best estimate. The regression methodology and results are provided in the appendix. Ultimately it was determined that total wages provided a better estimate of gross business income.

Direct and Indirect Impact of Jobs in the Forestry and Forest Products Sectors

Increases in the timber harvest activities on state forests can reasonably be expected to result in direct economic benefits for rural communities. Multiplier benefits derived from increased employment that ripple through the entire state economy will occur as well. Existing economic models to estimate the full impact of changes in the forest sector on the economy are dated. Recent estimates of direct employment impacts are incomplete and cannot be directly linked to models that characterize the full direct and indirect impacts. Warren (2004) estimated direct forest industry employment in Washington and Oregon at 13.2 workers per million board feet of annual timber harvest for the year 2002. Han et al. (2002) suggests that the number of direct jobs in Idaho may fluctuate from 9 to 11 workers per million board feet of timber harvest per year. In addition to direct forest industry employment, there are many more indirect jobs from timber harvest that provide benefits throughout the state. Conway (1994) developed a regional inter-industry econometric model called the Washington Projection and Simulation Model (WPSM). His model has been used to evaluate many policy and economic development changes in the state. He estimated the total direct and indirect jobs per year created from a million board foot of timber harvest in Washington State in 1992. He estimates that for every direct industry job per million board feet of timber harvest per year, an additional 4.2 indirect jobs were created within the state. For example, he estimated that in 1992 there were 7.7 direct jobs and 32.3 indirect jobs linked to each million board feet of timber harvest in Washington. In addition, revenue generated from DNR timber sales has a uniquely powerful impact on state wealth since one hundred percent of stumpage revenues are reinvested for the public good in government programs and services in Washington.

In 1994, Lippke and Conway developed an estimate of the economic costs associated with incremental decreases in trust revenue from reductions in the DNR timber sales program. Evidence at that time indicated that 29.7 Washington jobs would be lost for every $1 million in tax increases to replace lost trust revenue. Further public benefits are derived from DNR timber sales through the generation of state and local, and federal tax revenues. In 1996 these were calculated to be 11% and 19% of the Gross State Product, respectively (Lippke et al. 1996).

The original WPSM study on the forest sector provided information on seven direct forest products sectors, ten indirect sectors, associated sector incomes and product values, the Gross State Product, state and local taxes, federal taxes, and other downstream economic metrics of interest. The WPSM was used with a regional analysis methodology to produce regional economic impacts and multipliers. Unfortunately 1992 was the last time that the forest sector was updated in WSPM. Much has changed since then in both the processing stages and technology for wood products while the changing location of manufacturing facilities will affect the regional economic impacts.

In order to better understand the broad social and economic implications of adjustments in state harvest volumes and revenues, as well as changes in the production processes, we suggest that the old models be updated using the most recent data and develop updated survey-based estimates for different processing technologies (e.g., short vs. long rotation thinning regimes, biofuel removals, and new wood processing technologies) that will allow for the recalculation of the direct and indirect economic impacts from these activities for use with the most recent statewide economic model data. Developing updated multiplier models would be helpful to the Board of Natural Resources, the DNR, state and local economic development people, educators, and others interested in the unique contribution that state timber harvests make to Washington's economy, especially its timber rural communities.

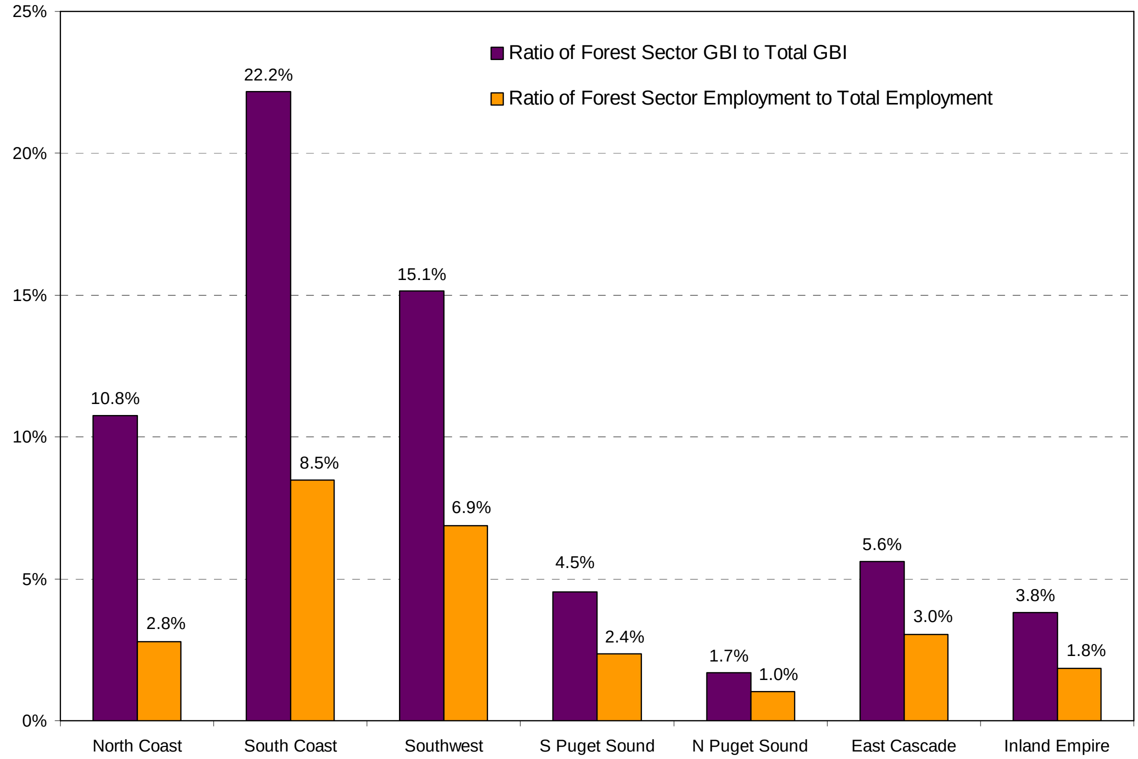


Figure 3.24. Forest sector GBI and employment with the timbersheds (2005).
Source: WA State Employment Security Department website 2006; .WA State Department of Revenue website 2006.

The forestry and forest products sectors included in this study play a different role within the economies of the seven timbersheds included in the study. Gross business income from the forestry and forest products sectors is much more important in the north coast, south coast and southwest timbersheds than in the others. On the other hand, employment in this sector is most important in the south coast and southwest timbersheds. However, it is important to remember that this sector makes an important contribution to the economies of all timbersheds. It should also be remembered that there is an interconnectedness between the forestry and forest products industries in each timbershed, with logs from the coastal timbersheds providing raw material inputs to processors in other timbersheds while waste by-products from sawmills are shipped to paper manufacturers in other timbersheds. The following figures (Figures 3.25 thru 3.38) provide a summary of the trends in employment and gross business income for specific industry sectors within each timbershed.

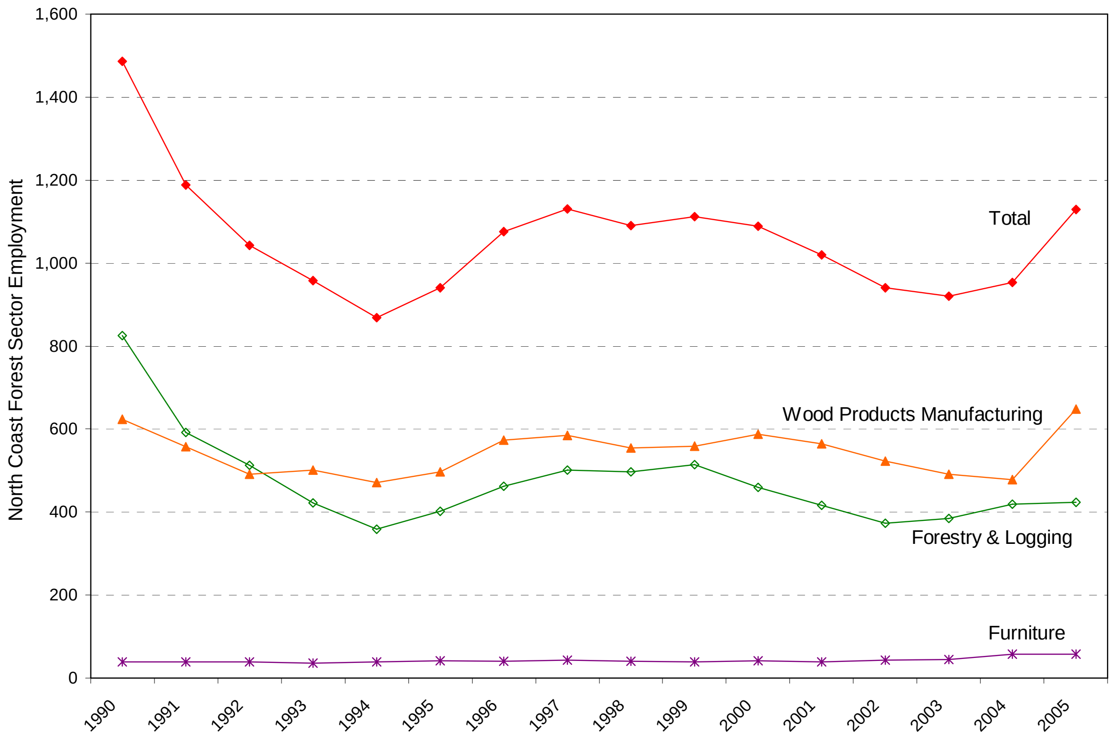


Figure 3.25. Employment within the North Coast forest sector.
Source: WA State Employment Security Department website 2006.

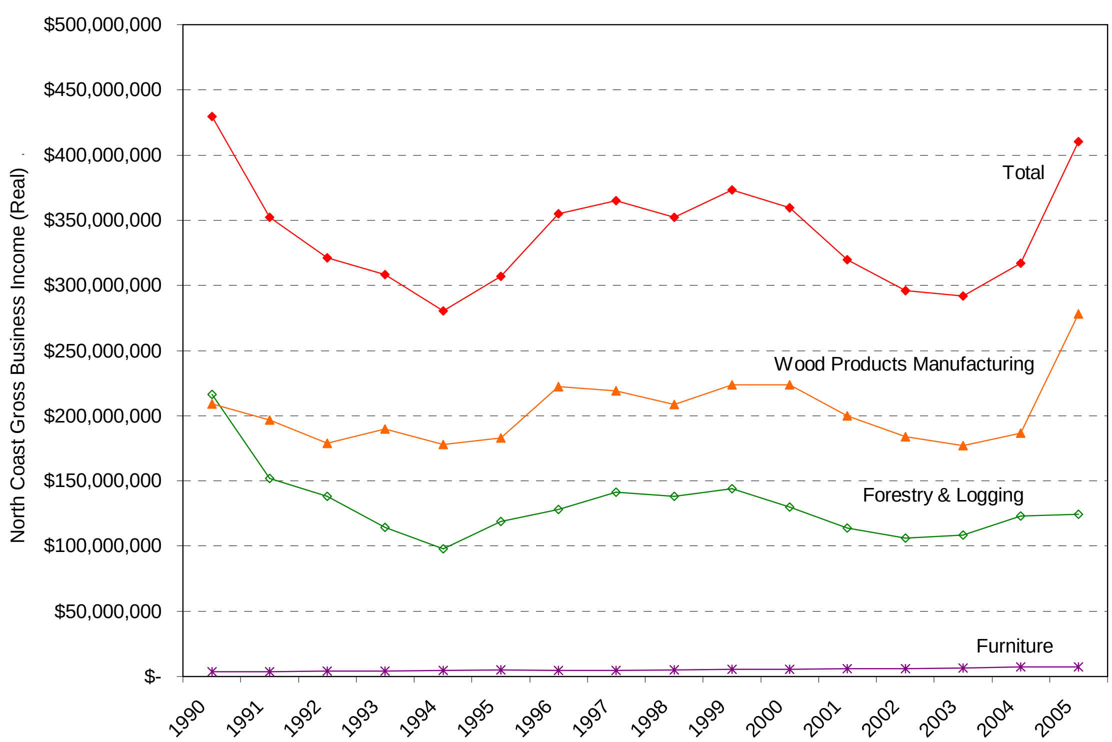


Figure 3.26. Gross business income within the North Coast forest sector.
Source: WA State Department of Revenue website 2006.

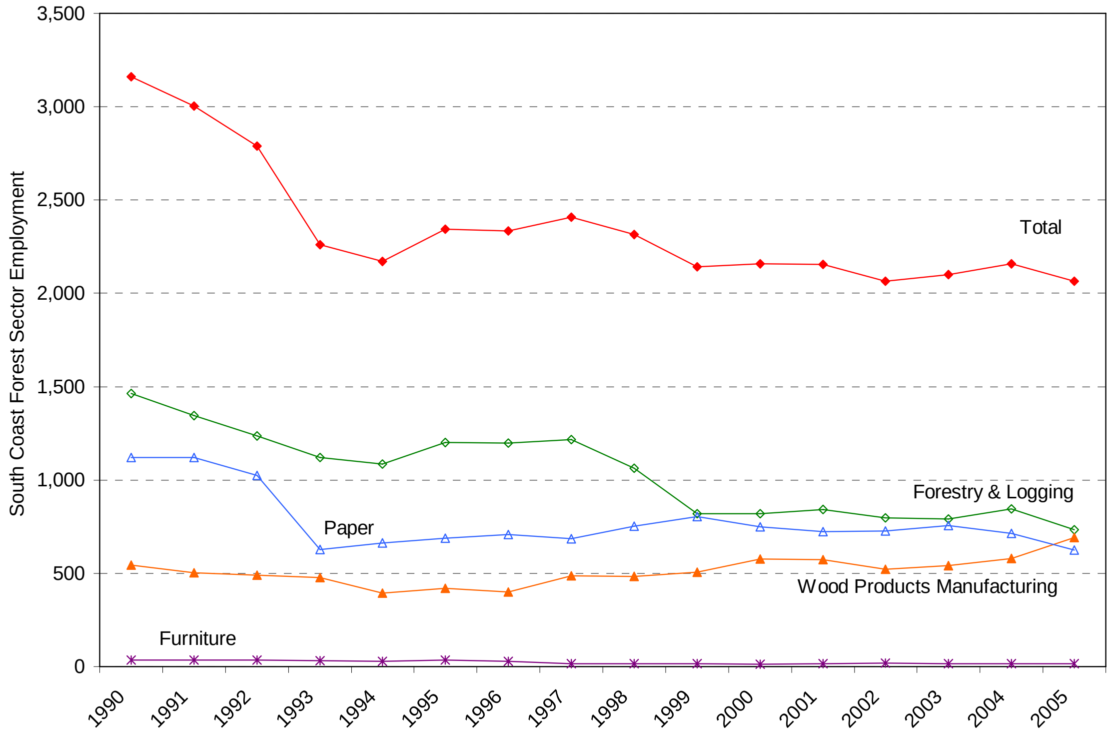


Figure 3.27. Employment within the South Coast forest sector.
Source: WA State Employment Security Department website 2006.

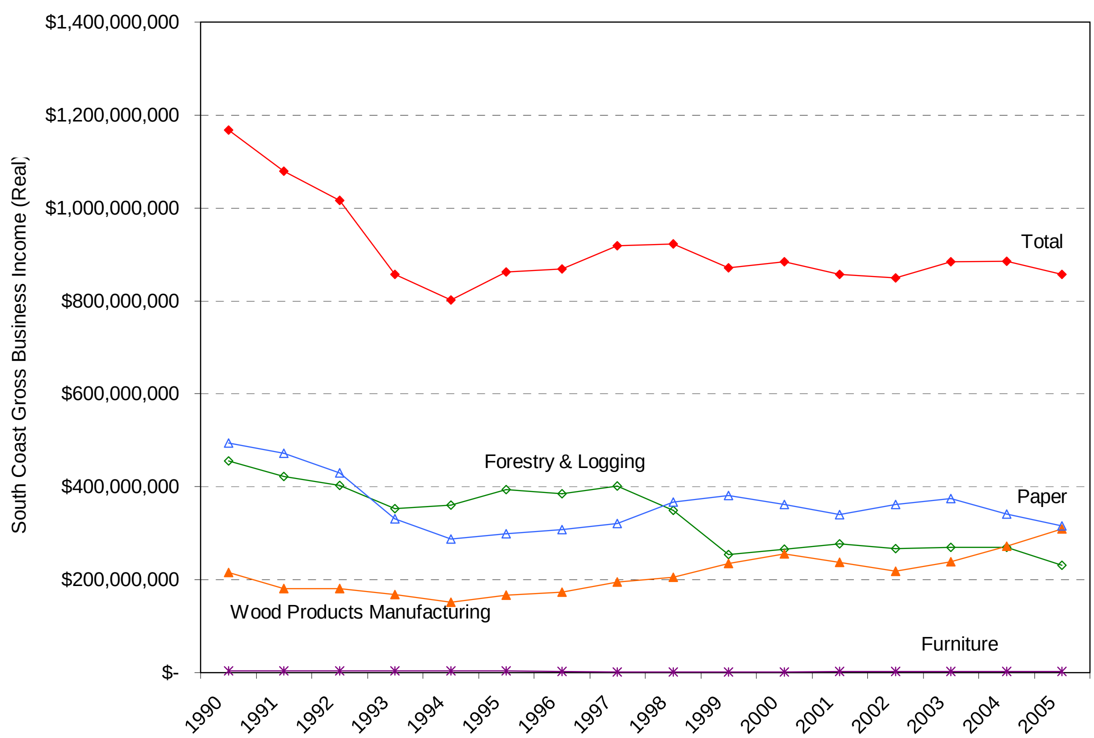


Figure 3.28. Gross business income within the South Coast forest sector.
Source: WA State Department of Revenue website 2006.

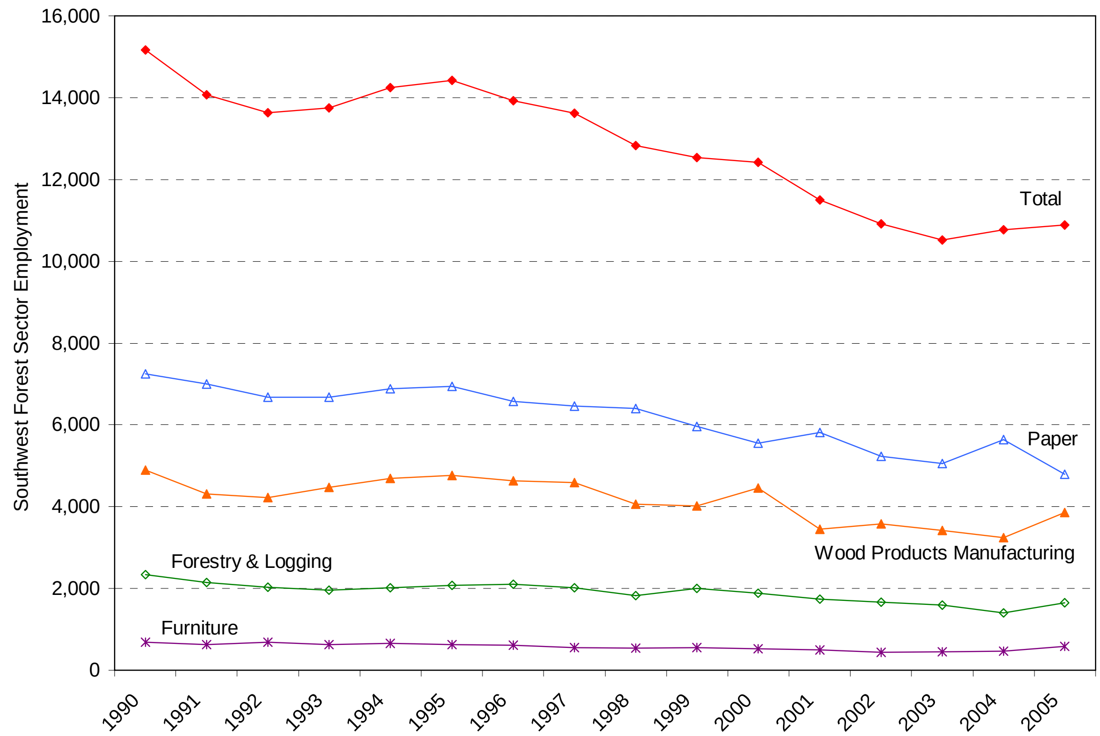


Figure 3.29. Employment within the Southwest forest sector.
Source: WA State Employment Security Department website 2006.

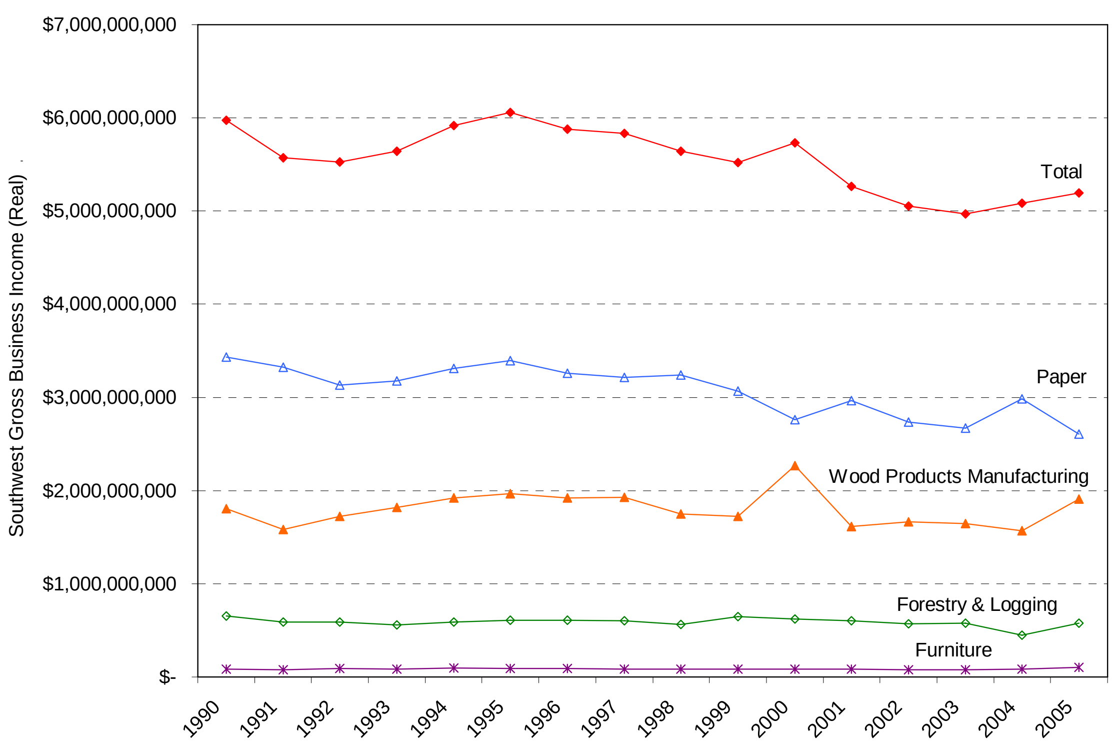


Figure 3.30. Gross business income within the Southwest forest sector.
Source: WA State Department of Revenue website 2006.

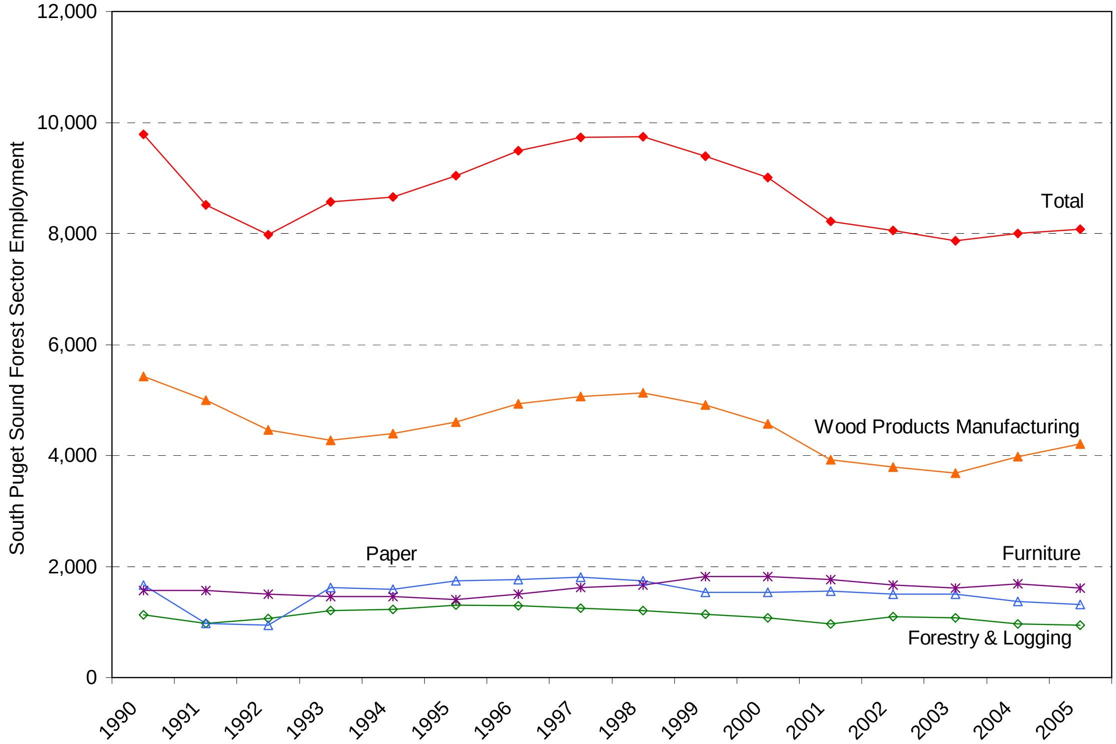


Figure 3.31. Employment within the South Puget Sound forest sector.
Source: WA State Employment Security Department website 2006.

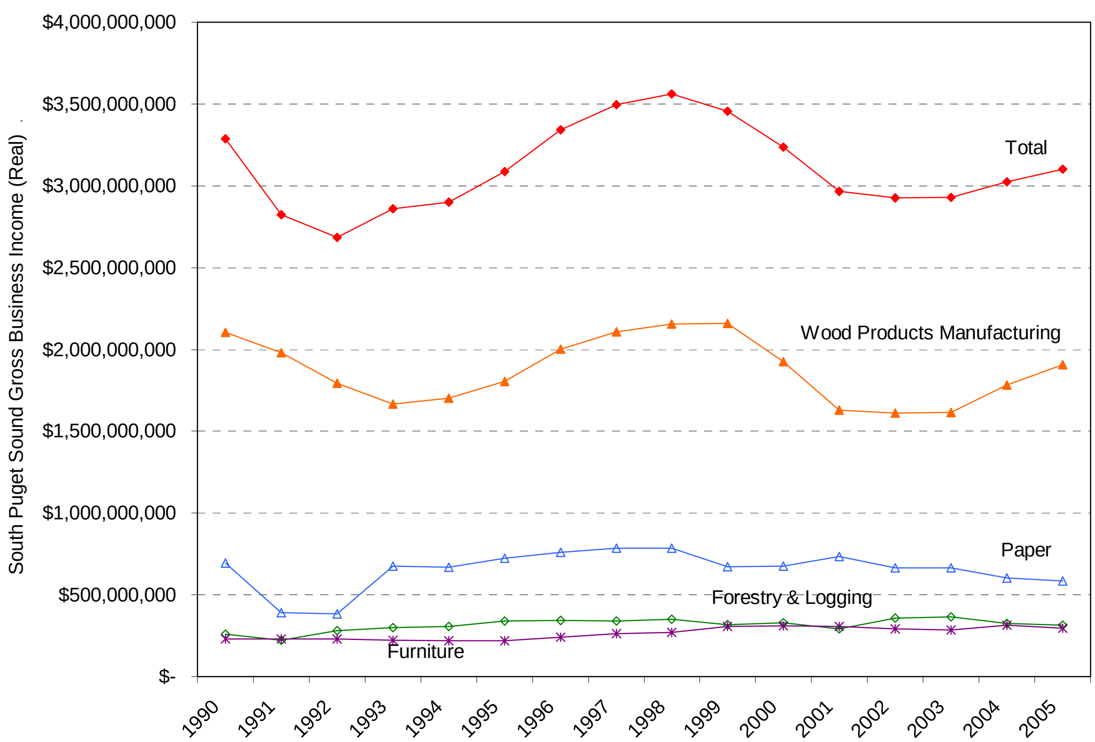


Figure 3.32. Gross business income within the South Puget Sound forest sector.
Source: WA State Department of Revenue website 2006.

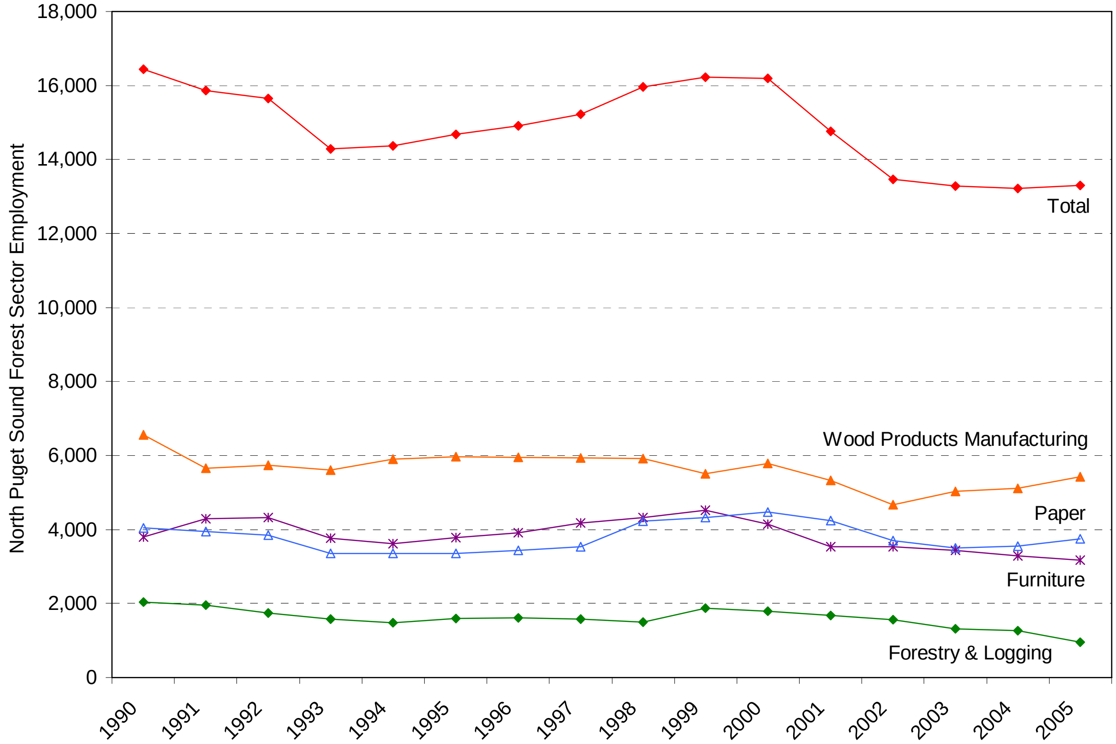


Figure 3.33. Employment within the North Puget Sound forest sector.
Source: WA State Employment Security Department website 2006.

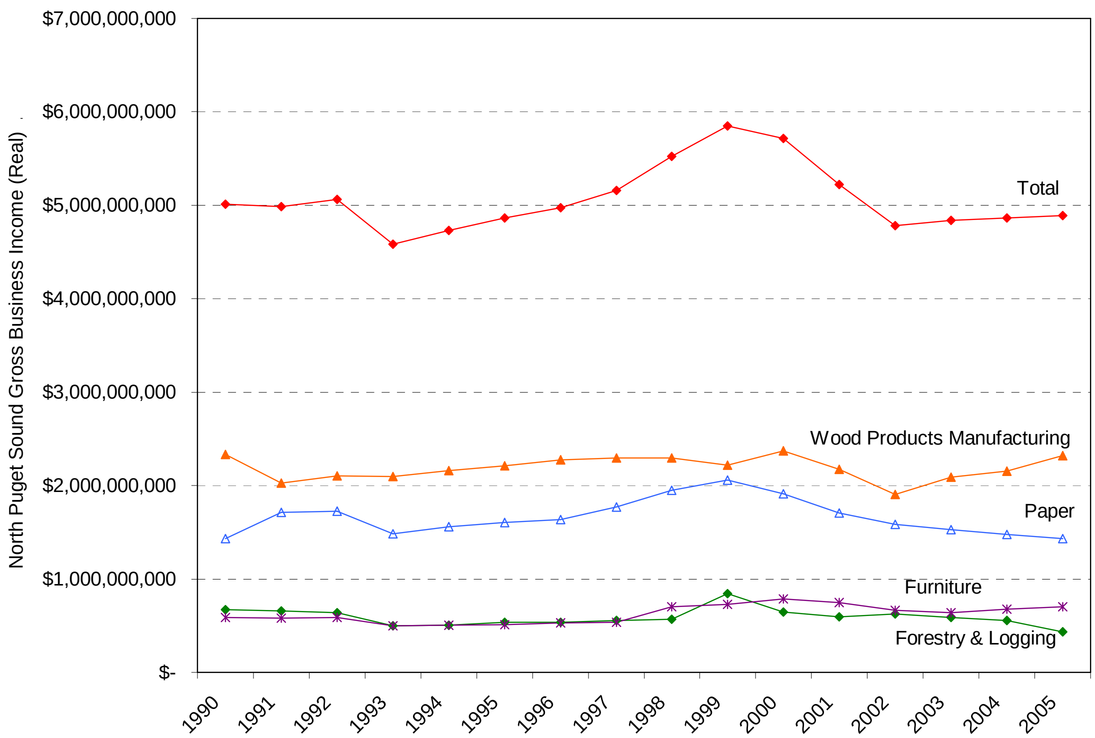


Figure 3.34. Gross business income within the North Puget Sound forest sector.
Source: WA State Department of Revenue website 2006.

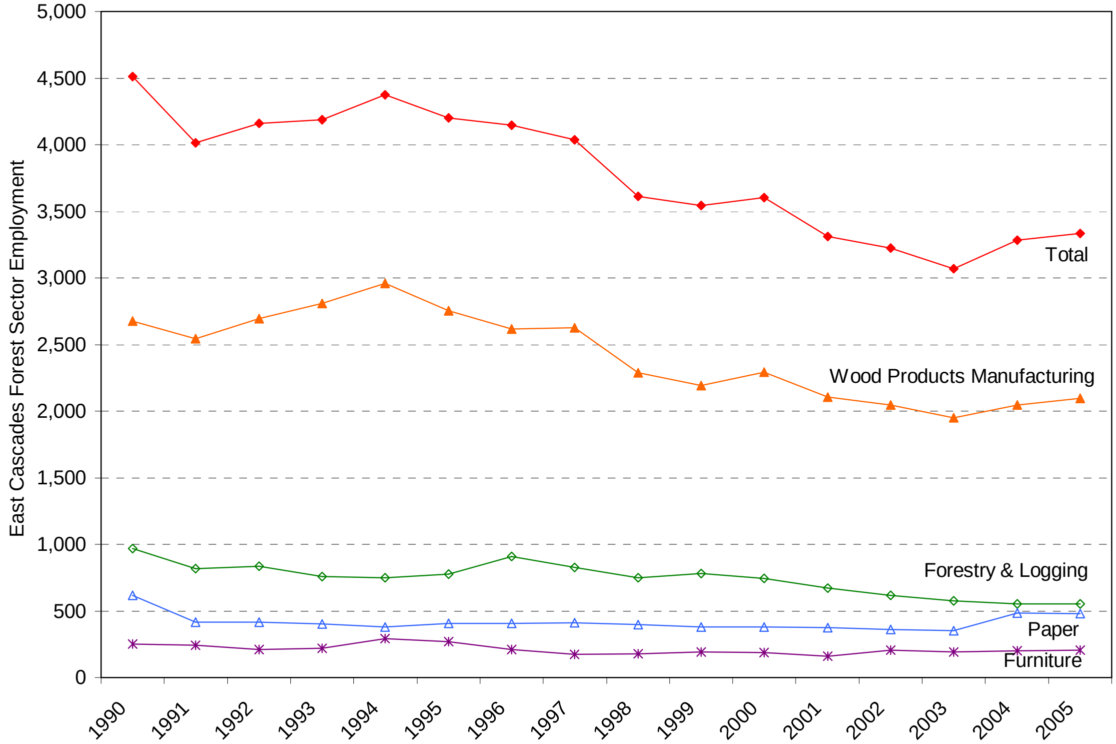


Figure 3.35. Employment within the East Cascades forest sector.
Source: WA State Employment Security Department website 2006.

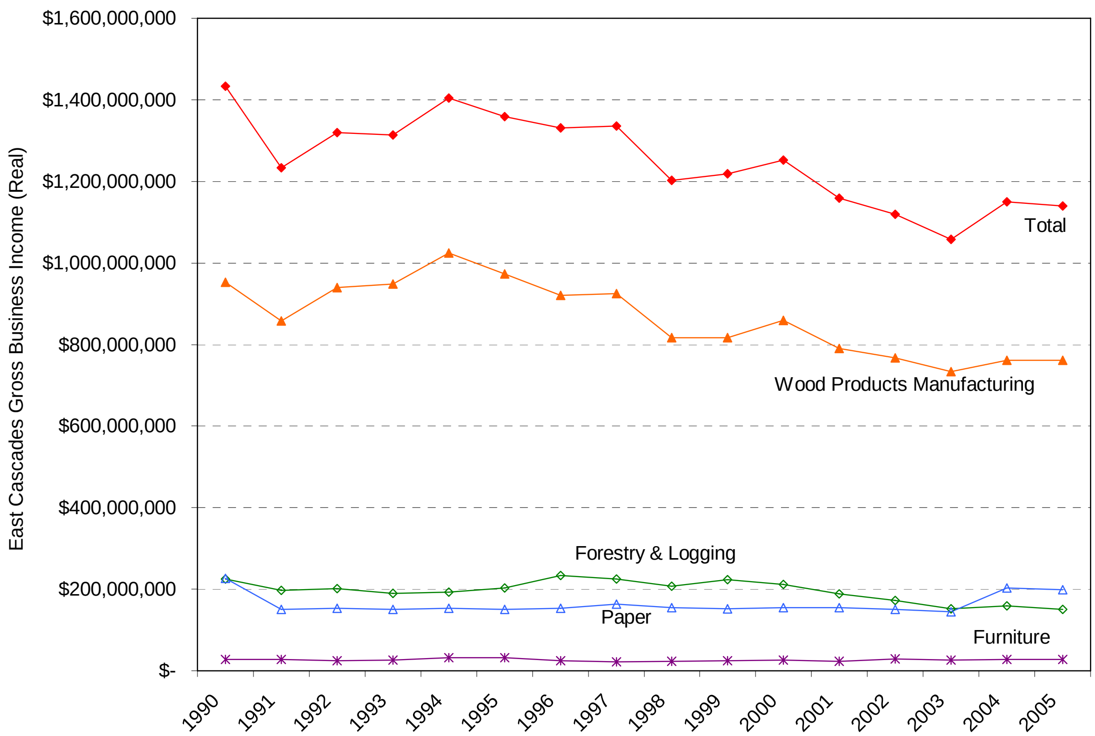


Figure 3.36. Gross business income within the East Cascades forest sector.
Source: WA State Department of Revenue website 2006.

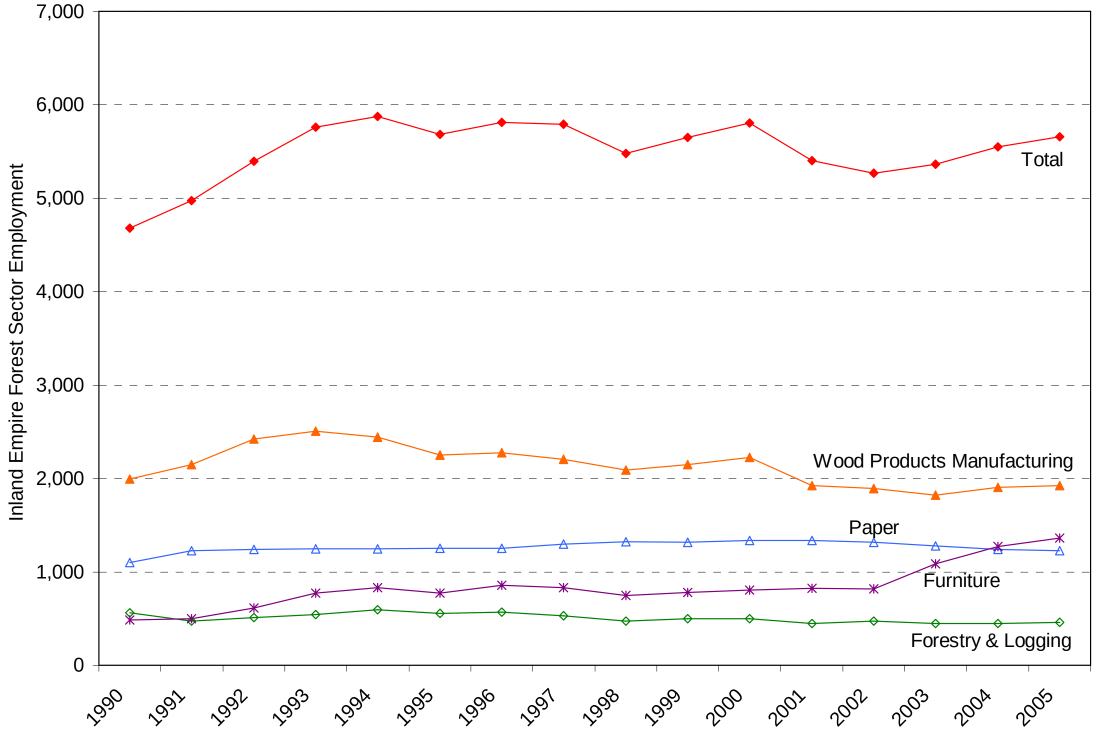


Figure 3.37. Employment within the Inland Empire forest sector.
Source: WA State Employment Security Department website 2006.

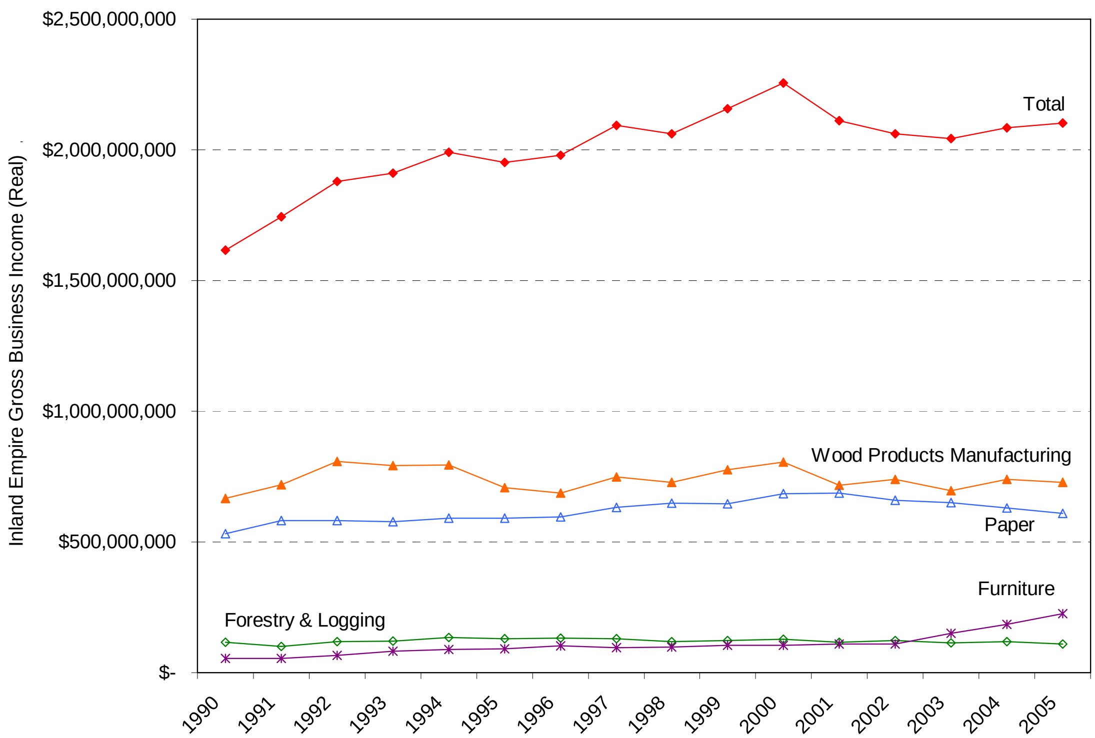


Figure 3.38. Gross business income within the Inland Empire forest sector.
Source: WA State Department of Revenue website 2006.

References

APA, various years. Annual Statistical Yearbook of the Engineered Wood Association. Tacoma, WA.

Conway, R. 1994. The Forest Products Economic Impact Study Current Conditions and Issues. Prepared for Washington Forest Protection Association, Washington State Department of Natural Resources, and Washington State Department of Trade and Economic Development. Seattle, WA.

Evans, R.J. and D.M. McCormick, 2006. River Valley Biomass Refinery Market Study. Final Report. MicroChem Technologies Inc. Lakewood, CO. 139 pages.

Han, H., H. Lee, L. Johnson, R. Folk, T. Gorman, J. Hinson, G. Jackson. 2002. Economic Feasibility of Small Wood Harvesting and Utilization on the Boise National Forest; Cascade, Idaho City, Emmett Ranger Districts. Prepared for the Gem County Commissioners. Moscow, ID.

Lippke, B. and R. Conway. 1994. Economic Impact of Alternative Forest Protection Rules to Protect Northern Spotted Owl Sites. Prepared for the Wildlife Committee of the Forest Practices Board for the State of Washington. Seattle, WA.

Lippke, B., J. Sessions, A. Carey. 1996. Economic Analysis of Forest Landscape Management Alternatives. CINTRAFOR Special Paper #21. Seattle, WA.

Warren, D. 2004. Production, Prices, Employment, and Trade in Northwest Forest Industries, All Quarters 2002. Resource Bulletin PNW-RB-241. Pacific Northwest Research Station. USDA Forest Service. Portland, OR.

WA State Employment Security Department website 2006. http://www.workforceexplorer.com/cgi/dataanalysis/?PAGEID=94&SUBID=149

WA State Department of Revenue website 2006. http://dor.wa.gov/content/statistics/

WWPA, various years. Annual Statiistical Yearbook of the Western Lumber Industry. Portland, OR.

Study 4: Land Conversion

Since the Second Progress Report was completed in July, 2006, further work has been to finalize the review of incentives and disincentives for forestland owners to conserve working forest lands, the general land use analysis has undergone preliminary accuracy assessment, a comparison of land use change and FIA data has been completed, and a detailed, parcel-level analysis of some of the main factors related to forest land conversion in King County (as a case study) are close to being complete.

This addendum to the Second Progress Report includes some of the main themes from this work, as well as some further clarification of methods, results, and anticipated outputs.
Still to be completed is the land use change analysis in eastern Washington and the detailed parcel-level analysis in Spokane County. This work is anticipated to be completed in mid-November.

Land Use Classification and Accuracy

Figure 2 clarifies the process used to classify land use, from the two levels (fine and coarse) of land cover classifications. Satellite images from three time periods were classified into built-up and not-built-up at a fine-scale, as well as seventeen land cover classes at a coarser level.

The coarse level land covers were grouped into larger classes (groups) in order to calculate contiguous land cover characteristics.

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

The built-up land cover classification was not grouped into the land cover groups; it was used to calculate percent developed and development density within the larger land cover groups.

- Built-up ⇨ *Percent developed and development density*

Land cover is the biophysical characteristics of the landscape, while land use is made up of multiple land cover types. In order to determine land use, rather than land cover, a series of analyses were done to determine land use from the land cover classification, based on neighboring cover characteristics, size of area, homo/heterogeneity of the area, percent developed, and more. Table 1 shows the rules used to determine land use from the classified images; each land use is described in more detail on pages 93-95 in the Second Progress Report.

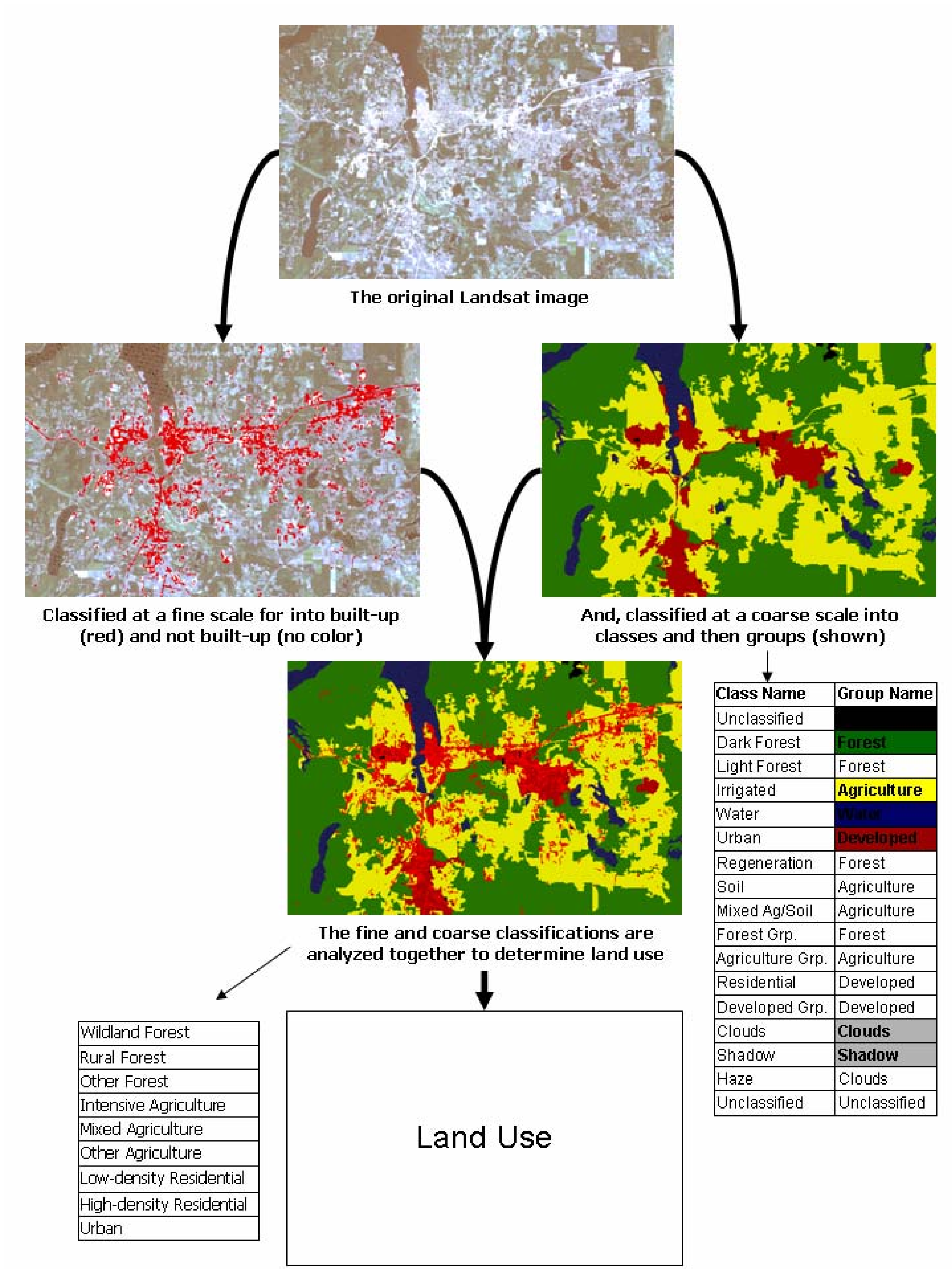


Figure 2. Classification Diagram

Table 1. Rules used to determine land use

Land Use	Land Cover Class/Group	Contiguous Acres	Percent Developed	Developed Clusters	Other
Wildland Forest	Forest (group)	≥ 640	≤ 5%	≤ 4	
Rural Forest		≥ 640	≤ 20%	4 < x < 8	Not Wildland Forest
		< 640	0%		
		> 640	≤ 5%		
Other Forest					Not Wildland Forest, Not Rural Forest
Intensive Ag	Irrigated or Soil (classes)	< 640	< 1%		
		≥ 640	≤ 5%	≤ 9	
	Mixed (class) or Agriculture (group)		< 1%		
Mixed Ag	Agriculture (group)	≥ 640	≤ 20%	≤ 12	Not Intensive Agriculture
Other Ag					Not Intensive Agriculture, Not Mixed Agriculture
Low-density Residential	Forest or Agriculture (groups)	≥ 40	20% < x < 50%		
High-density Residential	Developed (group)		< 50%		
		< 40	> 50%		
	Any non-developed group	≥ 40	> 50%		
Urban	Developed (group)	≥ 40	> 50%		

As can be expected with multiple land use classes, the number of possible changes (forest to urban, forest to agriculture, agriculture to forest, etc.) could be quite large. To correct for possible classification errors and to simplify the number of change possibilities, a one-way trajectory (shown in Figure 3) was assumed: a land use can only become more developed, not less developed. This type of analysis can result in an over-estimate of change than is actually taking place on the landscape since any classification errors in the first time step (i.e. a recent clearcut classified as built-up cannot then be classified as forest land in subsequent years) are carried through to the end and natural changes, such as a reforestation of agricultural lands or the "greening-up" of residential neighborhoods is not allowed.

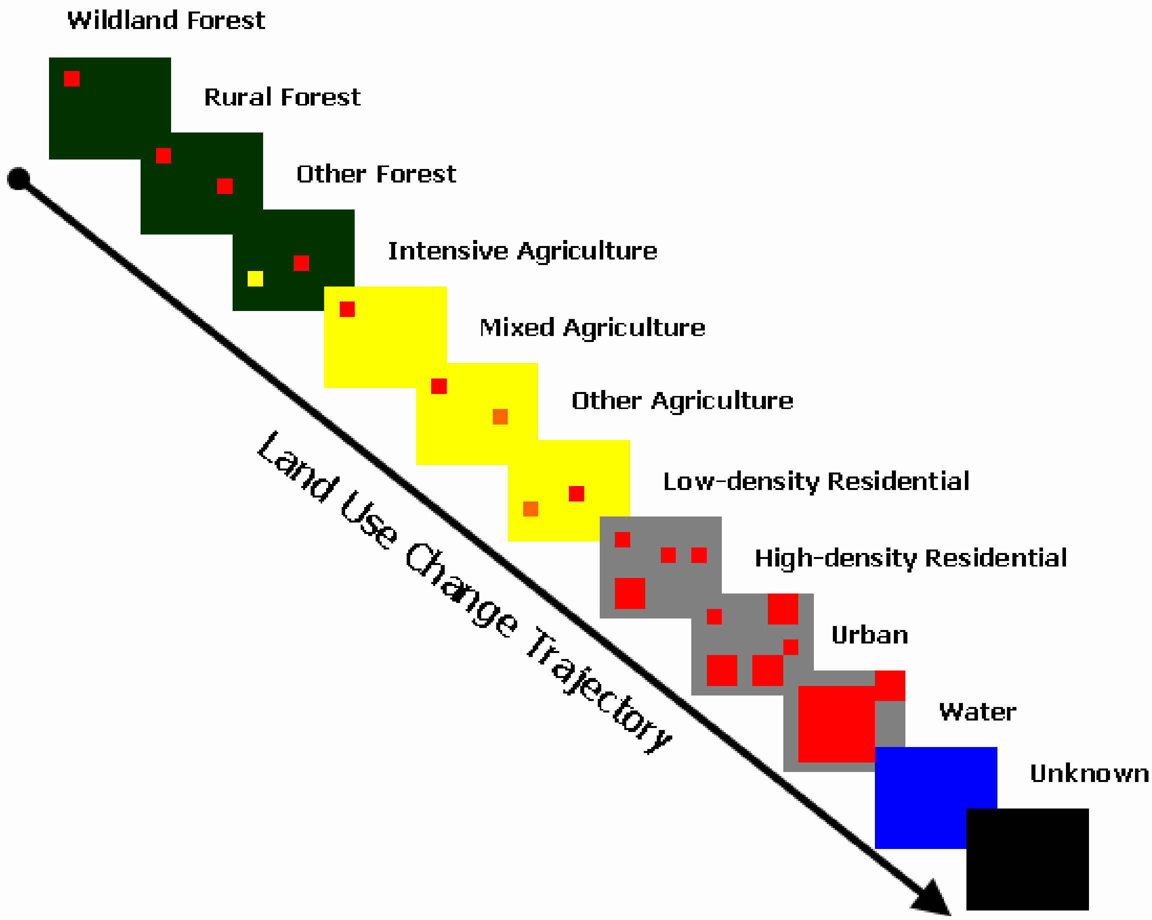


Figure 3. Change Trajectory

In order to assess the accuracy of the initial classification results, a correlation matrix was run to compare the overlapping areas of the images. Using a series of python scripts and Excel spreadsheets, agreement matrices were calculated. The correlation between the overlapping, classified images are shown in Table 2 .

Table 2. Classified Image Correlation

	1988	1996	2004
Built-up	93% (+/- 7.42)	92% (+/- 5.50)	96% (+/- 2.25)
Coarse	90% (+/- 3.16)	87% (+/- 9.60)	89% (+/- 4.86)

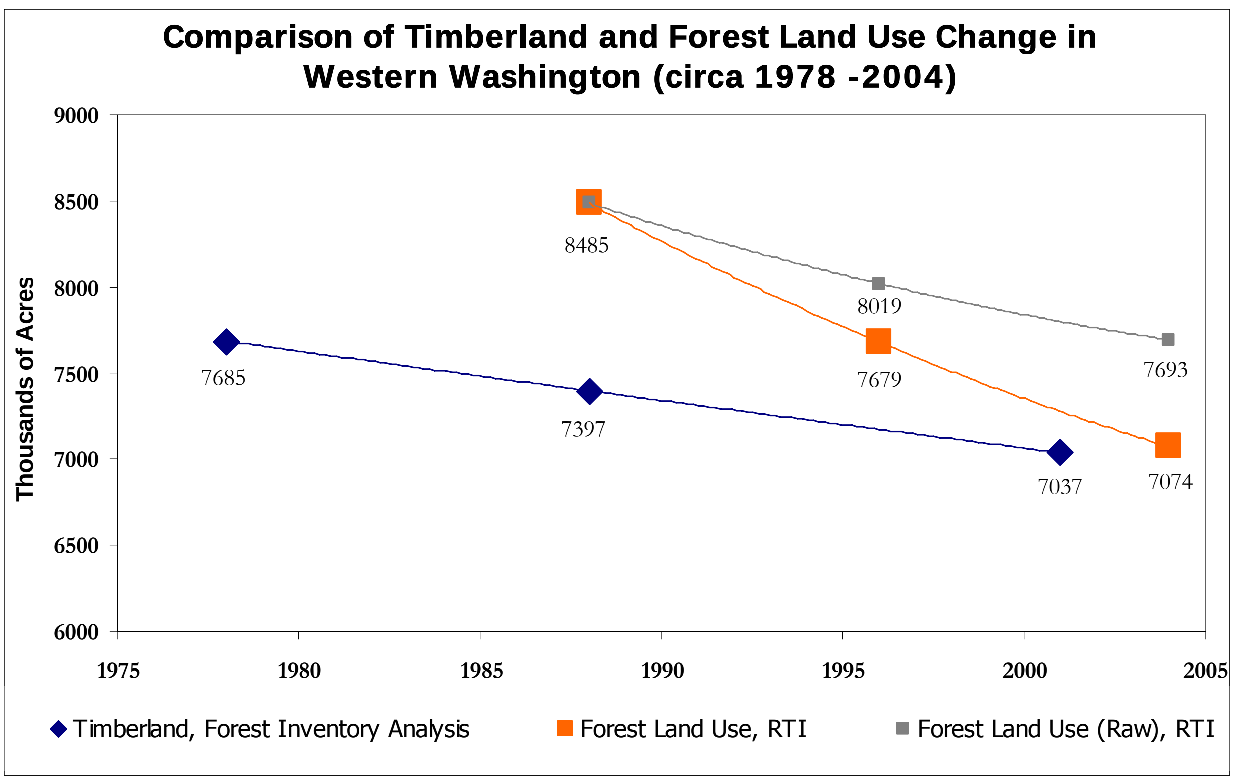
A preliminary accuracy assessment of the final land use classifications, using high-resolution aerial photography for 94 stratified random points through western Washington, resulted in an overall accuracy of 84% (Table 3). This result is consistent with many other land cover and land use classifications. The largest sources of error were distinguishing between transitional and rural, mixed agricultural lands common in areas undergoing scattered conversion of forest land to rural hobby farms and pastures.

Table 3. Land Use Classification Accuracy Matrix

Accuracy Matrix		Classified					
		Forest	Agriculture	Built-up	Water	Total	Percent Correct
Photo-Interpreted	Forest	28	6			34	82.4
	Ag	4	20	4		28	71.4
	Built-up	1		24		25	96.0
	Water				7	7	100.0
	Total	33	26	28	7	94	
	Percent Correct	84.8	76.9	85.7	100.0		84.0

Timberland and Forest Land Use Change Comparison: Which Trend to Use?

Using data from two Forest Inventory Analysis reports, *Washington's Public and Private Forests* (Bolsinger et al. 1997) and *Timber Resource Statistics for Nonnational Forest Land in western Washington, 2001* (Gray et al. 2005) it is possible to compare the land use change data classified for this study with the only other available data tracking forest land acreages in Washington state. Figure 4 shows the FIA estimates alongside the forest land use data analyzed for this study. An important consideration when viewing the graph: the lines represent different types of data, shown on the same graph purely for illustration.



Average Change/Year

Timberland, FIA	Forest Land Use (Raw), RTI
1978-1988: -0.37%	
1988-2001: -0.37%	1988-1996: -1.19% (-0.69%)
	1996-2004: -0.99% (-0.51%)
1978-2001: -0.37%	1988-2004: -1.04% (-0.58%)

Figure 4. Comparison of Timberland and Forest Land Use Change in Western Washington

Timberland, calculated from FIA data, was being converted to non-timberland at an average rate of 0.37% per year from approximately 1978 to 2001. A minimal amount of this land was reclassified out of the FIA inventory by moving into National Forest land. The remaining loss was to either urban, right-of-ways, or agriculture land uses.

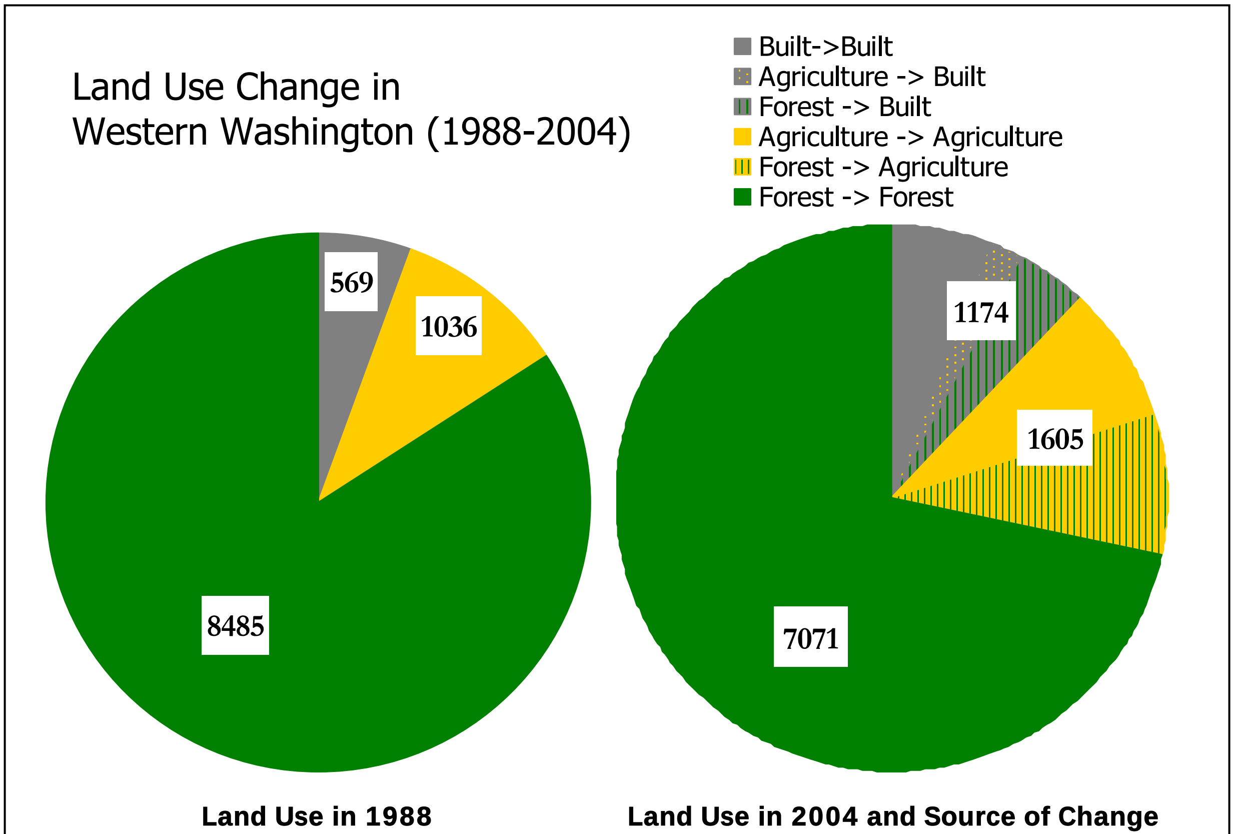
Alternatively, the forest land use data presented as part of this study shows a much steeper rate of change than the FIA data. From approximately 1988 to 2004, it is estimated that the areas in western Washington considered forest land use were converted to other non-forest land uses at an average rate of 1.04% per year. Even if the raw data – the non-trajectory data – is assumed, an average rate of 0.58% per year is still substantially higher than the assumed, and widely accepted, FIA rate.

The difference in these rates can be attributed to many things. The forest land use groups are made up of forest cover, as well as scatterings of residential homes, roads, and other uses (see pages 93 and 94 in the Second Progress Report for descriptions of the different land uses). The FIA data, on the other hand, classifies timberland based first on aerial photograph to determine forest land and then actual plot measurements of the forest land to determine if *the area is capable of growing 20 cubic feet or more per acres of industrial wood and if the land is not withdrawn from timber utilization by statute, ordinance, or administrative order*. It is next to impossible to determine this from satellite images, so the land use data represents slightly different data.

Even with these differences, it is clear that the FIA data may not be adequately assessing the rate of change of timberland (or forestland). The forest land use data, albeit coarse, appears to be capturing the changing nature of forest land in Washington: the large, uninterrupted tracts of forested lands are changing into a mixture of rural agricultural land uses, residential and urban lands uses, and smaller areas of forest land use. It is estimated that from 1988 through 2004, 9% of western Washington's non-federal land in a forest land use was converted to agricultural/rural land uses, while 5% was converted to residential or urban land uses; an additional 3% was converted to either other uses or was unclassified in the data. The remaining 83% of the land in forest land use in 1988 remained in the same land use in 2004.

The graph below (Figure 5) shows the original land uses classified in 1988 (approximately ½ million acres in urban and residential uses, 1 million acres in agriculture and pasture uses, and close to 8.5 million acres in forest land uses) and the change in land uses through 2004. The pie chart on the right depicts the different amounts of each land use class that converted from another class; for example, the bottom half of the agriculture land use came from land originally in a forest land use.

One important note is that since a one-way trajectory, described earlier, was assigned to any later classification data, there were no built-up lands moving into agriculture or forest land uses and no agriculture lands moving into forest. The raw data will be presented alongside this graph in the final reports and at the October roundtable discussions.



Direction of Change	Thousands of Acres
Built->Built	561
Agriculture -> Built	211
Forest -> Built	402
Agriculture -> Agriculture	809
Forest -> Agriculture	795
Forest -> Forest	7071

Note: Change to unknown, water, and other land use classes is not shown in graph or table.

Figure 5. Land Use Change in Western Washington, 1988-2004

Alternatively, based on the two FIA reports it is possible to track the changing ownership patterns and timberland flow in western Washington (data has yet to be released for eastern Washington). According to FIA data, during the period of 1978-1979, approximately, 1.6 million acres of timberland was in non-national forest public ownership, 4 million acres was owned by industrial owners (including traditional forest products companies and other large industrial owners), and 2 million acres was owned by other private owners (tribal, family foresters, conservation groups).

One apparent pattern shown from these data is the transfer of ownership from industry to other private and then the conversion to non-timberland out of the other private ownership group.

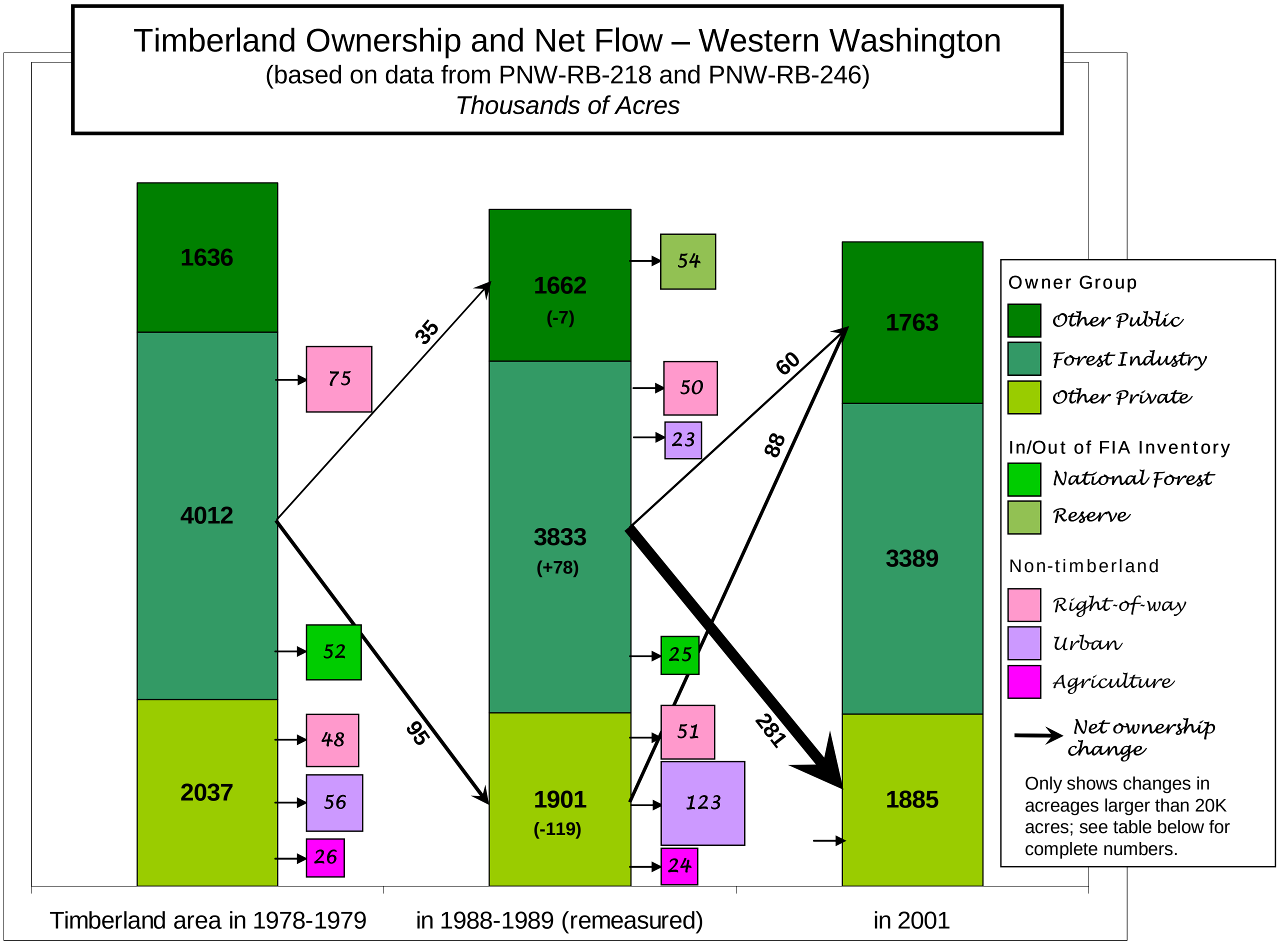


Figure 6. Timberland Ownership and Net Flow on Non-National Forest Lands - Western Washington

Changes in timberland area outside National Forests by owner, western Washington (based on PNW-RB-218 Table 33W and PNW-RB-246 Table 25a)

	Other Public	Forest Industry	Other Private	All Owners		Other Public	Forest Industry	Other Private	All Owners	SE (%)
	Thousand Acres					Thousand Acres				
Timberland area in 1978-1979	**1636**	**4012**	**2037**	**7685**	**in 1988-1989 (remeasured)**	**1662**	**3833**	**1901**	**7397**	
Area change owing to										
Changes in land class										
timberland to rights-of-way		-75	-48	-123			-50	-51	-100	35
timberland to urban		-7	-56	-63			-23	-123	-146	28
timberland to agriculture			-38	-38				-24	-24	71
agriculture to timberland			12	12						
christmas tree farm to timberland		6		6						
Net change		**-75**	**-130**	**-205**			**-72**	**-198**	**-270**	
Changes in inventory and ownership										
to national forest		-90		-90			-45	-12	-56	9
from national forest	3	38	17	58		7	20		27	25
to reserved	-5			-5		-54	-6		-60	
from other public	-111	111				-95	95			36
from forestry industry	146	-285	139			155	-456	300		16
from other private		44	-44			88	19	-107		35
Net change	**33**	**-182**	**112**	**-37**		**101**	**-373**	**181**	**-89**	
Timberland area in 1988-1989	1669	3755	2020	7443	**in 2001**	**1763**	**3389**	**1885**	**7037**	
Unknown change from remeasured plots	***7***	***-78***	***119***	***46***						

Summary

The land use change data, compared to the FIA data, estimates that approximately 800,000 (raw data) to 1.4 million (trajectory-based data) acres of western Washington has changed from forest land uses to either mixed agricultural or residential and urban land uses between 1988 and 2004. That is a substantially larger estimate than FIA's approximately 600,000 acres loss of timberland from 1978 to 2001. As mentioned, however, the land use data is measuring overall land use, rather than the timber production of a certain area. Even with these considerations, based on the accuracy of the land use change data combined with the large scope of the data (a seamless analysis of all of western Washington), it can safely be assumed that the scope of forest land conversion is larger than expected. Continuing with a 0.58% (raw) to 1.04% (trajectory-based) loss of forest land per year, western Washington could experience a sizable loss of forest land use in the future years.

One issue still to be addressed is the proper designation of “mixed agricultural” land uses. Simply grouping this land use with intensive agricultural lands may be overestimating the agricultural presence in western Washington. The mixed agricultural land use is a combination of farms, pastures, cleared forest land, homes, and roads; some land use experts call this “rural land.”

Although the FIA data may not be capturing the extent of forest land conversion, the pattern of industrial forest land transferring to other private ownership and then into urban lands is shown in Figure 5. Between 1978/1979 and 1988/1989, 95,000 acres of timberland transferred to other private owners; this pattern almost doubled between 1988/89 and 2001, with 281,000 acres transferred. Likewise, the amount of timberland in other private ownership converting to urban uses increased from 56,000 acres to 123,000 acres in the same time periods. If this trend continues uninterrupted, western Washington’s industrial forest lands could be facing a significant decrease in acreages, with much of the land transferring to other private owners and then into urban and residential land uses.

Two case studies: King and Spokane counties, will allow a more refined look at the other factors that contribute to the conversion (or non-conversion) of forest land into other uses, such as number and size of parcels, presence of Class IV General Forest Practice Applications, and development permits issued. This information will be presented at the upcoming Forum discussions and will help determine if certain factors can help determine locations, rates, and trends of forest land use in Washington state.

References

Bolsinger, C. L., N. McKay, D. R. Gedney, and C. Alerich. 1997. Washington's Public and Private Forests. Resource Bulletin. PNW-RB-218. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 144 p.

Gray, A. N., C. F. Veneklase, and R. D. Rhoads. 2005. Timber Resource Statistics for Nonnational Forest Land in Western Washington, 2001. Resource Bulletin. PNW-RB-246. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 117 p.

APPENDICES

Study 1 Appendix A:

Appendix: Table 2. Results for three analysis periods: acres burned, low and high hazard acres, acres unburned, tons of forest and total carbon, and economics.

		NA	12&Over Immediate	9&Under Immediate	BA45 Immediate	12&Over 25 Yr Phase In	9&Under 25 Yr Phase In	BA45 25 Yr Phase In
Fire Risk Reduction	**Acres Burned/Period**							
	Mean: 2000-2020	60375	63334	47546	18341	60967	51198	32033
	Mean: 2025-2050	40324	39708	35136	48247	40201	34006	35562
	Mean: All Years	49438	50447	40777	34653	49640	41820	33958
	High Hazard Acres							
	Mean: 2000-2020	234496	345845	112358	0	268573	134978	76260
	Mean: 2025-2050	190680	176979	67964	104120	187940	64133	37005
	Mean: All Years	210596	253736	88143	56793	224591	96335	54848
	Low Hazard Acres							
	Mean: 2000-2020	234896	320089	270081	525729	264639	240802	421769
	Mean: 2025-2050	198010	197387	165285	177105	198757	161324	184928
	Mean: All Years	214776	253161	212920	335570	228703	197451	292583
	Unburned Acres							
	Mean: 2000-2020	590415	584496	635700	735057	590267	613191	659736
	Mean: 2025-2050	305613	292049	393953	509605	302900	379332	485188
	Mean: All Years	435068	424979	503838	612083	433521	485632	564528
Carbon Impact	**Forest Carbon**							
	Mean: 2000-2020	25.9	18.2	23.2	17.9	21.5	24.6	21.5
	Mean: 2025-2050	24.0	21.1	24.8	22.7	20.3	24.3	20.7
	Mean: All Years	24.9	19.8	24.1	20.5	20.9	24.4	21.1
	Total Carbon							
	Mean: 2000-2020	25.9	35.7	27.8	30.7	31.4	27.0	29.5
	Mean: 2025-2050	24.0	37.5	29.0	34.7	35.0	27.7	33.0
	Mean: All Years	24.9	36.7	28.5	32.9	33.4	27.4	31.4
Economics	**Harvest Value**							
	NPV: All Years	0	$ 873	$ (185)	$ 36	$ 457	$ (100)	$ 20
	Firefighting Costs							
	NPV: All Years	$(237)	$ (241)	$ (181)	$ (90)	$ (237)	$ (202)	$ (147)
	Total Value							
	NPV: All Years	$(237)	$ 632	$ (366)	$ (54)	$ 220	$ (302)	$ (127)

Study 3 Appendix A: North American Industrial Classification System Codes

NAICS Industry Codes for Forestry and Wood Products Manufacturing Sectors

Forestry and Logging

113110	Timber Tract Operations
113210	Forest Nurseries and Gathering of Forest Products
113310	Logging

Wood Product Manufacturing

321113	Sawmills
321114	Wood Preservation
321211	Hardwood Veneer and Plywood Manufacturing
321212	Softwood Veneer and Plywood Manufacturing
321213	Engineered Wood Member (except Truss) Manufacturing
321214	Truss Manufacturing
321219	Reconstituted Wood Product Manufacturing
321911	Wood Window and Door Manufacturing
321912	Cut Stock, Resawing Lumber, and Planing
321918	Other Millwork (including Flooring)
321920	Wood Container and Pallet Manufacturing
321991	Manufactured Home (Mobile Home) Manufacturing
321992	Prefabricated Wood Building Manufacturing
321999	All Other Miscellaneous Wood Product Manufacturing

Paper Manufacturing

322110	Pulp Mills
322121	Paper (except Newsprint) Mills
322122	Newsprint Mills
322130	Paperboard Mills
3222	Converted Paper Product Manufacturing

333210 Sawmill and Woodworking Machinery Manufacturing

Furniture and Related Product Manufacturing

337110	Wood Kitchen Cabinet and Countertop Manufacturing
337122	Nonupholstered Wood Household Furniture Manufacturing
337129	Wood Television, Radio, and Sewing Machine Cabinet Manufacturing
337211	Wood Office Furniture Manufacturing
337212	Custom Architectural Woodwork and Millwork Manufacturing

NAICS Classification for Industry Comparisons used in Figure 3.8.

NAICS Code	***Manufacturing***
321	*Wood Product Manufacturing*
322	*Paper Manufacturing*
324	*Petroleum & Coal Products Manufacturing*
325	*Chemical Manufacturing*
326	*Plastics & Rubber Products Manufacturing*
327	*Nonmetallic Mineral Product Mfg*
331	*Primary Metal Manufacturing*
332	*Fabricated Metal Product Manufacturing*
333	*Machinery Manufacturing*
334	*Computer and Electronic Product Mfg*
335	*Electrical Equipment and Appliances*
336	*Transportation Equipment Manufacturing*
337	*Furniture and Related Product Mfg*
339	*Miscellaneous Manufacturing*
	Forestry & Wood Products
113	*Forestry and Logging*
11531	*Support Activities for Forestry*
321	*Wood Product Manufacturing*
322	*Paper Manufacturing*
33711	*Wood Kitchen Cabinets and Countertops*
337122	*Nonupholstered Wood Household Furniture*
337211	*Wood Office Furniture Manufacturing*
337212	*Custom Architectural Woodwork & Millwork*
	Agriculture and Food Processing
111	*Crop Production*
112	*Animal Production*
115111	*Cotton Ginning*
115112	*Soil Preparation, Planting, Cultivating*
115113	*Crop Harvesting, Primarily by Machine*
115114	*Postharvest Crop Activities*
115115	*Farm Labor Contractors and Crew Leaders*
115116	*Farm Management Services*
11521	*Support Activities for Animal Production*
311	*Food Manufacturing*
	Residential Construction and Remodeling
236115	*New Single-Family Housing Construction*
236118	*Residential Remodelers*
238111	*Residential Poured Foundation Contractor*
238121	*Residential Structural Steel Contractors*
238131	*Residential Framing Contractors*
238141	*Residential Masonry Contractors*
238151	*Residential Glass/Glazing Contractors*
238161	*Residential Roofing Contractors*
238171	*Residential Siding Contractors*
238191	*Other Residential Exterior Contractors*
238211	*Residential Electrical Contractors*
238221	*Residential Plumbing/HVAC Contractors*
238291	*Other Residential Equipment Contractors*

238311	*Residential Drywall Contractors*
238321	*Residential Painting Contractors*
238331	*Residential Flooring Contractors*
238341	*Residential Tile/Terrazzo Contractors*
238351	*Residential Finish Carpentry Contractors*
238391	*Other Residential Finishing Contractors*
238911	*Residential Site Preparation Contractors*
238991	*All Other Residential Trade Constractors*

Study 3 Appendix B: Summary Tables for the WA State Forest Sector

Forestry and Logging Sectorl

	Firms	Employment	Total Real Wages	Total Real GBI	Taxes Paid
1990	1,142	9,374	$327,324,907		
1991	1,084	8,352	$295,852,749		
1992	1,148	7,981	$299,062,779		
1993	1,159	7,649	$269,999,507		
1994	1,145	7,576	$276,891,810	$1,722,016,367	$10,921,051
1995	1,132	7,979	$294,904,883	$2,066,083,907	$11,876,368
1996	1,129	8,207	$298,956,702	$2,075,777,002	$11,779,757
1997	1,114	7,970	$303,864,617	$1,961,588,881	$11,470,818
1998	1,078	7,400	$291,408,157	$1,681,106,440	$10,203,445
1999	1,039	7,711	$323,448,894	$1,790,872,850	$10,743,199
2000	966	7,386	$295,888,722	$1,751,688,916	$10,381,534
2001	913	6,645	$271,152,857	$1,439,885,015	$9,000,922
2002	854	6,497	$276,621,386	$1,459,148,161	$9,081,513
2003	725	6,082	$274,784,668	$1,635,873,128	$9,650,493
2004	698	5,810	$248,348,486	$2,092,037,699	$11,701,789
2005	680	5,704	$244,473,009	$1,946,381,867	$11,109,171

Sector includes the following industries (and NAICS codes):
Timber Tract Operations (113110), Forest Nurseries and Gathering of Forest Products (113210), Logging (113310), and Support Activities for Forestry (115310)

Wood Manufacturing Sector

	Firms	Employment	Total Real Wages	Total Real GBI	Taxes Paid
1990	708	23,998	$785,624,359		
1991	674	21,938	$716,758,867		
1992	679	21,826	$737,301,647		
1993	681	21,870	$732,530,432		
1994	692	22,390	$753,148,388	$7,034,564,266	$53,845,479
1995	699	22,339	$759,375,452	$6,814,094,928	$50,408,378
1996	655	22,423	$777,233,837	$6,659,060,540	$48,077,039
1997	659	22,581	$798,388,514	$6,859,893,047	$47,229,857
1998	648	21,679	$776,856,869	$5,961,055,853	$43,196,289
1999	636	20,958	$776,776,645	$6,580,542,099	$46,202,095
2000	635	21,670	$827,857,277	$6,405,577,767	$46,145,639
2001	593	18,636	$693,937,008	$5,733,381,962	$41,353,808
2002	536	17,700	$666,547,283	$5,943,297,721	$39,488,358
2003	510	17,561	$675,380,519	$6,346,716,312	$41,025,093
2004	490	18,037	$700,026,485	$7,409,677,099	$46,068,565
2005	518	18,857	$734,885,906	$7,571,154,185	$48,548,514

Sector includes the following industries (and NAICS codes):
Sawmills (321113), Wood Preservation (321114), Hardwood Veneer and Plywood Manufacturing (321211), Softwood Veneer and Plywood Manufacturing 321212), Engineered Wood Member (except truss) Manufacturing (321213), Truss Manufacturing (321214), Reconstituted Wood Product Manufacturing (321219), Wood Window and Door Manufacturing (321911), Cut Stock, Resawing Lumber and Planing (321912), Other Millwork (including Flooring) (321918), Wood Container and Pallet Manufacturing (321920), Manufactured Home (Mobile Home) Manufacturing (321991), Prefabricated Wood Building Manufacturing (321992), All Other Miscellaneous Wood Product Manufacturing (321999)

Pulp and Paper Manufacturing Sector GBI Subtotal

	Firms	Employment	Total Real Wages	Total Real GBI	Taxes Paid
1990	106	16,663	$890,210,498		
1991	112	16,148	$868,505,292		
1992	118	15,754	$836,534,815		
1993	118	15,415	$831,743,708		
1994	119	15,393	$853,714,407	$5,180,096,460	$24,703,081
1995	124	15,826	$879,896,301	$5,954,544,630	$28,039,570
1996	126	15,647	$873,625,017	$5,532,893,207	$24,869,468
1997	130	15,616	$891,478,668	$5,368,032,619	$26,128,322
1998	130	15,602	$913,042,884	$5,491,354,945	$26,988,255
1999	128	15,238	$891,071,541	$5,749,031,959	$26,046,639
2000	129	14,427	$840,936,157	$5,829,588,172	$26,078,474
2001	129	14,038	$842,651,822	$5,046,162,391	$22,613,531
2002	107	13,210	$783,784,789	$5,330,945,429	$21,640,421
2003	105	12,875	$768,345,018	$5,108,224,772	$21,346,943
2004	101	13,244	$792,619,653	$5,233,974,187	$21,936,407
2005	93	12,117		$4,494,476,936	$19,399,044

Sector includes the following industries (and NAICS codes):
Pulp Mills (322110), Paper (except Newsprint) Mills (322121), Newsprint Mills (322122), Paperboard Mills (322130), Converted Paper Product Manufacturing (3222)

Furniture Manufacturing Sector GBI Subtotal

	Firms	Employment	Total Real Wages	Total Real GBI	Taxes Paid
1990	196	2,144	$54,974,407		
1991	536	5,404	$137,831,418		
1992	538	5,230	$136,187,827		
1993	540	5,094	$134,473,760		
1994	536	4,914	$126,726,119	$515,878,107	$16,801,486
1995	531	4,811	$125,613,256	$510,818,214	$15,906,962
1996	519	4,805	$127,658,123	$531,562,968	$16,108,694
1997	502	5,028	$136,436,808	$581,592,893	$17,043,631
1998	513	5,441	$151,155,187	$644,445,677	$18,233,210
1999	507	5,747	$171,358,787	$703,376,304	$19,038,498
2000	500	5,923	$180,548,058	$742,291,685	$19,874,024
2001	491	5,723	$174,910,054	$718,407,092	$18,687,011
2002	474	5,259	$163,005,311	$691,768,258	$17,355,473
2003	455	5,146	$160,285,215	$753,592,388	$17,741,596
2004	418	5,614	$186,750,519	$842,973,626	$18,726,552
2005	521	7,584	$258,675,849	$898,953,747	$20,522,962

Sector includes the following industries (and NAICS codes):
Wood Kitchen Cabinet and Countertop Manufacturing (337110), Nonupholstered Wood Household Furniture Manufacturing (337122), Wood Television, Radio and Sewing Machine Cabinet Manufacturing (337129), Wood Office Furniture Manufacturing (337211), Custom Architectural Woodwork and Millwork Manufacturing (337212)

Study 3 Appendix C. Regression Equations for Estimating GBI Within the Timbersheds

Regression Model to Estimate GBI

We utilized two data sets from different sources; one from the Employment Security Department and the other from the Department of Revenue. The Employment Security Department has historical employment and wage data for each county and in each of the industrial sectors included in the study (NAICS or SIC). Similarly, the Department of Revenue has historical GBI data for each industrial sector (NAICS or SIC). However, the Department of revenue GBI data is only available at the statewide level and no information is available for specific industry sectors at the county level. Since one of the objectives of this study was to estimate the economic contribution of the forestry and forest products sectors within each of the timbersheds, it was important that we develop simple regression models to estimate GBI for each timbershed using county level wage and employment data.

1. <u>Total GBI (all sectors) in each timber shed</u>

In order to estimate the total GBI of each timber shed, a linear regression model was developed. Sample data used for the regression included total wages, total employment and total aggregated GBI in Washington state from 1994 to 2004, where the dependent variable was Gross Business Income. GBI showed a much higher correlation with total wages (.951) than with employment (-.567). Furthermore, wages and employment showed a relatively high correlation (-.679). When two highly correlated independent variables are included in a regression model, multicolinearity produces unacceptable uncertainty in estimating regression coefficients. With these considerations in mind, it was determined that total wages would be used as the independent variable.

The simple linear regression using the Ordinary Least Square (OLS) method provided the following:

Total Real GBI for all sectors in timber shed = Total Wages * 4.229

T-value of coefficient is 53.4 (significant at .001 level).

This suggests that an increase in $1 in total wages in each timbershed leads to an increase of $4.229 in total real GBI (across all sectors) in each timbershed.

2. <u>GBI of each forest industrial sector in each timber shed</u>

The dependent variable is GBI for the five forest product industry sectors from 1994 to 2004 (n=54). The independent variable is either total wages or total number of workers in each forest industry. Employment shows higher correlation with GBI (.961) than wages (.949). Wages and employment show high correlation (.892), so only one variable can be used as independent variable in order to avoid multicolineality problem. Five sectors are regarded as dummy variables. It is natural to think that sector differences effect on the magnitude of trend rather than base level. Hence, dummy variables are used in terms of trend rather than constant.

2-1. <u>Wages as an independent variable</u>

The linear regression by using Ordinary Least Square (OLS) method for GBI estimates is

GBI = (7.936 * Total Wages * Dummy113) + (11.176 * Total Wages * Dummy321) + (8.194 * Total Wages * Dummy 322) + (12.866 * Total Wages * Dummy 3332) + (5.265 * Total Wages * Dummy 337)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
wag113	7.936	0.644	0.203	12.321	0
wag321	11.176	0.248	0.743	45.076	0
wag322	8.194	0.218	0.619	37.57	0
wag3332	12.866	3.286	0.065	3.916	0
wag337	5.265	1.143	0.076	4.606	0

In conclusion,

- An increase of $1 in total wages for forestry and logging in each timbershed leads to an increase of $7.936 in real GBI for that industry sector in each timbershed.
- An increase of $1 in total wages for wood product manufacturing in each timbershed leads to an increase of $11.18 in real GBI for that industry sector in each timbershed.
- An increase of $1 in total wages for pulp and paper manufacturing in each timbershed leads to an increase of $8.194 in real GBI for that industry sector in each timbershed.
- An increase of $1 in total wages for wood machinery manufacturing in each timbershed leads to an increase of $12.87 in real GBI for that industry sector in each timbershed.
- An increase of $1 in total wages for wood furniture manufacturing in each timbershed leads to an increase of $5.265 in real GBI for that industry sector in each timbershed.

Study 3 Appendix D. Summary Tables For Forest Sector Within Each Timbershed (2005)

North Coast	Firms	Emp	Total Wages	Avg Wage
1131	5	32	$1,341,272	$41,915
1133	66	397	$14,352,691	$36,153
3211	17	416	$17,765,717	$42,706
3212	*	*	*	*
3219	6	26	$809,043	$31,117
3221	3	501	$31,093,270	$62,062
3371	13	54	$1,198,999	$22,204
3372	*	*	*	*

South Coast	Firms	Emp	Total Wages	Avg Wage
1131	*	*	*	*
1132	*	*	*	*
1133	90	722	$28,837,322	$39,941
3211	35	1204	$54,069,953	$44,909
3212	*	*	*	*
3219	11	693	$27,663,641	$39,919
3221	3	614	$38,114,541	$62,076
3222	*	*	*	*
3371	4	6	$41,391	$6,899
3372	*	*	*	*

Southwest	Firms	Emp	Total Wages	Avg Wage
1131	7	15	$345,201	$23,013
1132	3	71	$1,237,041	$17,423
1133	154	1565	$70,714,297	$45,185
3211	31	2603	$124,607,933	$47,871
3212	14	625	$26,008,855	$41,614
3219	35	629	$20,058,874	$31,890
3221	11	3939	$275,865,767	$70,034
3222	13	861	$42,529,273	$49,395
3332	*	*	*	*
3371	40	513	$17,279,008	$33,682
3372	*	*	*	*

South Puget Sound	Firms	Emp	Total Wages	Avg Wage
1131	7	57	$4,487,926	$78,736
1132	9	66	$1,139,550	$17,266
1133	85	822	$34,147,782	$41,542
3211	32	1891	$89,343,373	$47,247
3212	14	800	$30,205,907	$37,757
3219	70	1551	$52,209,410	$33,662
3221	6	608	$37,332,857	$61,403
3222	15	711	$33,846,407	$47,604
3371	78	736	$22,407,123	$30,444
3372	9	393	$15,243,877	$38,788

Study 3 Appendix D. Summary Tables For Forest Sector Within Each Timbershed (2005), continued

North Puget Sound	Firms	Emp	Total Wages	Avg Wage		
1131	13	85	$21,982,323	$258,616		
1132	*	*	*	*		
1133	122	833	$32,204,669	$38,661		
3211	35	1,551	$75,104,038	$48,423		
3212	15	766	$28,855,240	$37,670		
3219	143	3,116	$103,755,007	$33,297		
3221	9	503	$26,412,005	$52,509		
3222	32	2,668	$148,152,987	$55,530		
3332	*	*	*	*		
3371	205	2,271	$78,484,683	$34,560		
3372	28	709	$27,130,135	$38,265		

East Cascade	Firms	Emp	Total Wages	Avg Wage		
1132	*	*	*	*		
1133	71	559	$18,983,343	$33,959		
3211	16	1151	$41,908,776	$36,411		
3212	6	201	$5,804,008	$28,876		
3219	27	747	$20,386,420	$27,291		
3221	4	232	$11,253,451	$48,506		
3222	3	248	$13,058,833	$52,657		
3332	*	*	*	*		
3371	27	148	$3,713,809	$25,093		
3372	*	*	*	*		

Inland Empire	Firms	Emp	Total Wages	Avg Wage		
1131	*	*	*	*		
1133	97	461	$13,683,031	$29,681		
3211	20	832	$33,169,491	$39,867		
3212	10	475	$17,571,295	$36,992		
3219	41	623	$14,390,433	$23,099		
3221	7	784	$53,711,633	$68,510		
3222	8	443	$20,627,081	$46,562		
3332	3	45	$1,371,709	$30,482		
3371	54	1009	$28,373,949	$28,121		
3372	5	59	$1,570,423	$26,617		

** Screened due to confidentiality (either 3 or fewer firms, or one firm was more than 80% of employment)*