Study 1: Timber Supply and Forest Structure

Bruce Lippke, Larry Mason, Kevin Zobrist, Kevin Ceder, Elaine Oneil, Jim McCarter, Hiroo Imaki, Alicia Sullivan

Table of Contents

List of Figures

List of Tables

Statement of Intent and Connection to Policy Issues

We begin the timber supply analysis by examining past study projections. We conclude that prior timber supply studies inadequately anticipated the harvest impacts of changing public policies, the development of alternative scenarios and the sensitivity of changes to key assumptions to reflect a range of policy changes and other assumption variables is more important for policy analysis than predictions of the future. As demonstrated by the review of prior study projections, policy developments can have significant influences on which management alternatives are adopted by different forest owner groups, with consequences to forest industries and other harvest beneficiaries. A description of the economic and ecological impacts for a range of management alternatives follows the review of prior forecasts.

The timber supply study updates projection information developed in prior studies (prior data for 1990 Westside; 1992 Eastside) and provides potential ranges of future harvests, log supplies, and representative ecological measures including selected habitat indices. It provides projections for five timbersheds on the Westside and two on the Eastside and highlights differences across owner groups and location. The data are categorized to characterize riparian zone differences from uplands. The study in conjunction with the economic, competitiveness and land conversion studies provide an analysis of why timber harvest levels have dropped well below prior projections and how this has affected the forest inventory and forest sector performance. Discussion of forest management changes and their impacts relative to multiple objectives are developed for past, present, and future conditions. Computer-generated simulations of potential future conditions provide insight on how ecological and habitat changes are linked to harvest fluctuations and changes in forest practices.

We generate timbershed projections with an analysis of changing management plans (forest treatment strategies) by owner type, as influenced by regulatory impacts, forest health issues, market shifts, and other factors. A review of management options at the stand level including a survey of industry management intentions as well as other owner groups provide the basis for allocating owner specific management plans across the forest by timbershed for a base case (i.e.. current trend conditions) and for alternative scenarios (i.e.. future possibilities). Understanding the changes in timber supply in concert with other information on competitiveness and land-use should contribute to a better understanding of forest policy effectiveness past and prospective.

Roadmap for the Study

We first summarize the acres in timberlands by ownerships and timbersheds prior to a brief review of the projections made in prior studies compared to actual harvest levels over the last 15 years as a background for the importance of policy impacts, methods, and key assumptions. We follow this introduction to the forestlands with an analysis of growth, mortality, harvest and inventory change providing an aggregate perspective on how state timberlands are being used and how they are changing. We provide an appended Discussion Paper (DP1) on *Growth, Mortality, Removals, and Conversion Loss Summary for WA Timberlands* supporting this brief analysis. We use these more detailed discussion papers to provide a stand alone analysis on a number of complex issues as support for our brief summaries in the main report.

Since the issues are frequently very different between Westside management and Eastside, we first characterize a range of Westside upland management alternatives supported in more detail by appended Discussion Paper (DP2-W) *The Economics of Westside Forest Management Treatment Alternatives*. The range of alternatives covers no-management or no-action beyond regeneration to several levels of intensive commercial management and finally biodiversity pathways that can contribute to restoring old-forest habitat, the forest structure that has been reduced the most by commercial management and other human intervention such as fire suppression. We discuss how the different objectives of different owners lead to their likely selection among these different treatments. We extend the economic analysis of these alternatives from the perspective of the owner to the regional economic impacts supported in more detail by an appended Discussion Paper (DP3) *Impact of Management Treatment Alternatives on Regional Economic Activity*, which develops the economic model to estimate regional economic impacts from our treatment alternatives when they are allocated across the region.

We then extend the analysis of these treatments to include the impact on habitat supported by Discussion Paper (DP4) *Wildlife Habitat Modeling* and the impact on carbon supported by Discussion Paper (DP5), *Carbon as an Emerging Ecosystem Service*. We then develop owner intentions to implement specific management alternatives as gathered from surveys and other reports supported by Discussion Paper (DP6-W) *Changing Private Forest Management Intensities: Western Washington*, but defer the development of stratified management scenarios across owners until we further develop the substantially different management alternatives and intentions for the Eastside. We conclude the development of management issues on the Westside by an analysis of the regulatory impacts supported by Discussion Paper (DP7-W) *Westside Regulatory Impacts and Responses* which can to a degree be compared to the survey findings on management intentions.

Switching to the Eastside we characterize alarming changes in forest health conditions that require much different treatments than the Westside by first looking at insect outbreaks and climate change supported by Discussion Paper (DP8-E) *Eastside Climate Change, Forest Health and Fire*. We demonstrate management alternatives that are responsive to Eastside conditions supported by Discussion Paper (DP9-E) *Eastside Forest Management Treatment Alternatives*. We then develop relationships between fire hazard and the avoidable costs that are directly related to treatments to reduce fire hazard supported by Discussion Paper (DP10-E) *Benefits/Avoided Costs of Reducing Fire Risks* and extend that further summarizing the findings from simulations introducing treatments to reduce fuel loads with the impact on fire, carbon and avoidable future costs supported by Discussion Paper (DP11-E) *Impacts of Thinning and Implementation Schedules on Fire Hazard Reduction Effectiveness, Carbon Storage & Economics.* We characterize some of the biofuels opportunities supported by Discussion Paper (DP12-E) *Eastside Forest Biofuel Opportunities*, and conclude the Eastside treatment discussion with some of the complications caused by regulations supported by Discussion Paper (DP13-E) *Regulatory and Policy Impacts in Eastern Washington*.

With this background on management plans and their impacts on many economic and environmental attributes we develop baseline projection scenarios for both the Westside and Eastside. For the Westside, the alternative scenarios analyze the impact of conversion losses and the cost to increase biodiversity and habitat. For the Eastside we note the much more heterogeneous forest structure and as a consequence the need for different management treatment plans. We analyze the impacts of several typical management strategies for dry pine forests and moist mixed conifer forests on economics, insect infestations and fire risk.

We then assess the potential role of ecosystem services using carbon as a candidate that might be closest to having a market impact. It should be noted that our ability to make projections that include environmental metrics as well as harvest and economic outcomes traces directly to our ability to start with tree lists from sampled inventory plots and track changes over time based on growth models customized to mimic owner specific treatments plans. Regulatory impacts relating to stream buffer protection were estimated from a spatial representation of streams in GIS. The projection methodology is best characterized as a statistical representation of the land base stratified by timbershed regions, owner specific objectives (treatments), and stand types.

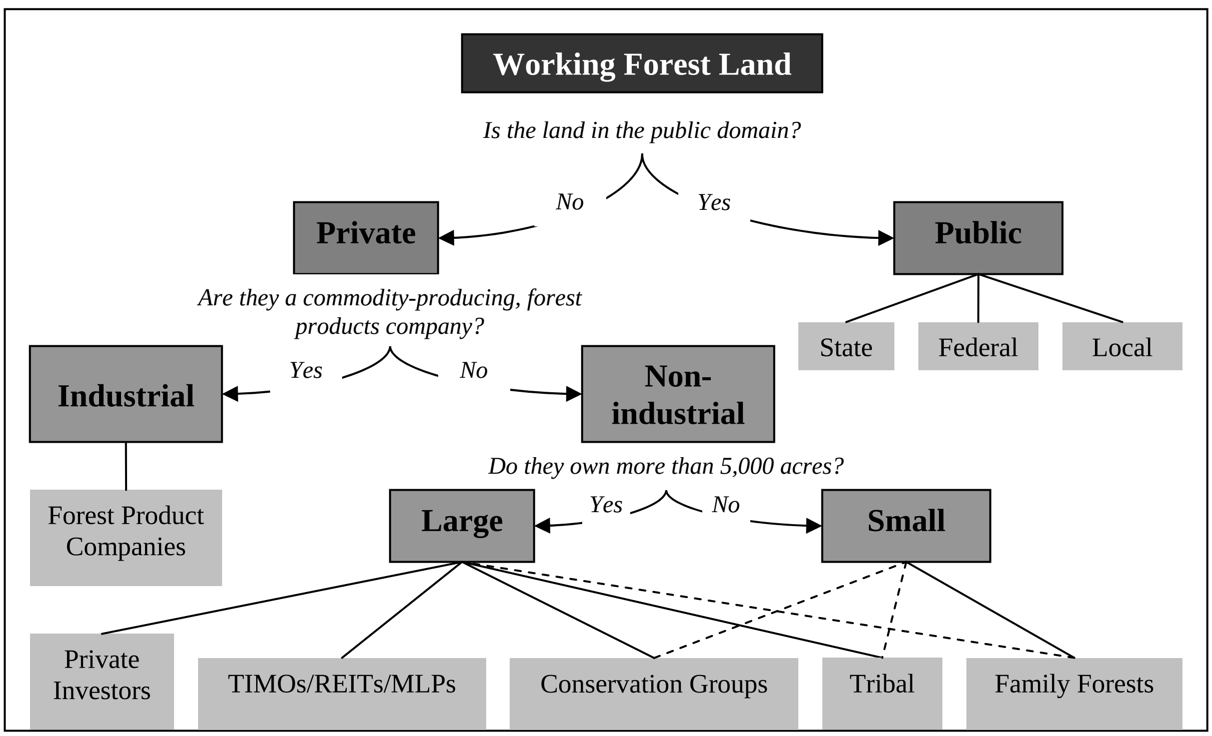
We finally summarize the assessment by an abbreviated topical list of the issues raised.

Setting: Prior Timber Supply Projection Errors and Issues Raised

Acreage by Owner Issues

Prior timber supply studies have started by describing the acreage devoted to working forests on which the supply projections are based. The schematic below demonstrates the classifications of land owners of interest. The general source used for classifying acres by owner groups is the Forest Inventory Analysis (FIA) survey provided by the US Forest Service (McKay et al. 1995, Bolsinger et al. 1997, Gray et al. 2005, Gray et al. 2006) based on a fixed set of sample plots. Since FIA plot locations are proprietary and historically were only updated every ten years, it is difficult to cross correlate FIA data with other sources hence there always remains some uncertainty in ownership shares. Each landowner class has different management objectives and will be managed differently so it is important to develop as good a database on acreage allocations as possible. Since the FIA data updating procedure has changed to partial sampling of the plots every year instead of a complete sample of plots every ten years, and other data sources such as tax parcel information and remote sensing sources are improving, the reliance on multiple sources of data has increased, frequently raising consistency issues in data reporting while at the same time developing new approaches that will ultimately provide a more robust characterization of change. Acreages for sub-categories of interest such as the new legal structures owning much of what was formerly industry (TIMOs/REITs/MLPs) are not available from FIA survey data and it is difficult to characterize any influences of their possibly unique management style.

Schematic: Classifying Working Forest Land by Landowner Groups



Of Washington State's 43 million acres of land, 21 million are forested (Bolsinger et al 1997), with 18 million classified as timberland (producing at least 20cubic ft/acre/yr) of which 2 million are restricted by statute leaving 16 million as unreserved timberlands i.e.. potential working forests. Working forests are however further restrictions to use such as stream buffers, or other habitat sensitive areas as well as inaccessible areas and in particular all federal acres have been managed for ecological values rather than timber production over most of the last 15 years, complicating the original context of what is an unreserved forest. Of the 16 million unreserved acres almost 5 million are federal, 2.5 million state managed (or local), and more than 8 million are private which includes tribal forests. Excluding the federal acres now managed for ecosystem values as well as the state and private acres lost to roads, stream buffers, inaccessible and other sensitive areas being set aside reduces the acreage still largely available for timber production to roughly 8.9 million acres, (6.9 million Westside and 2 million Eastside) only 43% of the total forested acreage reported in 1990. And among these lands, many of the non-industrial private lands including small family owned forests and tribal lands as well as state and local forested lands are managed for multiple objectives suggesting that the timberland being managed with a primary emphasis for growing timber for markets may be as low as 1/3 of the total forested acres with the other 2/3 devoted to a range of non-timber objectives with some timber harvest. Westside land is more productive for growing timber producing about 700 bd ft/acre per year, more than twice the 300 bd ft/acre per year produced on the Eastside.

Projection Errors and Issues Raised

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

Table 1.1 provides a summary of recent Westside harvests by owner group with comparisons to the earlier projections. Predicted results are the product of simulated projections developed with analytical methodologies and based upon a stated set of assumptions. Errors in prior study assumptions and projection methodologies are important considerations for establishing priorities for analysis within the current study. Table 1 shows that using the '86-90 harvest levels as a base period for the prior timber supply report, total Westside harvest levels in the last several years were 36% below projections and 45% below the base period harvest. This is a very substantial decline, not foreseen by the prior study and of considerable importance when considering the impact of policy.

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

Most surprising is the unanticipated substantial reduction in private harvest. The total private harvest is 31% below projection and 34% below the base period as the 1992 projection did include a modest decline in non-industrial and tribal harvest volumes. While there are some ownership transfers that may have affected the within-owner class-accuracy it appears that the projected harvest for non-industry lands was quite close and that the decline in actual industrial harvest levels explains most of the error. While policy changes no doubt also affected private harvest levels, the magnitude of actual decline is so much larger than other prior studies had anticipated (Lippke and Conway 1994, Perez-Garcia et al. 2000) that other sources of error also appear to be important. As will be shown later, the estimated impact of regulatory constraints on industry harvest levels and forestland conversion losses may explain 2/3 of decline with the final 1/3 not easily explained. In the prior study researchers had access to both FIA plot data and proprietary industry inventory data and no significant difference was identified between these sources as a possible source of error.

Table 1.2 provides a summary of Eastside harvests by owner group with comparisons to earlier projections (Bare et al 1995). While this table uses the same base periods, it is important to note that the Eastside projections were developed from inventory data collected several years later than that used in the Westside study and that the Eastside study was also developed from a much smaller number and density of inventory plots. The 1990 Westside inventory sample had been doubled from prior decades to improve data accuracy. Total Eastside harvest levels in the last several years were 20% below projections and 29% below the base period harvest as the projection included an 11% decline based on an expected reduction in harvest volumes on Federal lands that would only be partially offset by projected increases in harvest on State and private lands.

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

However the implications for the future may be more dire as the dominant review critique for the prior study focused on inadequate consideration for forest health issues that would likely reduce future growth. So that while the harvest levels did not decline substantially from projections, they may reflect increased liquidation of inventory accelerated by forest health problems, which will affect harvest levels over the next several decades.

Table 1.1: Westside Harvest History, 15yr Prediction & Variance

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

Table 1.2: Eastside Harvest History, 15yr Prediction & Variance

Eastside mmbfs	Pre-90's 86-89	Predicted 05 +/-	Change Predicted	Last 4 yrs Act. 98-02	Act. Change	Error in Predicted
Ind	371	248		188		
NIPF	190	318		294		
Tribe	189	305		300		
Total Private	751	871	16%	782	4%	-10%
S&L trusts	122	162	33%	81	-34%	-50%
Federal	431	133	-69%	65	-85%	-51%
All Owners	1305	1166	-11%	928	-29%	-20%

While the total statewide harvest projection error was almost 2 billion board ft, the actual harvest decline viewed as a changing trend is almost 3 billion bd ft as noted in Figure 1.1 as the earlier projections did anticipate a 1 billion bd ft decline. Hence the structural change experienced by the forest sector has been driven by a 45% decline in harvest in concert with substantial changes in forest structure in response to changes in the objectives being pursued by policy makers as well as owners.

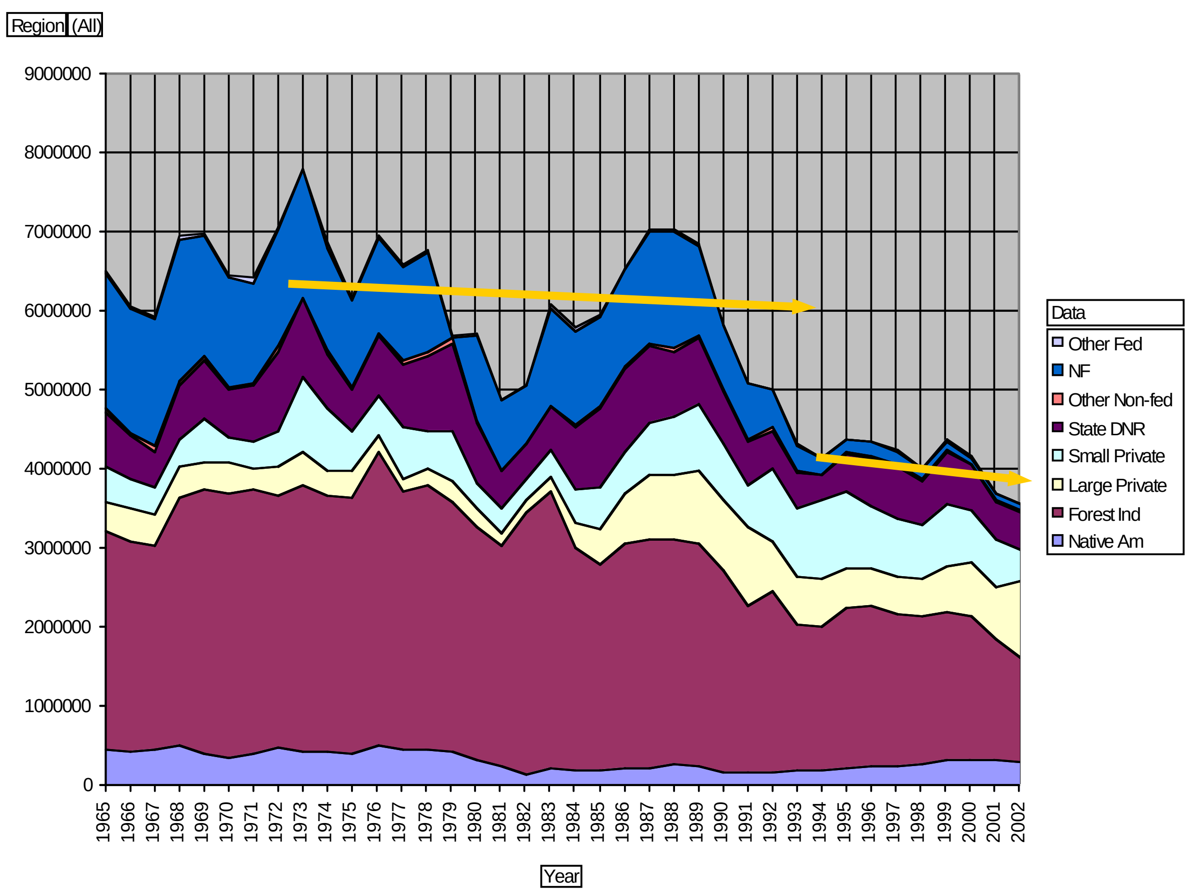


Figure 1.1: Total Washington Harvest History Trend Change (mbf)
(not adjusted for ownership classification changes)

A conclusion that prior timber supply studies inadequately anticipated the harvest impacts of changing public policies suggests that development of alternative scenarios to reflect a range of policy changes and a sensitivity analysis to key assumptions is important for policy analysis and should be a major focus of this study. It raises questions about whether the policy changes were effective in achieving their objective. As demonstrated by this review of prior study forecasts, policy developments can have significant influence on which management alternatives are adopted by different forest owner groups, with consequences to forest industries, and other harvest beneficiaries as well as impacting public values associated with forest development. Consequently, the timber supply analysis provided in this study will focus heavily on different management alternatives and strategies. But first we summarize aggregate changes in growth, mortality, removals, conversion losses and inventory change available from the two previous decadal Forest Inventory Surveys for the Westside and Eastside, noting some of the links between changes in policy and other factors to the change in inventory.

Growth, Mortality, Removals, Conversion Losses and Inventory Change

Conversion losses result from complex changes taking place in urban growth and parcel fragmentation. In the timber supply analysis we restrict our analysis to only those changes measured in the FIA survey as a loss to forest use. Study 4 provides a much more detailed examination of land fragmentation and conversions, which may suggest that the impact characterized in the timber supply analysis is too little as the ultimate loss of land to a working forest is impacted by parcel fragmentation and other management concerns long before the land is ultimately categorized in a non-forest use. We summarize here the information that can be gleaned from changes in the FIA inventory plots as a conservative estimate of the impact on managed timberlands. A more detailed treatise of growth, mortality, removals, conversion losses and inventory change as summarized from forest inventory data is provided in an appended discussion paper (DP1).

Conversion Loss:

Based on the FIA survey of unreserved timberlands producing more than 20 cubic ft per/acre year, the net conversion losses from the Westside private timberland acreage increased from -0.45%/yr average over the 1980 to 1990 decade to -0.62% for the 1990 to 2000 decade. The net loss was primarily on industry lands increasing from -0.64% per year on average in the 1980's to -0.89% in the 1990's as non-industrial (NIPF) owners purchased from industry almost the same amount as they sold. The 350,000 acre reduction in timberland over the last decade, almost all a net loss from industry lands, seems likely to continue unabated or perhaps continue to increase since the industry loss rate increased by 39% from the 1980's to 1990's.

The Eastside net conversion loss rate on private lands decreased from -0.66%/yr average in the 1980's to a +0.05%/yr average in the 1990's. However, the re-measured inventory plot data for the Eastside is based upon a small sample, and the number of other owner classification changes is large, limiting the accuracy of these changes. Conversion losses on State and Federal lands are more likely to reflect trades and reclassifications than direct conversion losses to other uses since very few of these lands directly border on urban growth areas.

Table 1.3: Western Washington Unreserved Acreage (thousands of acres based on re-measured FIA plots)

	Industry	Non-industrial	Private	State & other	Federal(a)	Total
1989	3833	1901	5734	1662	2208	9604
2001	3389	1885	5274	1763	2320	9357

(a) Federal CVS data was collected at different times and excludes reserve acres; acreage differences with other tables reflect the impact of different surveys.

Table 1.4: Eastern Washington Unreserved Acreage (thousands of acres based on re-measured FIA plots)

	Industry	Non-industrial	Private	State & other	Federal(a)	Total
1991	884	2292	3176	761	3292	7229
2002	829	2367	3196	731	3292	7219

(a) Federal CVS data was collected at different times and excludes reserved acres; acreage differences with other tables reflect the impact of different surveys.

Westside: Growth, Mortality and Harvest

Mortality on Westside private lands increased from 9.8% of gross growth during the 1980's to 16.2% in the 1990's. A partial explanation for this increase is the increased number of acres set-aside which resulted in reduced harvest and increased mortality. Mortality on state and other non-federal public lands (Other Public) was substantially higher than on private lands and increased from 12.5% during the 1980's to 27.9% during the 1990's. The higher Other Public mortality in the 80's relative to private may be explained by longer rotations. The substantial increase in the 90's is likely the result of much reduced harvests under the Habitat Conservation Plan (HCP) covering state managed lands in Western Washington. Mortality on Westside Federal lands was 26.3% of gross growth during the mid 90's. Mortality on Federal lands is almost 3 times higher than Private and 2 times higher than Other Public. While it is likely that mortality on Federal lands will increase with the harvest reductions affecting the 90's, the lack of periodic surveys makes comparisons problematic.

Growth and mortality do not change nearly as rapidly as harvest levels and since harvest levels have declined across all owners the most recent removal share of growth and inventory provide the most useful current indicators. When current harvest rates (the last 3-year average available; 2000 to 2002) are compared with the decadal average growth and mortality, the removal shares of gross growth for the Westside are 84% for Industry, 37% for Other Private, 27% Other Public, and 2% Federal.

Gross growth less mortality and removals shows the inventory change share of gross growth at 2% for Industry (although it had been negative in the prior two decades), 42% for Other Private, 45% for Other Public, and 78% for Federal. In effect, with the declining harvest levels, inventories are increasing as a share of growth for all owners in spite of declining rotation ages on Industrial ownerships, which one would otherwise expect would draw down the inventory. The most recent annual inventory-change as a share of total inventory was 0.1% for Industry, 1.9% for Other Private, 1.8 % for Other Public, and 1.4% for Federal, all with increasing inventory.

Eastside: Growth, Mortality and Harvest

Mortality on Eastside private lands decreased from 35% of gross growth during the 1980's to 20% in the 1990's. Mortality on Other Public lands (State and other non-federal public) at 26% was higher than on Industry lands but lower than Other Private lands and increased to 54% in the 1990's, a substantial increase, with only a modest decline in harvest. Eastside Federal estimates available from different surveys show mortality at 49% of gross growth very similar to the most recent decade for Other Public lands. Unfortunately no field inventory survey information is available for the last 5 years, a period with a severe escalation in Mountain Pine Beetle infestations; hence mortality is almost certainly understated on Federal acres and to a lesser degree for other owners.

Current harvest rates (last 3-year average available 2000 to 2002) measured as the removal share of gross growth for the Eastside are 123% for Industry, 54% for Other Private, 23% for Other Public and 7% for Federal. While Industrial harvests appear to be drawing down inventories, the increasing inventories for Other Public and Federal ownerships are contributing to overstocked conditions with consequent forest health impacts as noted in other sections of the report.

A computation of the current inventory change (i.e. Gross Growth less mortality and removals) shows the inventory change share of gross growth at -38% for Industry, +25% for Other Private, +23% for Other Public and +44% Federal. The most recent inventory change/yr as a share of total inventory was -2% for Industry, +1% for Other Private, +0.7 % for Other Public and +1% for Federal. Increases in insect and fire associated mortality not reflected in the last field survey but reported elsewhere in this study based on aerial forest health reports will alter these rates significantly in the future.

Inventory and Productivity

The different management strategies employed by different owner groups and some differences in land productivity result in a wide range of standing inventory and growth per acre. Westside inventory per acre ranges from 10.3 mbf/acre for Industry lands, 13.5 mbf/acre for Other Private lands, 26.5 mbf/acre for Other Public lands and 29.8 mbf/acre for Federal lands. Net growth per year ranges from 571 bf/acre/yr on Industry lands, 472 bf/acre/yr on Other Private, 768 bf/acre/yr on Other Public, and 447 bf/acre/yr on Federal. Since extending rotations beyond the economic harvest age should increase average growth/acre/yr, low net growth for Federal forests reflects higher mortality and lower site class productivity. The comparatively high growth on Other Public forestlands may be partially explained by longer rotations with growth closer to optimum volume growth rotations which are longer than optimal economic rotations. Survey errors given the small sample of the most recent survey may also be a contributing factor.

Comparing current harvest rates with net growth over each owner's total timberland provides a rough indicator of the sustainable timber harvest including the impact of recent management performance. The current Westside Industry harvest relative to net growth is 98%, Other Private 47%, Other Public 37% and Federal 2%. Harvest levels below 100% reflect the impact of managing for many other non-timber objectives.

Eastside average inventories by ownership range from 5.4 mbf/acre on Industry land, 9.2 mbf/acre on Other Private, 15.6 mbf/acre on Other Public, and 12 mbf/acre on Federal forestlands. Net annual growth ranges from 252 bf/acre for Industry, 280 bf/acre for Other Private, 218 bf/acre for Other Public, and 135 bf/acre for Federal.

Using the ratio of harvest to net growth as a timber harvest sustainability measure, the current Eastside Industry harvest relative to net growth is 145%, Other Private 68%, Other Public 50% and Federal 14%. Ratios in excess of 100% reflect a draw down in the inventory whereas ratios substantially below 100% may be contributing to increasing forest health problems as the forest density increases.

Table 1.5: Growth Mortality Summary

Westside (90-1999)	**Industry**	**OthPriv**	**Private**	**OthPub**	**Federal**
Acres (000)	3616	1928	5544	1585	2320
Inventory (mmmbf)	37.3	25.9	63.3	42.0	69.2
Inv/Acre (mbf/a)	10.3	13.5	11.4	26.5	29.8
Growth/A (gross bf/a)	663	595	640	1064	562
% Mortality	14.0%	20.7%	16.2%	27.9%	20.4%
% Removals	84.0%	37.0%	69.0%	27.0%	2.0%
Inv. Change% of Inv.	0.1%	1.9%	0.8%	1.8%	1.5%
Eastside (91-2000)	**Industry**	**OthPriv**	**Private**	**OthPub**	**Federal**
Acres (000)	830	2388	3218	714	3292
Inventory (mmmbf)	4.5	21.9	26.3	11.2	38.6
Inv/Acre (mbf/a)	5.4	9.2	8.2	15.6	11.7
Growth/A (gross bf/a)	299	356	341	473	263
% Mortality	16.0%	21.0%	20.0%	54.0%	49.0%
% Removals	123.0%	54.0%	69.0%	23.0%	7.0%
Inv. Change% of Inv	-2.1%	1.0%	0.4%	0.7%	1.0%

Westside and Eastside Issues:

Declines in Westside harvest volumes have ended the period of inventory/acre reductions on Private lands, as the impact of the increase in acres reserved from management by regulatory constraints is more than offsetting any impact of shortening rotations. However, continuing losses of private forest acreages to land-use conversions suggest that harvest volumes will continue to decline. The increase in inventory in both Other Private and Other Public is very large reflecting the substantial impact of the State HCP on Other Public lands and the varied management objectives compounded by regulatory issues, such as the longer rotations and fewer entries in riparian zones practiced by many small private landowners.

The high Eastside harvest levels are not sustainable on Industry lands although they have most likely contributed to a reduction of the forest health problems that currently plague public ownerships. The increase in harvest on Other Private appears to reflect a changing balance of mature stands and perhaps a response to forest health concerns.

The observation that Eastside removals as a percentage of gross growth has declined from 33% for Other Public and 43% on Federal to just 23% on other Public and 7% on Federal should be expected to worsen forest health problems associated with both insect and fire risk

Westside Management Alternatives and Impacts

Introduction to stand/owner specific management alternatives

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

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

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

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

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

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

When viewed across the nearly 20 million acres of forested lands in Washington, the broad and changing range of management practices and the many different owner objectives, will result in alteration of the forest landscape over time with significant economic and ecological implications. To anticipate how these changes might evolve, it is important to understand the potential range of management options, ownership types, and implications for economic, social and environmental outcomes. We develop growth projections for treatment alternatives and evaluate a range of treatments relative to forest economics, habitat and other ecological attributes, including carbon storage. We then consider how allocation of those treatments over the region might change to meet owner objectives including federal, state and private.

We consider commercial upland management alternatives first and compare their structural impacts to older forest conditions in order to better understand issues associated with protection and restoration of threatened or endangered species. We extend these results to riparian management alternatives for the Westside that can protect and restore riparian functions that may have been compromised by human population density or commercial management. Collectively these management alternatives are intended to portray the range of possible future options and outcomes that could be expected for Washington's future forests on the Westside.

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

Multiple treatment alternatives are developed and modeled for expected outcomes. No-action i.e.. no-management is considered as one treatment alternative for comparison to other options. The purpose of analyzing many different management treatments and intensities is to better understand the multiple consequences of any individual treatment and how it fits different objectives as well as how it might be better motivated if different outcomes are desired. The cumulative effects of multiple treatments staggered through time and stratified over timbershed landscapes are examined in a final section.

Westside Management Treatments: Options and Outcomes

We capture the major impacts for a wide range of management options using 6 treatment alternatives. A *no action* **(NA)** alternative assumes restocking as required by Forest Practices but no subsequent removals. It characterizes the impact of many lands that while once stocked are now set-aside for non-timber objectives. A *plant* and subsequent *clearcut* on an economic rotation **(PC)** characterizes the lowest cost commercial investment alternative generally practiced by many non-industrial owners and others, especially on low site (low productivity) land. A third treatment includes thinning, i.e.. *plant, commercially thin and clearcut* **(PCT),** a practice that grew substantially as one method to avoid stand stagnation from excess density while transferring more growth to a fewer number of trees to reach larger sizes more quickly. A fourth treatment has in recent years been shown to be better for commercial returns with a greater emphasis on early *vegetation control* and faster young growth reducing the need to thin but harvesting on shorter rotations **(PVC)**. And lastly to simulate the impact of long rotation *biodiversity pathways* **(Bio-short)** used to more rapidly move stands from densities much higher than natural regeneration to emulate old forest conditions quickly. While long rotations are inherently more costly the bio-short pathway accelerates the treatment both to quickly reach ecological objectives and lower the losses associated with long rotations. A longer biopathway **(Bio-long)** is included to hold a minimal number of retention trees instead of a long rotation clearcut as it may be more economic and practical for riparian buffers. While there are many variants of these treatments that have been developed for tutorial purposes they span the space of a wide range of different alternatives from no management to intensive commercial management to restoration management.

On the Westside, plantation growth response is heavily influenced by shade. Douglas-fir (*Psuedotsuga menziesii*), shade intolerant, has historically been considered the premium plantation species for Westside forests and received higher prices than western hemlock (*Tsuga heterophylla*). The first four treatments involve a final harvest where all trees, except those reserved by law for wildlife, are removed so that plantation seedling growth is not compromised by shade and are also referred to as even-aged management. The economic rotation length for Westside commercial management on good (medium to high) sites has typically been around 50 years but may be less where the initial growth is higher such as under vegetation control (PVC) and longer on less productive sites.

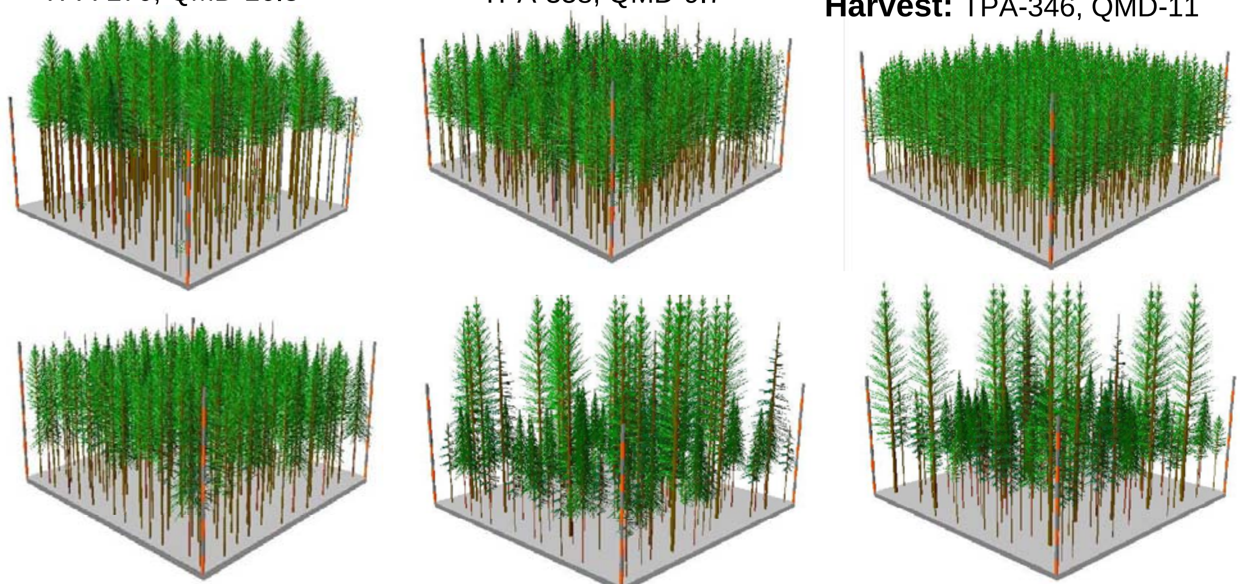


Figure 1.2: Stand Visualization, Trees per Acre & QMD (at 100 yrs or end of second rotation)

As noted in the stand visualizations the unthinned alternatives contain almost 350 trees per acre at time of harvest but with a significantly larger quadratic mean diameter from vegetation control. The commercial thin alterative with 168 TPA has an even larger QMD and the same number of trees as the twice as old unthinned and unharvested stand. The biopathways provide substantially more diverse structure and fewer, but much larger trees, with QMD approaching 30 inches comparable to old forests. Each structure has unique impacts on landowner economics as well as habitat. Harvest volume tends to be larger for no thinning options except vegetation control which produces the highest volume growth. Tree height and QMD respond more directly to progressively larger thinning treatments and longer rotations, although vegetation control produces more early growth even without thinning. We provide a more detailed analysis of Management Treatment Alternatives and their impacts in Discussion Paper DP2-W appended to this study.

Economic Performance Affects Management Choices – West:

When investing in a forest rotation, expected future harvest revenues must be weighed against the up-front costs of stand establishment and tending. Costs and revenues occurring at disparate times are discounted to the present for a *Net Present Value* (NPV) using the desired interest or discount rate (5% in our analysis) to allow for investment option comparisons. The best economic performance is equivalent to the highest NPV (net profit including time valued revenue and costs).

Forest management treatment choices have significant impacts on NPV outcomes. The magnitude of early-rotation costs is particularly important, as greater (or sooner) future harvest revenues may be needed to offset greater early-management investments. If forest managers perceive that pre-commercial thinning (PCT) and commercial thinning (CT) treatments do not result in sufficient revenue increases, then these activities are logically foregone. The most significant factor in driving the NPV is the cost of money influenced by the length of the rotation. The optimum rotation age is reached when revenue growth falls below the target discount rate (5% illustrated) or approximately 50 years for medium site stands (60+ for lower sites, 40- for highest sites). Discounting the return from perpetual future rotations to the time of planting provides an estimate of Soil Expectation Value (SEV) an NPV calculation that computes the amount a willing investor would pay for the bare land ready to plant to achieve the target return. SEV is the measure most associated with the market value of sustaining the land in forestry, the economic return to the land managed perpetually under a prescribed treatment plan.

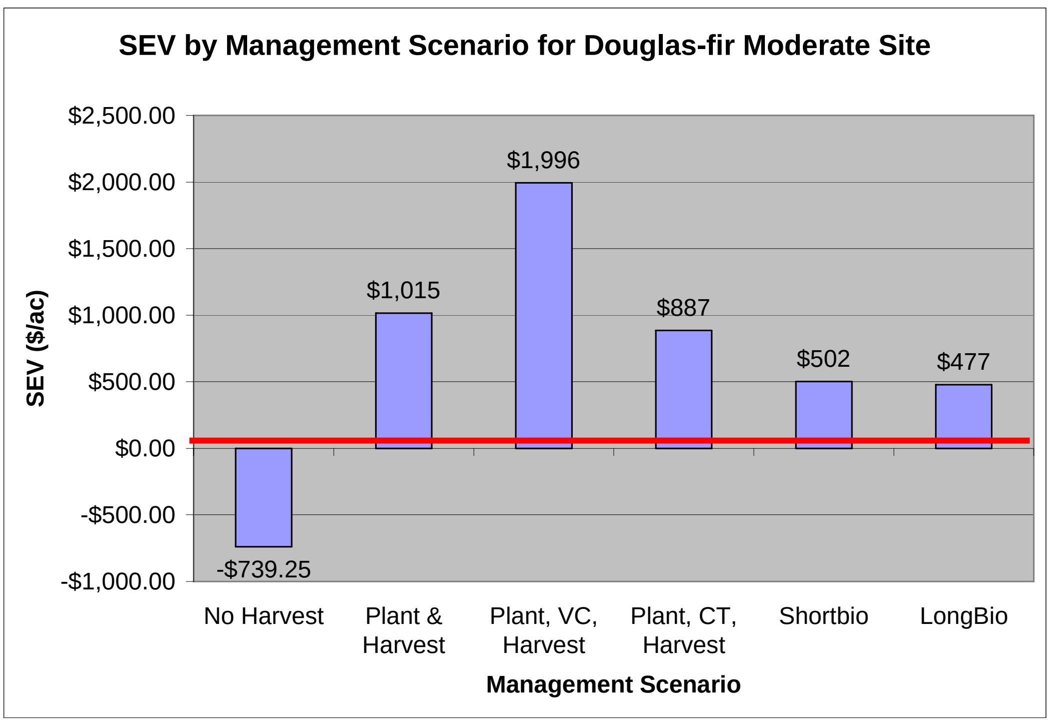


Figure 1.3: Stand Expectation Value (return to bare land) for a range of management treatments

The SEV for the commercial thinning option (CT in Figure 1.3) is not substantially different than the no thin harvest option and their relationship may change with modest differences in inventory and log prices. The much higher return from vegetation control (VC) is noteworthy and driven largely by the much faster early tree growth further leveraged by a shorter rotation. It is however a more experimental simulation based only on the tree data provided by young experimental plots. The biodiversity management scenarios result in a much reduced return, approximately half that of the commercial treatments. Since there is no revenue returned to the no harvest alternative it simply reflects the market value of the land, stocking and holding costs assuming the initial investment was based on the expectation of a commercial return.

Economic Activity: The economic impacts induced by these management alternatives are determined by the direct labor and other purchases required for each treatment activity and the downstream processing activities spawned by the availability of timber carried through an analysis of indirect impacts based on an economic model for the state. The economic model used to develop these links is described in the appended Discussion Paper 3 (DP3) and has been updated in several steps using recent surveys of processing mills and logging operations calibrated to several Washington State Input/Output models of inter-industry activity which capture indirect impacts. The comparison of impacts across treatments are modestly different than the direct return (SEV) to landowners as each treatment results in a different share of wood going into primary processing, secondary processing, or paper. While the biopathways may support more secondary manufacturing in the long term if facility investments take place to process large logs for higher valued uses, we demonstrate the economic impact as a Net Present Value of future state and local taxes, approximately 1/10th of the sectors business output.

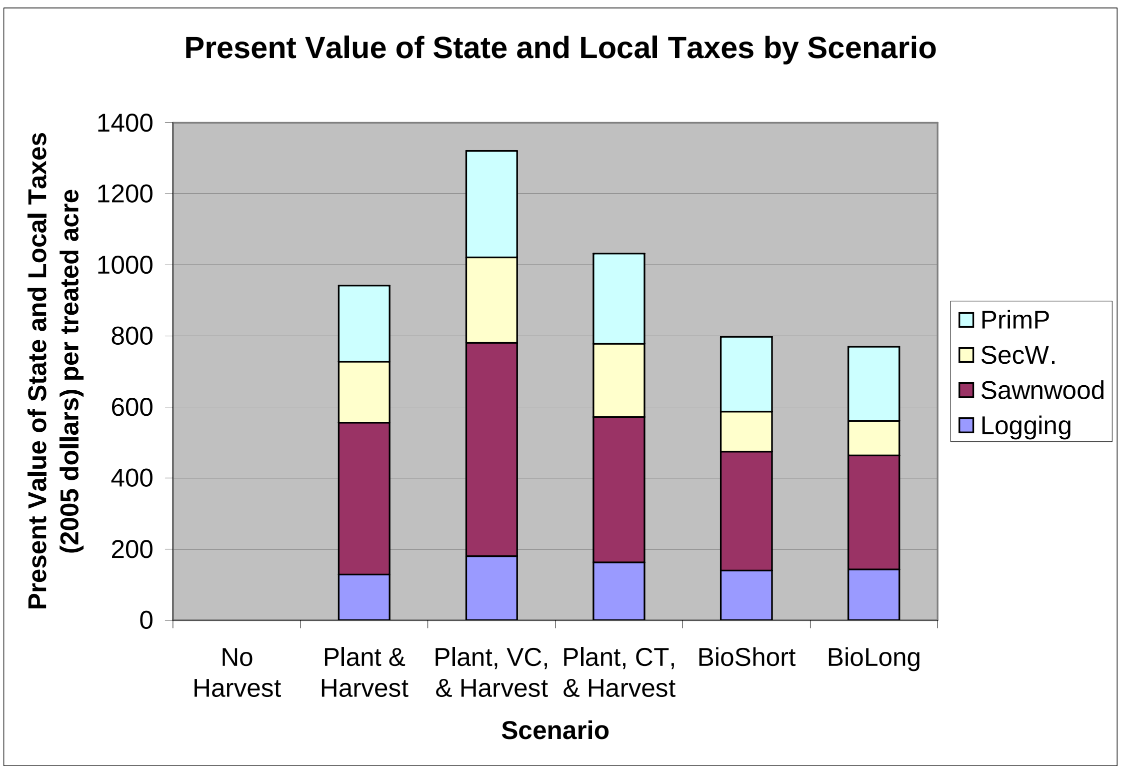


Figure 1.4: Present Value of State & Local Taxes from the economic activity created by different management treatments and downstream processing

It is noteworthy that the short rotation commercial thin (Figure 1.4) produces a higher NPV than the no thinning alternative whereas the return to the landowner (Figure 1.3) was less. More intensive operations generally will create more economic activity with the benefits flowing to local communities. Similarly the biopathways which may require incentives for landowners to be willing to devote their land accordingly, do not reflect as large a loss compared to the commercial treatments as was the loss to the landowner. This provides some opportunity for social benefits to accrue through regional economic values coupled with non-market ecological benefits if incentives are provided for some biopathways.

Environmental Outcomes – West:

While shorter rotations have the economic advantage of faster investment recovery, they also result in more of the landscape being harvested at any given time. The landscape is further skewed toward younger stand structures, which may cause problems for species that utilize older structures (Curtis 1997). A shift away from thinning may also have other undesirable environmental outcomes. Stands that are maintained in a highly dense condition have a paucity of understory vegetation and do not support high levels of biodiversity (Oliver and Larson 1990). In contrast, thinning in managed stands has been found to promote understory development and promote development of multiple canopy layers (Bailey et al. 1998; Bailey and Tappeiner 1998, Muir et al. 2002). Thinning has been linked to increased wildlife abundance (Havari and Carey, Hayes et al. 2003, Suzuki and Hayes 2003; Wilson and Carey 2003) and it can accelerate the development of desirable old forest conditions (Busing and Garman 2002, Garman et al. 2003, McComb et al. 1993, Tappeiner et al. 1997).

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

Old forests are the structures in shortest supply as a consequence of commercial management. A scientifically advanced method to determine how to effectively manage stands to intentionally produce old forests could develop statistical measures of existing old forests as target stands for comparison to the same parameters for managed stands. Figure 1.5 demonstrates that the old forest cluster of stands in the Olympic Experimental State Forest (OESF) is quite well defined by just two variables, QMD and TPA, and this discrimination between stands can be further enhanced by adding other variables such as canopy closure. By accepting the 90% of the old forest stands closest to the center of the distribution as the desired target and comparing the percentage of time any given treatment to a managed stand is not significantly different than the target stand in say 100 years, we have a robust statistical test for assessing whether a given treatment is successful in restoring old forest structures (Gehringer 2006).

Assessment of stand equivalence to an old forest target structure

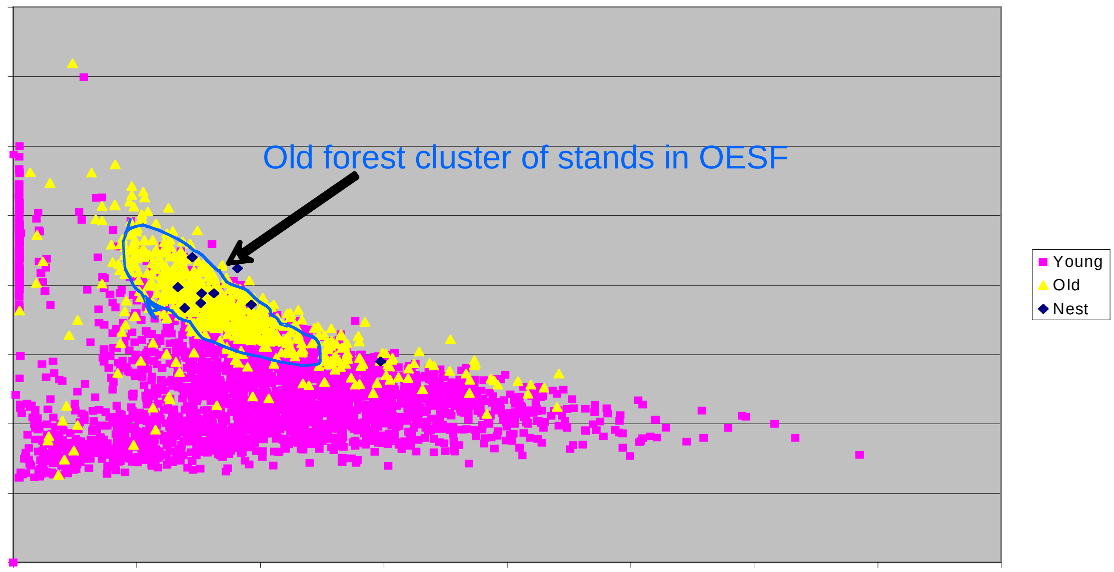


Figure 1.5: Old Forest conditions as discriminated from all other conditions

The cluster of old forest (greater than 80 years old) shown in Figure 1.5 includes all of the known one time productive Northern Spotted Owl nests on the OESF within the old forest structure. The cluster provides a useful target for managing stands to take on the characteristics desired by the structure. As an assessment procedure we can test the percentage of time any given management treatment will produce statistically equivalent structure as demonstrated for our range of management treatments in Figure 1.6.

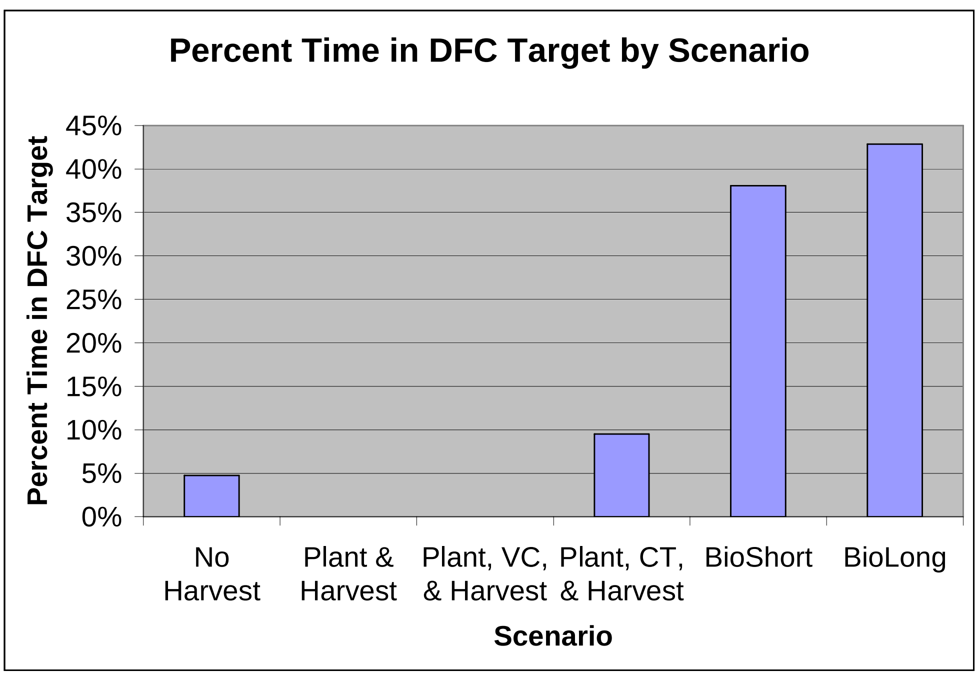


Figure 1.6: Percentage of time that a given treatment is in the desired future condition eg. Equivalent to old forest structure

As demonstrated in Figure 1.6, the bio-pathways are reasonably effective at producing the equivalent of old forest structures. As should be expected, neither of the short commercial rotations without thinning reaches the condition at all and the single thin treatment essentially is just beginning to take on the characteristics of the old forest structure at the time of harvest. It also has the advantage of providing an attractive starting point for a biopathway as an optional pathway after the early thinning. Even the no harvest scenario barely reaches the desired condition, as it takes natural mortality in dense stands a long time to provide adequate thinning.

Habitat Suitability Measures:

Measures of forest structure can also provide prediction of habitat suitability for individual species. We characterize the percentage of time each treatment provides either essential or supportive habitat for several species known to prefer different forest structures, The Pileated Woodpecker prefers *complex forest structure* much like the owl, the Douglas Squirrel is identified with *coniferous forests*, the Gold-Crown Kinglet prefers *very dense closed forest structure* and the Roosevelt Elk prefers *more open structures.* Using the Johnson and O'Neil (O'Neil et al. 2001) categorization of forest structure into 38 different structure classes we demonstrate the habitat suitability for the Pileated Woodpecker since we would expect the old forest structure for which we developed a statistical test to be a good measure. As shown in Figure 1.7, the short biopath provides substantially better habitat defined as Closely or Generally Associated (CA or GA with P or "Present" being marginal habitat) but the long retention biopath appears to retain too few overstory trees. Whether this a weakness in the habitat criteria or an accurate assessment may require additional research. Since there are many species we illustrate only a few for demonstration. Specific objectives will likely involve different species in different regions.

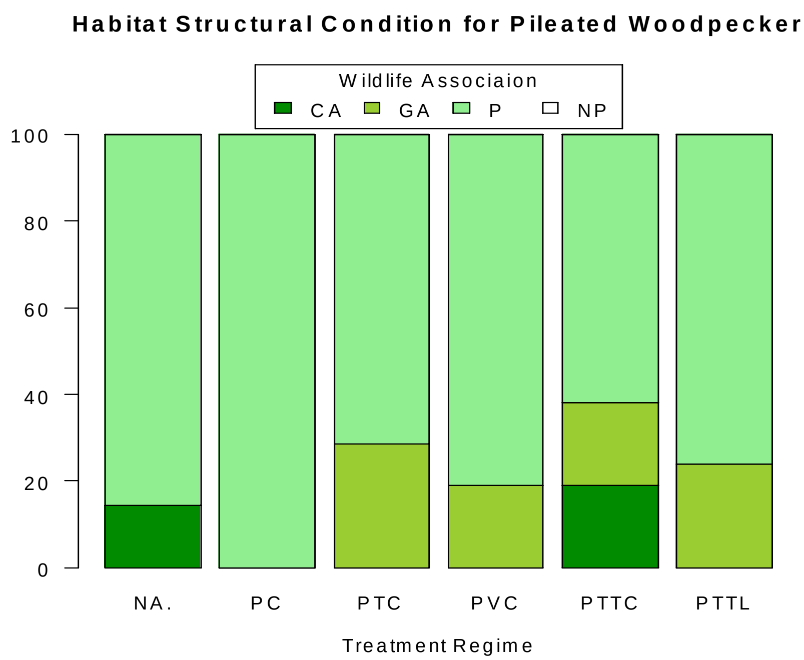


Figure 1.7: Habitat suitability for Pileated Woodpecker under different treatment regimes

Looking across the selected species and treatments in Table 1.6 it is noteworthy that the old forest sensitive Pileated Woodpecker has the lowest amount of suitable habitat with the short biopathway treatment the best support. The Douglas squirrel receives somewhat lower scores in the commercial pathways but still tolerates a large range in forest density. The Golden-Crown Kinglet prefers dense forests but receives relatively high scores even under short rotation commercial stands. The Roosevelt Elk was least sensitive to the different structures.

While these measures do not establish the monetary worth of habitat, they can be used to determine the opportunity loss associated with changing treatments to produce more of any given habitat, while noting that continued research into these habitat measures will likely improve over time, much like the old forest target assessment procedure appears to provide a more robust statistical test for reaching a target forest condition. We discuss old forest DFC and habitat suitability modeling in greater detail in Discussion Paper DP-4.

Table 1.6: Closely Associated and Generally Associated Habitat for Four species with different structural preferences under different treatment regimes

	NA	PC	PTC	PVC	PTTC	PTTL
Pileated Woodpecker	14.3	0.0	28.6	19.0	38.1	23.8
Douglas' Squirrel	71.4	33.3	38.1	19.0	66.7	71.4
Golden-Crown Kinglet	85.7	61.9	57.1	57.1	76.2	81.0
Roosevelt Elk	100	100	100	100	100	100

As an estimate of the opportunity cost to produce various habitat we cite the sensitivity found in the OESF study to produce additional old forest habitat. It costs (revenue loss) $80 for each one % of time in DFC starting with stands already 30 years old, the earliest time for a first thinning. A target of achieving 30% of the acres in DFC (old forest structure) in about 20-30 years would result in an NPV loss (cost) of about $2,400/ total acre or an annual annuity payment of $120/year/acre. This cost could be lowered substantially by delaying the time to reach target to about 50 years as the NPV cost to reach DFC in 50 years is only about $500 or $167 to reach a 30% target requiring a perpetual payment of only $8.50 per total acre i.e. $8,500 per year applied to 1000 acres producing 300 acres or 30% in DFC.

Life-Cycle Analysis and Carbon Storage:

Forest ecosystems absorb large quantities of carbon which is stored in solid wood, vegetation, litter, and soils thereby reducing atmospheric CO_2. Young healthy forests take up carbon at high rates, while the net carbon uptake in older forests ultimately slows with age followed by release from mortality, decay, and/or wildfire. The end-use of timber harvested from forests is an important factor in evaluating the net consequences of forestry to the global carbon cycle. Forest products that are durable goods, such as building materials or furniture, store embodied carbon for the life of the product. Short-term products, such as paper and cardboard, once used and allowed to decay or burn, release carbon that had been taken from the atmosphere some years earlier, releasing the carbon back to the atmosphere. Carbon embodied in milling residuals and discarded wood products may be sequestered in landfills for long periods of time. When forest products are used in place of non-wood products such as steel and concrete, that are much more energy-intensive in their manufacture, releases of atmospheric carbon are avoided. When forest biomass is used to generate energy as a substitute for fossil fuels, releases of fossil carbon are avoided (Birdsey 1992).

The Consortium for Research on Renewable Industrial Materials (CORRIM), has recently released reports covering full life cycle assessment of the environmental performance of using wood products in residential construction (Bowyer et. al. 2004, Lippke et. al. 2004). Included in this research is accounting for four major carbon pools: 1) carbon in the forest; 2) carbon in products that leave the forest; 3) carbon associated with the use of forest biomass and product residuals as an energy source; and 4) the carbon offsets from the substitution that occurs when wood building materials displace products like steel or concrete. A major finding in the CORRIM report is that forests that are periodically harvested, planted, and re-grown to produce a continuing series of short- and long-lived products and energy feedstocks, sequester and offset more cumulative carbon than forests that are left unharvested. This finding is illustrated by the graphs below that depict comparative examples of carbon accounting associated with an even-aged managed forest

(Figure 1.8) and an unmanaged forest (Figure 1.9) in western Washington. Figure 1.8 characterizes the time dynamic nature of carbon storage as quantified in metric tons per hectare for a 45-year commercial rotation as a cumulative sequence of carbon storage and release in the forest, in products, and the impact of product substitution for non-wood alternatives. Figure 1.9 shows the accumulations of carbon over time but with no post-regeneration treatments, no disturbances, and no products and hence no substitution for fossil fuels or energy intensive product alternatives.

While the carbon in the forest in Figure 1.8 is shown to cycle with each rotation around a steady state trend line, the carbon in product pools, net of energy used in harvesting, processing and construction, gradually increases over time. When the avoided carbon emissions from the displacement of fossil fuels and fossil fuel intensive building products are included, there is a substantial increase in total stored and offset carbon that can be seen to surpass the cumulative carbon storage in forest biomass when there is no harvest activity as displayed in Figure 1.9. While carbon stored in the forest reaches a steady state, the use of wood in construction displaces fossil fuel intensive products, thereby storing carbon while also reducing carbon emissions. Increasing the acreage under forest provides a one-time increase in forest carbon. If the forests are harvested and reforested, additional carbon storage is provided by the periodic production of long-lived products, and by displacement of fossil fuels for energy and substitution of energy intensive building materials with carbon neutral wood products.

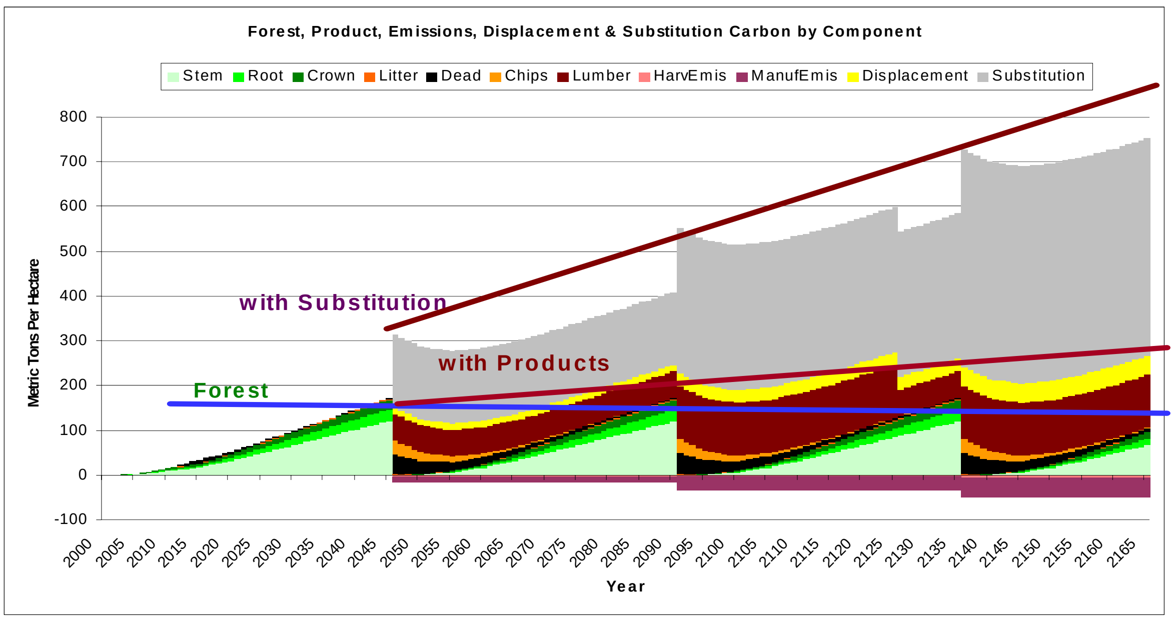


Figure 1.8: Carbon pools for a single acre of commercial forest under a 45-year rotation.

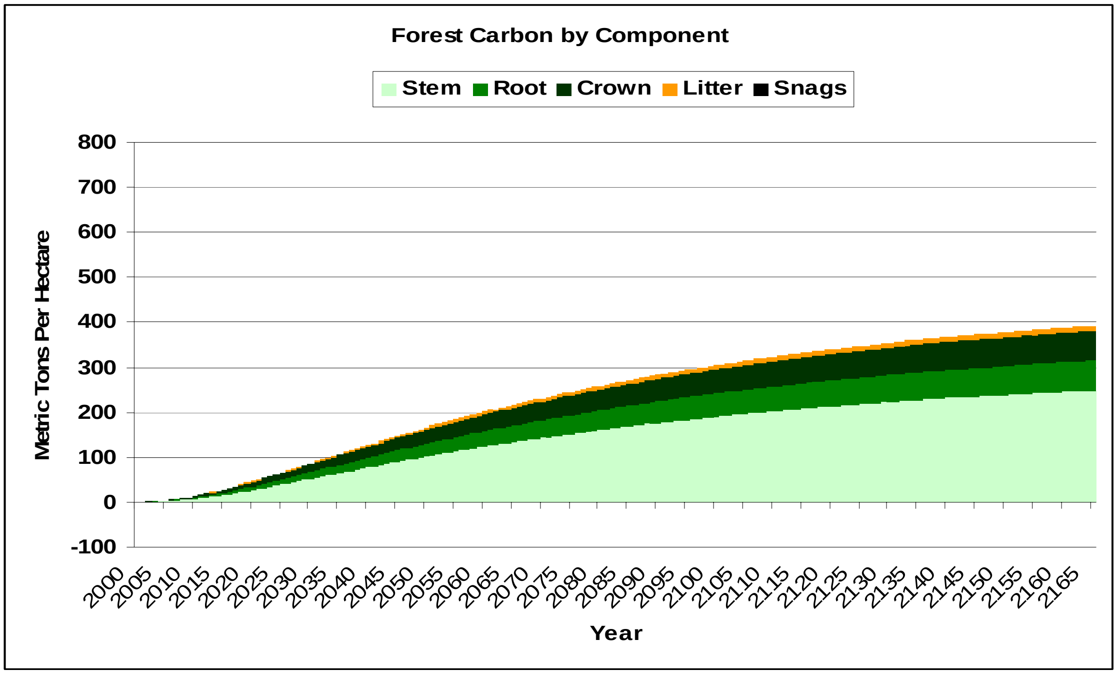


Figure 1.9: Forest carbon pools for a single acre with no harvest and no disturbance.

Phase II CORRIM research has applied the same life cycle assessment principles, displayed in Figures 1.8 and 1.9, to Eastern Washington forests where slower growth, uneven-aged management, and more diverse silvicultural pathways make analysis more complex. To accommodate variability in Eastern Washington forests, summaries of cumulative carbon pools through time have been developed for the entire landscape rather than as a single-stand example. Figure 1.10 displays simulated estimates of the weighted-average amount of carbon produced per year per hectare in the forest, product, displacement, and substitution pools for all non-federal forests in Eastern Washington (Johnson et al. in prep). These simulations assume that these forests will continue to produce timber volumes approximately equal to the volumes removed from 1980-2002 and also assumes that the forest products and co-products include lumber, chips, and hogfuel. The product streams do not account for anticipated increases in biomass removal associated with the current focus on using forest residuals as bioenergy and biofuel. How clean energy policy initiatives alter the relative mix of energy, co-product and product outputs from industrial production will alter the relative importance of the product, displacement, and substitution carbon pools depicted in these graphs, but will not likely significantly alter the relative importance of these pools to the forest pool.

Figure 1.10 indicates that after 100 years the average carbon per hectare stored in the forest is only one third of the total carbon benefit accrued on non-federal eastern Washington forests. While Eastside forests produce less biomass carbon per hectare than Westside forests, effective management of Eastside forests for fuel removal can reduce the amount, intensity, and duration of wildfire and related carbon release. The extent of wildfire risk reduction based largely on management strategies developed prior to climate change is uncertain. What is clear is that the risk exposure to wildfire is reduced with less carbon left on the landscape. Reducing this risk, in combination with increased carbon storage in products and displacement of fossil intensive products, offers the potential for managed forests to mitigate global warming trends while producing historically significant product outputs. We discuss carbon in greater detail in Discussion Paper DP5.

Federally managed forests produce a different set of carbon related issues as they are currently at high risk of burning with substantial CO2 emissions and no opportunity for the wood to displace fossil fuel intensive products. This more complex situation is discussed later in relationship to Eastside Issues and Discussion Paper DP11.

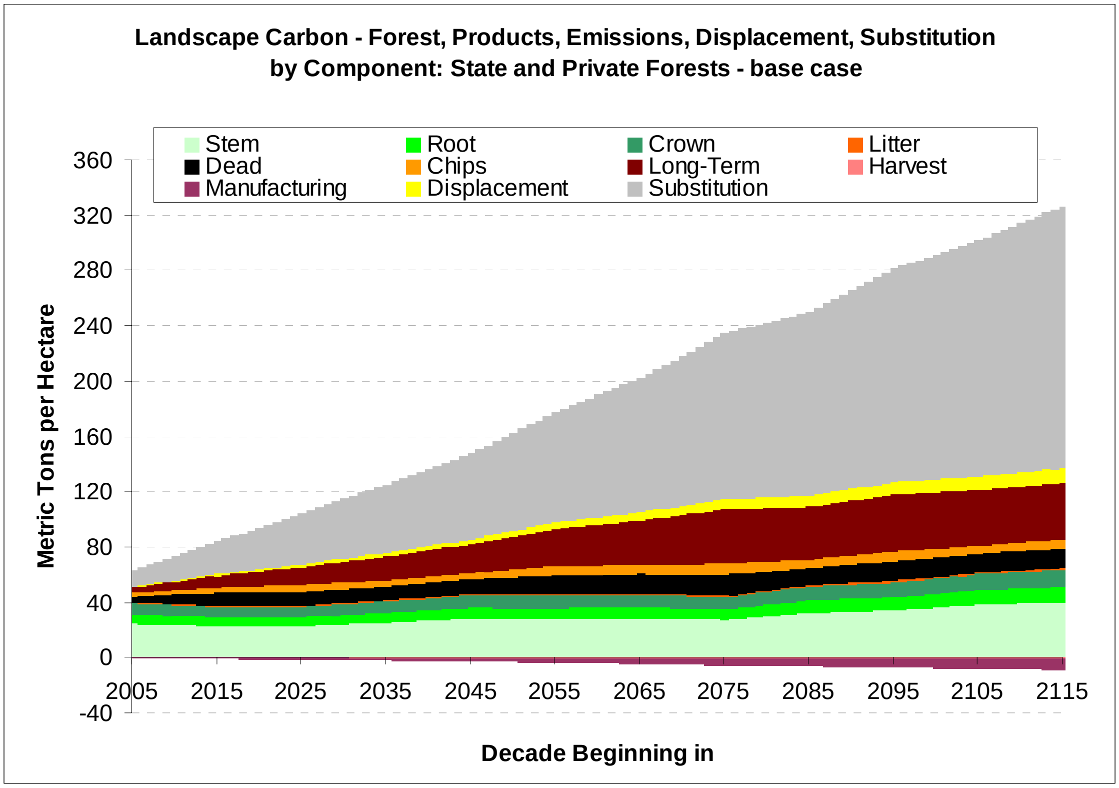


Figure 1.10: Tons per hectare carbon pools for non-federal forests in eastern Washington

Management Intentions - West

Surveys of industrial management intentions show substantial changes in management treatments planed for the future in comparison to prior periods. While a 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 all but been abandoned in recent years, and to a degree been replaced by the increases in planting of genetically improved seedlings to accelerate growth. As much as 10 years shorter rotations to final harvest are occurring 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 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 best practice vegetation control.

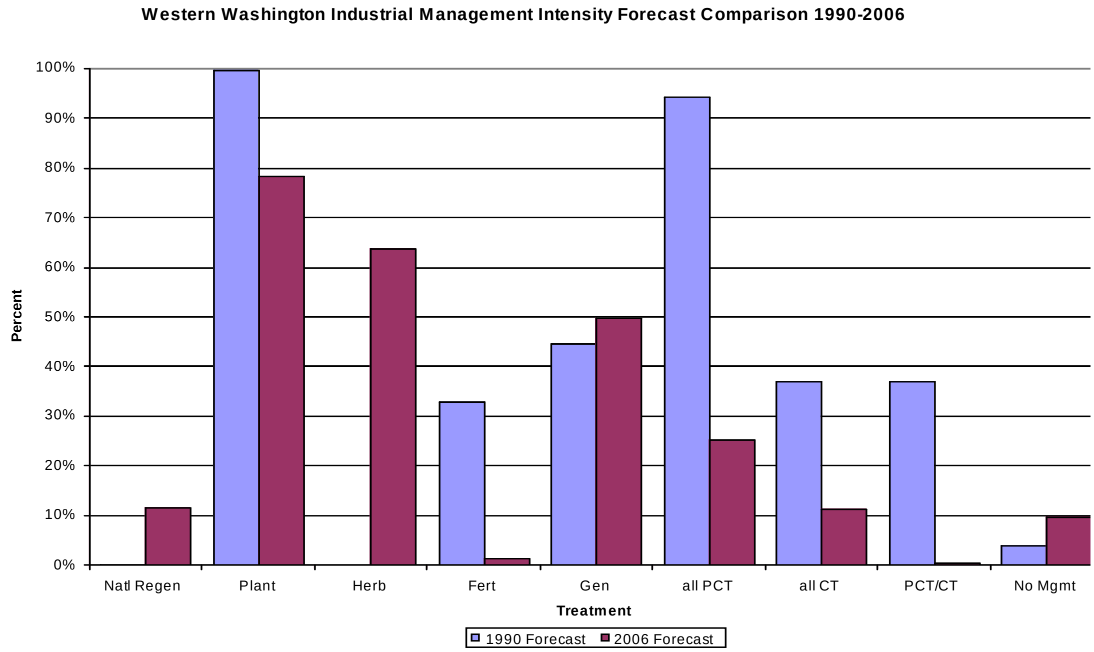


Figure 1.11: Changes in Westside management intensification plans 1990 to 2006

The greatest apparent difference between 1990 expectations and current practices is the dramatic reduction in pre-commercial and commercial thinning (Figure 1.11). 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, today increases in forest practice restrictions, primarily associated with riparian regulations, have resulted in 10% of industrial forests removed from harvest with a substantial variation across timbersheds.

Non-industrial private forests (NIPF) in Western Washington are generally family enterprises and often serve dual purposes as working forest and home site. Family forest owners are many and are diverse. Some manage their own lands while others rely upon management guidance from professional forestry consultants. Most ownerships are small (less than 100 acres) and as a consequence are subject to infrequent harvest activities that appear to be driven more by personal circumstances than by revenue maximization as evidenced by the relatively large inventory of mature timber retained on non-industrial forestlands as compared to industrial and tribal forests. We found that, in contrast to industry, this owner group is more likely to incorporate regular thinning treatments (nearly half of treatments appear to be commercial thins) into forest management regimes.

In contrast to industry divesture of forestland assets for conversion, Western Washington Indian Nations are increasing reservation forests through purchases of allotments and non-Indian lands and by reclamation of Tribal titles. Indian forests are managed to benefit Tribal communities in many ways - by producing timber and revenue as well as a wide variety of non-timber products such as traditional foods and medicines, cultural values, and firewood. Spiritual use, water, and fish and wildlife habitats are also important. Western Washington Tribal timberlands are dominated by lower site quality forests and a greater abundance of western hemlock and other softwoods than on industrial and non-industrial counterparts. Subsequently, very little commercial thinning is employed and rotations are extended to 50 or 60 years. Plantation of harvested areas is followed by pre-commercial thinning to reduce overstocking. Tribal foresters report very little use of chemical herbicides or fertilizers.

These surveyed management intentions provide the critical assumptions for developing baseline harvest and forest structure projections and are provided in greater detail in Discussion Paper DP6-W.

Regulatory Impacts and Responses - West

Regulatory constraints have increased significantly in recent years due to a major update to the forest practices regulations known as the Forests and Fish Rules (FFR). The FFR,, finalized in 2001, increased harvest restrictions around streams and other sensitive areas in an effort to help restore salmon populations and comply with the Endangered Species Act (ESA).

Forest and Fish Rules

In Western Washington, the FFR require a three-zone riparian harvest buffer along either side of a fish-bearing stream (see Discussion Paper DP7-W for details). The three-zone combined buffer width is one site potential tree height (SPTH), with different management restriction is each zone. A 50-foot no-harvest buffer is also required around portions of non fish-bearing streams and around sensitive features such as seeps and springs.

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

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

Small Ownership Case Studies:

An examination of the lost economic value of the forestland from the regulations for 10 small owner case studies showed losses ranging from 34 to 164% of the total economic asset value, demonstrating a wide disparity of impacts across small owners and concern for the sustainability of forest management as a viable option. Losses greater than 100% suggest that with the current riparian harvest restrictions, forestry is not economically viable for some owners (present value of expected costs exceeds present value of expected revenues).

Efforts to mitigate the economic impacts of the FFR included reduction in the Forest Excise Tax from 5% to 4.2% of the stumpage value of harvested timber, however the value of the timber restricted from harvest is usually many times greater than the value of the tax credit (Reeves 2004). A Forest Riparian Easement Program exclusively for small landowners provides direct compensation for 50% of the stumpage value of the restricted timber in return for a 50-year easement on that timber. The program is ineffective in that the money made available applies only to existing timber and does nothing to compensate for the lower return to sustainable management and thus does not mitigate for any diminished motivation to pursue future rotations once the existing timber has been harvested. Program funding is also far below the need to compensate for the impacted acres.

Management Alternative to Achieve Desired Future Conditions:

The prescribed harvest restrictions are also not effective in achieving the DFC. Commercially dense regenerated stands along streams would typically be thinned but is not practical under the regulations. The absence of thinning leaves the areas closest to the stream in a dense, overstocked condition that inhibits the development of the DFC (Carey et al. 1996, Carey et al. 1999, Chan et al. 2004).
While the FFR allows landowners to deviate from the default buffer prescriptions using approved alternate plans the approval process has been challenging resulting in little progress. Approved templates utilizing thinnings throughout the riparian zone could expedite approval and the development of mature forest structure. In particular, "biodiversity pathways" that utilize repeated, heavy thinnings over long rotations show promise as a management approach for quickly developing the DFC while reducing economic costs (Carey et al. 1996, Carey et al. 1999, Lippke et al. 1996).

Example templates have demonstrated that the time in DFC can be more than doubled while reducing the impact on land value from an $842/acre loss to a $207% reducing the cost to produce DFC by 4 times. The resulting stand structure, within the riparian buffer, has greater structural diversity including larger trees, deeper crowns, and height differentiation with less than 17% of the area outside of the riparian core ever adjacent to a recent harvest of the uplands.

(a) **(b)**

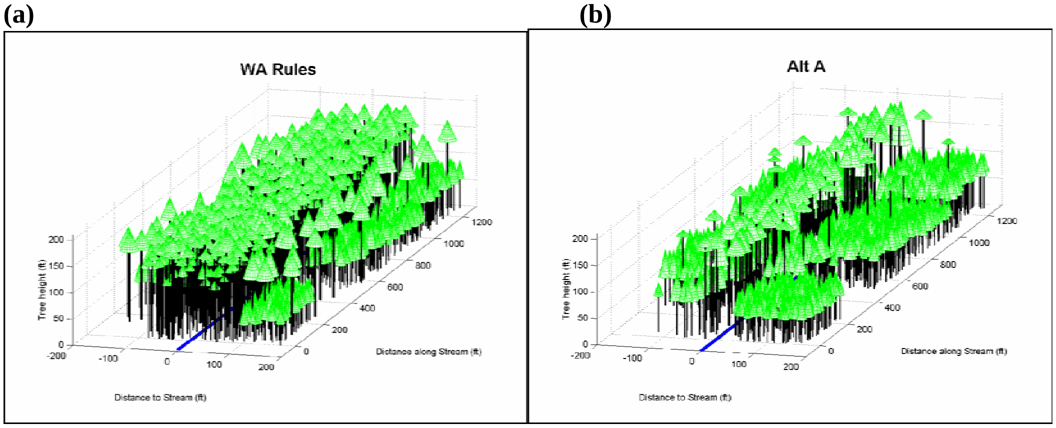


Figure 1.12: Visual results after 110-year landscape simulations of the default regulatory buffers for FFR Max Harvest (a) and an example alternate plan templates

The alternative plan template framework is not limited to overstocked riparian zones, but can be applied to other situations where objective measures are needed for achieving multiple objectives. The approach has been evaluated for the Olympic Experimental State Forest (OESF) to examine management pathways for accelerating the development of both young and old forest northern spotted owl habitat while generating revenue for the trust beneficiaries (Lippke et al. 2007).

Buffer Variability:

The impact of new stream typing rules were examine for Lewis county showing a 67% increase in buffers along fish bearing streams and 143% for non fish bearing streams for small owners compared to 35% and 133 % increases for large owners. The non-fish bearing stream impact may however be much larger as sample LiDAR data shows many more headwater streams than exist in the DNR hydrography database.

Buffers computed on a county by county basis range from 3% to 17% of timberland. For the Westside, analysis of the hydrography database produces 52,000 miles of streams resulting in 753,000 acres in buffers on 7.2 million acres of timberland. Contrary to the intent that the regulations would provide regulatory certainty, the impact of buffers has changed significantly in both definition and ability to estimate their impact accurately, and should not be considered optimal from either an economic standpoint or a protection standpoint, although offering much more protection than prior to the adoption of the regulations. Regulatory impacts are provided in greater detail in Discussion Paper DP7.

Eastside Management Alternatives and Impacts

Forest Health Trends and Implications for Management:

Eastside forests present very different problems and opportunities than the Westside. Eastside investments in forestry are very marginal hence forest management plans are more about how to sustain a revenue stream from treatments than the pay out from investing in intensive regeneration. While on the Westside the focus is on obtaining the best economics and controlling density to reach a desired future condition, on the Eastside the focus is on finding a treatment path with sustainable economics while avoiding the much more critical problems associated with excess density contributing to elevated fire and insect risk. To reduce the investment cost in the face of generally lower growth rates and sometimes problematic regeneration, management has historically relied on selective harvesting, uneven-aged management, natural regeneration and limited planting and thinning treatments. Declines in forest health associated with overstocking, past management practices, insect infestations, drought and climate change, wildfire, and other factors have become widespread making treatments that restore health of prime importance (Western Governors Association 2001 and 2002). A Forest Health Strategy Working Group was commissioned in Washington to focus attention on forest health needs and to develop recommendations. Many of the findings in their report are covered here (WADNR 2004). We will first characterize changes in forest health and regulatory impacts before tackling commercial management practices and potential alternatives. Projections must take into account mortality from forest health problems and wildfire as well as removals and growth.

Mortality from Damage Agents:

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

Recent overview flights to assess insect and disease damage suggest that upwards of 13% of annual growth is lost to damaging agents (DNR 2007). In 2005 alone, 11.9% of the total forested area of Washington State showed elevated insect and disease damage, with most of that damage located in Eastern Washington. This loss is sometimes captured in inventory data, but the timing of re-measurement, sampling changes and lack of a complete re-sample may obscure important trends. In addition, five-year trends in insect and disease outbreaks suggest a recent and significant shift in mortality patterns that have not been captured by data collected prior to 2001. Of the inventory data currently available, only 23% of the National Forest Continuous Vegetation Survey (CVS) plots have been resurveyed since 2001. The Forest Inventory Analysis (FIA) data on state and private lands pose even more challenges with respect to insect and disease correlations as plot locations are obscured to protect proprietary ownership data which makes confirming damage extent and trends problematic. Forest health overview flights can, however, be cross-correlated between re-measurements and historical aerial survey data to provide estimates of the current degree of damage and impact by owner group and forest type over time. Estimated extent and degree of damage can then be used to calibrate growth models to more effectively capture any current forest health trends.

To gauge the extent of potential damage, the time series data provided in Figure 1.13 identify the mortality and mortality per acre in Eastern Washington from a single insect; the mountain pine beetle (MBP), on only two of its hosts: lodgepole (LPP) (*Pinus contorta*) and ponderosa pine (PP) (*Pinus ponderosa*). Across all ownerships, the average mortality rate for 1980-2000 is 2.2 trees per acre while for 2001-2005 the average is 8.4 trees per acre. In 2005 alone, MPB affected over 415,000 acres resulting in over 4 million dead pine trees in Eastern Washington. These and other data analyzed in Discussion Paper DP8 *Eastside Climate Change & Forest Health* suggest that there has been an alarming change in the character of MPB attacks related to changing climate. The ubiquitous nature of the MPB attacks means that impacts are no longer largely confined to LPP in National Forests, but have now become a major element in more valuable timber producing forests as well. An analysis of the aerial overview flight data indicates that in 2005, the area affected on non-federal lands was approximately three times that in 2004 while National Forests had 1.5 times the number of acres affected in 2004.

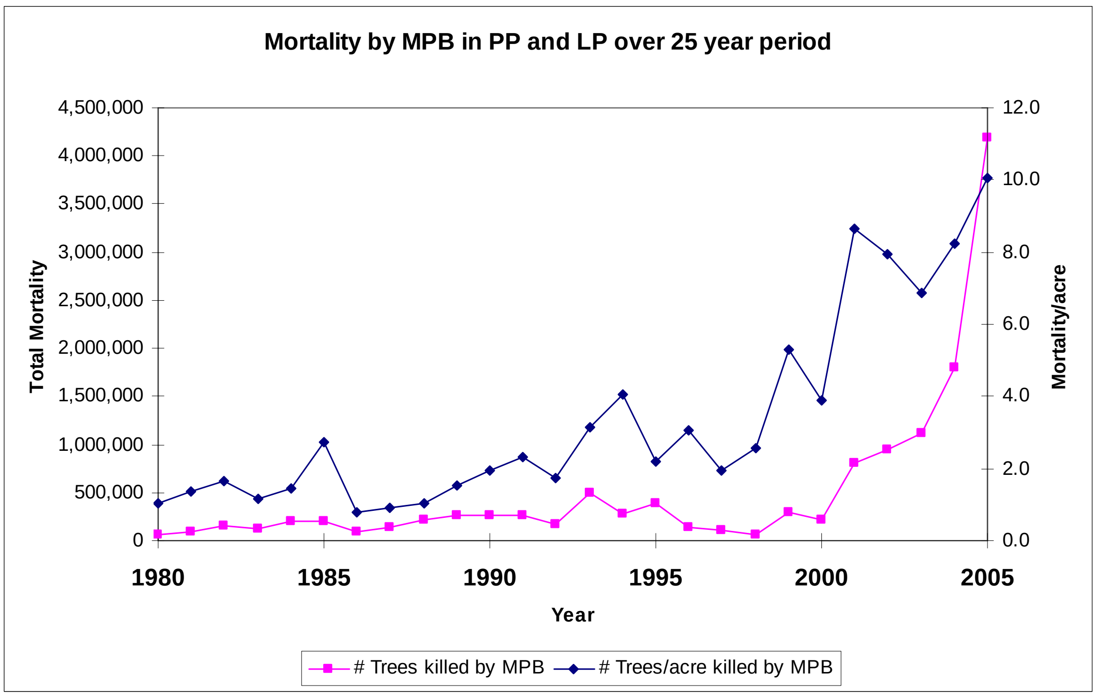


Figure 1.13: Time series of mortality from MPB in Eastern Washington.

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

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

Before concluding how to incorporate insect mortality into projections, it is important to characterize the interaction between insect attacks and fire as well as the opportunity for management to reduce the resulting mortality and related environmental and economic impacts.

Forest Fire Risks and Impacts:

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

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

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

A brief summary on avoidable costs and non-market values associated with fire hazard reduction (Mason et al. 2003, 2006) has been included in Discussion Paper DP10-E to provide more complete accounting on the multiple public benefits of investments to reduce forest fire hazard. This discussion paper also provides information on the accelerating costs of fighting forest fires.

With this introduction to the severe consequences of changing forest health and fire risk, we introduce a range of management alternatives to begin to characterize whether there are opportunities to mitigate hazard or manage for greater resiliency in the face of these risks.

Treatment Regimes for Eastside Forests

Forest Groups:

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

Heterogeneity within Forest Types:

Within the dry, moist, and cold forest categories there are a large number of habitat types that reflect unique moisture and species composition gradients. We simulate growth, yield, and a range of potential management actions, mortality, and recruitment for sample plots prior to aggregating into the appropriate strata. The plot level predictions are scaled and aggregated to strata based on broad forest group (dry, cold, moist), timbershed, and ownership type.

To estimate growth and yield we use the three regional variants of the Forest Vegetation Simulator (FVS), a Forest Service growth and yield model, which cover the geographic extent of Eastern Washington forests. These variants are the Inland Empire/North Idaho (IE/NI) variant for Northeastern Washington, the East Cascades (EC) variant for the East Cascades, and the Blue Mountains (BM) variant for Southeastern Washington. Within each FVS variant there are a range of habitat types that generate substantially different yields for a given species reflecting the inherent variability in growth potential. Figure 1.14 provides an estimate of the range of growth expected for ponderosa pine in all the habitat types where it is found in the FVS EC variant. In this example the ponderosa pine was ‘planted’ at 400 TPA and grown for 100 years without further treatment. Yield as measured by basal area varies from a low of 83 square feet per acre on the driest sites to a high of 290 square feet on the wettest and most productive sites.

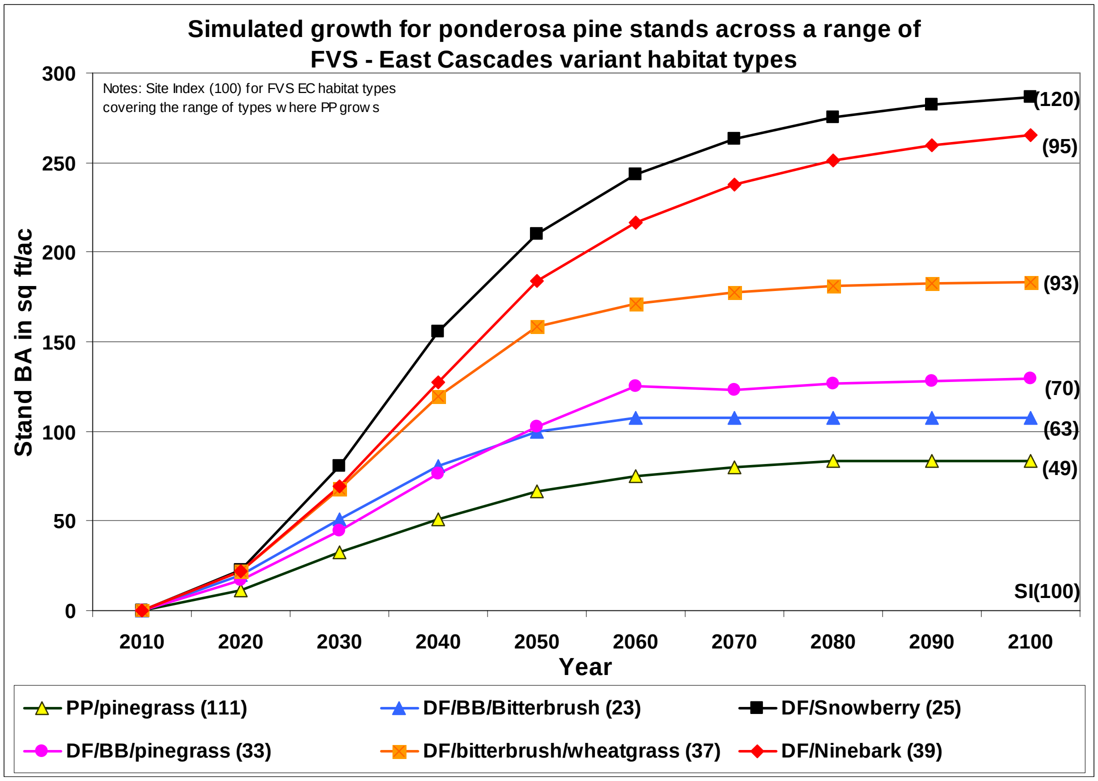


Figure 1.14: Simulated ponderosa pine yield for a range of habitat types in the FVS East Cascades variant

To capture this range in growth potential, individual plots are grown in the habitat type indicated by their respective data sources (FIA or CVS).

Single Acre Simulation Examples of Alternative Strategies to Address Forest Health:

Treatment alternatives were simulated on the two most prevalent forest types: a ponderosa pine type in the Okanogan area and a mixed conifer type in Northeastern Washington. The analysis identified break points between economic return and reducing stand susceptibility to insects, disease, and fire. For each alternative, in our Discussion Paper 9 (DP9) on management alternatives we report on the likelihood of risk reduction, economic outcomes, and the subsequent level of additional cost or incentive that might be needed to encourage landowners to adopt a specific treatment. Given the array of management goals across the ownerships of Eastern Washington, there is no best single management alternative. Analyzing alternatives provides a useful comparison of trade-offs, costs, and expected outcomes for meeting forest health goals.

In the ponderosa pine forest type, the stand used for analysis was a fully stocked merchantable ponderosa pine stand that is currently experiencing mountain pine beetle (MPB) mortality because of excessive density and basal area relative to site carrying capacity. On this very dry site, the ponderosa pine is regenerating (albeit poorly) under its own shade, which allows for treatment approaches that would not be as successful on wetter sites. Periodic stand entries were simulated using four different treatment regimes: (1) **Max NPV**—maximizes net present value of cash flows through removal of merchantable volume to the limits permitted by state forest practices laws; (2) **Partial Retention**—partial cutting from below to a target basal area; (3) **Overstory Maintenance**—treatments to move the stand toward a high canopy fire resistant old forest overstory; and (4) **No Action**—assuming no disturbance (note that with high fire hazard the stand would likely burn in the projection period) (Table 1.7).

These few treatment alternatives provide a useful range for understanding how different owner objectives can be pursued with consideration for forest health and fire risk. Max NPV would largely be associated with an industry objective modified to the degree necessary to reduce forest health and fire risk. It provides sustainable economics and with some removal of non-merchantable small diameter residuals would result in low insect risk and fire risk. However where removal costs are high and ladder fuels are left as forest residuals even post-harvest fire risk will remain high. Partial Retention emphasizes some initial overstory retention to facilitate regeneration as well as some attempt at maintaining overstory trees depending on leave tree characteristics. Both partial retention and overstory maintenance treatment regimes can immediately move stands away from high hazard thresholds for fire, insects, and disease, regardless of differences in the long-term management goal. These two alternatives would likely be acceptable choices for an array of private landowners that had various degrees of interest in maintaining large diameter trees for their long-term habitat attributes. In contrast to the first two alternatives, Overstory Maintenance treatments are designed to produce a widely spaced dominant pine overstory. Reduced returns from these treatments are a function of lost revenue beyond the second entry coupled with continuing financial obligations for understory removal, either mechanically or by burning, to ensure that the stand does not become overstocked and multi-layered and thus susceptible to MPB attack and increasing fire risk. The overstory maintenance approach is not considered economically sustainable or viable for private landowners, but may meet non-market goals of public and Tribal landowners. The No Action alternative also assumes no disturbance so is most like the recent history of no harvest with active fire suppression of on federal forests. The result is unsustainable economics with increasing fire and insect risk with trees stressed beyond the lands growth capacity. The stands become overly dense increasing the likelihood of infestations and unusually intense fires over time.

Table 1.7: Forest Health risks and economic returns for dry forests under four treatment scenarios

Ponderosa Pine Scenarios	Max NPV	Partial Retention	Overstory Maintenance	No Action
BA ave. (sq.ft.)	32	28	68	161
Crowning index average (mph)	63	61	98	48
TPA ave.	164	157	96	105
NPV $@5%	$3,586	$2,652	$1,109	(-)
Cash Flow (decades entered)	5 times	5 times	2 times	none
Beetle risk	Low	Low	Marginal	High
Fire risk	Low	Low	Very low	Moderate
Sustainable econ	Yes	Yes	No	No

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

Periodic stand entries were simulated using four different treatment regimes: (1) **Max NPV**—removal of merchantable volume at regular cutting cycles; (2) **OS with Retention**—overstory conversion to a seral species mix with retention of dominant Douglas fir to provide structural diversity; (3) **OS without Retention**—no retention of dominants (required wildlife trees in adjacent riparian zones are retained); and (4) **No Action**—assumes no disturbances (Table 1.8). While the 'No Action' alternative stand is identical prior to these treatments and reflects the assumption of no stand altering disturbance for the rest of the period, risk of loss from root rot, budworm and fire are all high suggesting that stand conditions will likely be altered by a disturbance. This simulation demonstrates that the timing of treatments to address forest health is critical. In this case the simulation indicates that the investment required for overstory conversion to forests with reduced fire and root rot risk must be amortized over a minimum of 40 years prior to any returns. A status quo treatment regime of continuing overstory removal maximizes economic gain while doing little to alleviate risks associated with fire, insects, and disease.

Table 1.8: Forest Health risks and economic returns for mixed conifer forests under four treatment scenarios

Mixed Conifer Scenarios	Max NPV	OS convert with Retention	OS convert without Retention	No Action
BA ave. (sq.ft.)	23	37	29	264
Crowning index average (mph)	54	76	51	13
TPA ave.	250	197	198	315
NPV $@5%	$2,814	$1,213	$2,164	(-)
Cash Flow (decades entered)	5 times	4 times	4 times	none
Root rot risk	Marginal	Better	OK	High
Budworm risk	3 bad decades	OK	OK	High
Fire risk	Low	Very low (just)	Low (just)	High
Sustainable cash flow	Yes	Yes	Yes	No

While return per acre in the species conversion scenarios continues to improve through the simulation period, discounting at 5% negates the gains in later years as compared to the Max NPV case. Thus the economic trade-offs may dissuade conversion to species and stand structures that can avert forest health problems unless small diameter timber becomes more valuable, resulting in earlier merchantability of the current inventory. Retaining even a few large trees into the next forest stand in the 'with Retention' case impacts both immediate timber value and subsequent growth of understory trees resulting in a 44% loss in economic return over the 90 year period relative to the 'without Retention' case.

Reducing forest health risks is accomplished in all three mixed conifer scenarios where active management is pursued. Delaying the transition from a multi-layered stand to an even aged stand composed of seral species is responsible for the reduced forest health benefits of the Max NPV case with respect to root rot and budworm risk. Fire risk varies substantially through time as managed stands transition from regeneration through sapling, pole, and mature phases, whereas it remains high throughout the simulation for the No Action scenario. All stands have periods when they are at high risk of crown fire, but the managed stands do not stay in the high risk.

Management Intensities East

The timber supply analysis includes one management treatment scenario developed to reflect current practices for each owner group (the base case) and a series of management scenarios developed to investigate potential alternative management intensities and forest health treatments dependent upon owner type.

Large Private and Industrial Treatment Regime

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

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

High Elevation Forests and Wet forests (includes LPP): The treatment regime is a No Retention even-aged strategy that leaves a minimum of 4 TPA>10"DBH following regeneration harvest to meet statutory requirements for green tree retention.

Tribal Treatment Regime

Dry Forests: The treatment regime is an uneven-aged individual tree and group selection favoring retention of Ponderosa pine and western larch. Post harvest basal area targets range from 40-80 square feet per acre depending upon stand conditions with insect and mistletoe damaged trees prioritized for removal.

Moist Forests: The treatment regime is a periodic entry to remove merchantable volume, favoring retention and under-planting of Ponderosa pine and western larch. Post harvest basal area targets range from 60-100 square feet per acre depending upon stand conditions with insect and mistletoe damaged trees prioritized for removal.

High Elevation Forests and Wet forests (includes LPP): The treatment regime is a No Retention even-aged strategy that leaves a minimum of 4 -12 TPA>10"DBH following regeneration harvest for green tree retention.

Small Private Treatment Regime

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

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

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

State Lands Treatment Regime

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

National Forests Treatment Regime

National forests alternate case management intensity applies restoration strategies to reduce fire and insect risk to plots located in dry and moist forests that roughly correspond to areas within the Wildland Urban Interface (WUI). Treatment regimes assume thinning from below up to a diameter limit of 12" dbh or to a basal area of 60 square feet/acre in pine stands at risk of a mountain pine beetle outbreak. Natural regeneration is assumed with species compositions based on forest type, overstory species composition, and habitat type. The base case applies these treatments but only at the acreage observed in harvest trends from 1995 to 2003.

Stratification of Management across Owners

Stratification - West

Methodology:

We provide a complete analysis for industry lands from 2004 to 2104 exploring the many key assumptions that affect both economics and habitat as largely dependent upon harvesting and forest structure. Most of the change in the forest sector is being driven by changes affecting the industry lands including land conversions, the response to declining public harvests and changing markets, and management intensity changes. An analysis of forest landuse trends indicates that conversions to non-forest uses are occurring with declines in industrial ownership at the rate of about 0.9% per year that in part include transfer to small forestland owners as intermediaries to other land uses. The near cessation of federal harvest has resulted in the majority of the current harvest volume being provided from industrial forestlands. And in addition, industrial forest managers are obligated to achieve the highest possible economic return on timber investments and subsequently are quick to adapt practices to changing markets, and have made substantial changes in their management intensity planning.

We provide numerical details for the Westside stratification process in Appendix 1. In brief, Forest Inventory Analysis (FIA) tree list plot data are updated to the 2004 base year and stratified by owner, timbershed, age class, site class and species. The updating process requires allocating removals that occurred since the last comprehensive FIA survey to appropriate age classes as well as characterizing acres that have been unmanaged and are likely to remain so. For the industry lands it was assumed that timber age classes over 100 years were constrained from harvest by voluntary or regulatory constraints that continue into the future resulting in 2% of the acres remaining as older forest types.

Riparian buffers are allocated to a no-management growth treatment with the buffer descriptions and regulations characterized in DP7-W. Riparian buffers plus the non-riparian acres that were not harvested constitute an unmanaged set of acres. Results of surveys of management intensions are used to allocate anticipated silvicultural treatments by timbershed to those acres available for management (DP6-W). There is general consistency between the industry survey on acres that cannot be managed and the estimated area in buffers plus older forests that have not been harvested. Similarly, forestland conversions to non-forest uses are allocated by the decadal trend rate of land conversions observed by timbershed thereby reducing the acres in industrial ownership over time.

The results of each treatment simulation to a percentage of acres as determined by survey allocations are summed across the timbersheds producing estimates of potentially harvestable volumes and associated changes to standing inventories. We do not impose even flow harvest constraints for industrial harvest simulations since prior experience has tended to show that this arbitrarily obscures age class distributions that may be important in understanding impacts. We describe that which is harvestable recognizing that there are many nuances including data and model deficiencies and market fluctuations that could affect the actual timing of harvest. We use the timber economic model characterized with the description of management alternatives to estimate potential return to landowners (DP2), and the forest sector economic model (DP3) driven by the annual log supply to characterize the impact on jobs, labor income and state and local tax receipts. Finally we assess the number of acres with forest structures statistically similar to old forests as a desired future condition (DFC) for species that are thought to require old forest habitats. We also estimate the number of acres considered as suitable habitat for several species that demonstrate a strong structural preference for a range of forest structures (DP4).

The base case, therefore, reflects a 100-year timbershed-dependent (1) update of the starting inventory, (2) estimates of unmanaged acres in stream buffers along streams and older forest areas, (3) declines in acres remaining in forests as a result of conversion trends, and (4) allocation of different management treatments as simulated for various stand types and age classes to reflect the variability in owner management plans. Results are linked to a state economic model for an estimate of economic impacts and to several measures of habitat suitability to reflect the impact of changes in stand structure distributions.

Industry Base Case Results

Results for harvestable timber, inventory and growth:

The age-class distribution observed for the FIA data in the 1989 survey is provided in Figure 1.15 along side the resulting age class distribution for 2004 (Figure 1.16) as updated by interim harvest allocations and stand growth (the first decade in 1989 shows harvested acres not yet regenerated; the first decade in 2004 shows half regenerated as a consequence of half a decade being regenerated). It can be noted that most of harvestable acres i.e.. above the 40-50 year old decade have been removed by 2004 except for stands much older than the economic rotation age. This narrowing of the available age-class distributions is reflective of industrial commercial forest management, based upon available inventory and harvest information.

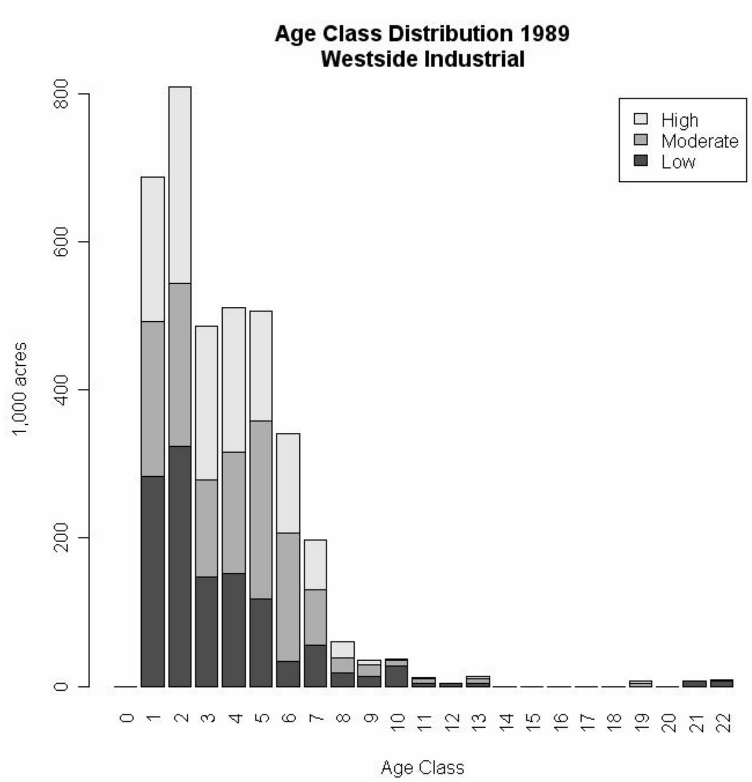


Figure 1.15: Westside industrial age-class distribution 1989

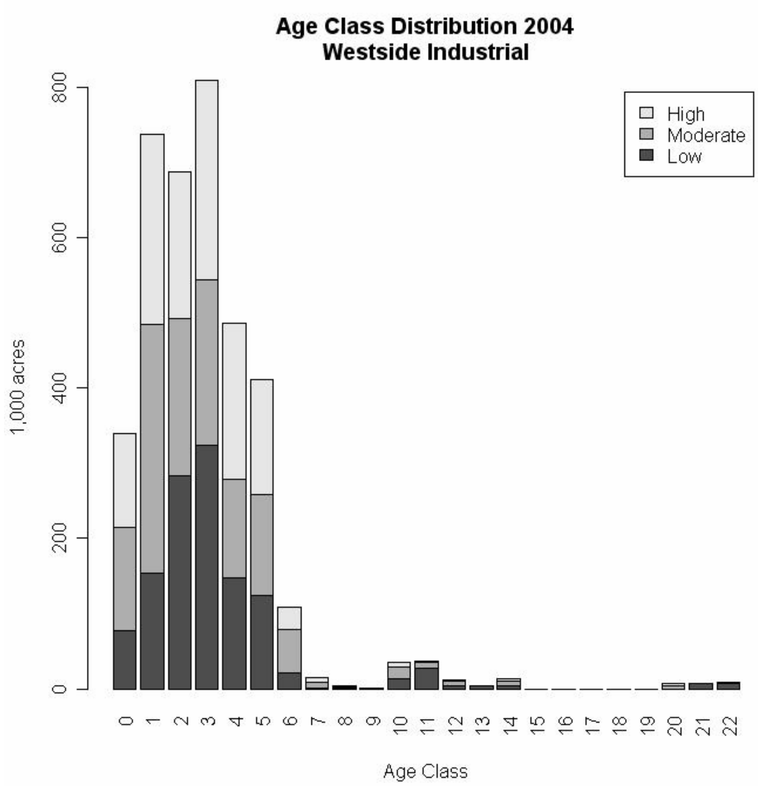


Figure 1.16: Westside industrial age-class distribution updated to 2004

Timber volume of approximately 1.4 billion board feet scribner (BBF) per year (yr) for Westside industrial lands is noted as harvestable for the first three decades (Figure 1.17). Unlike our initial estimate provided in Progress Report 3 which was based on a more aggregate identification of harvestable volume, a greater emphasis on age-class and treatment differences across timbersheds has resulted in a modest increasing trend over the first three decades rather than a decreasing trend. Both estimates show a build in harvestable volume by the fourth decade. The relative level of available harvest is not significantly different but the stratified management baseline highlights the importance of the initial uneven age-class distributions. Due to skewed age-class distributions, the number of acres becoming available for harvest over the first four decades appears to be increasing faster than the rate at which land conversions are reducing the acres available. The peak volume harvestable in the fourth decade is a consequence of the shift to more intensive management (vegetation control) accompanied by shorter rotations and an abundance of younger age-classes in the simulation start year (2004). The longer-term available Westside harvest averages nearly 1.5BBF/yr in spite of land conversions as the management intentions are narrowly focused on high growth short rotations from intensive management treatment alternatives. However, the share of harvest volume from the North Puget Sound and South Coast timbersheds noticeably declines as these regions have the greatest land conversion losses

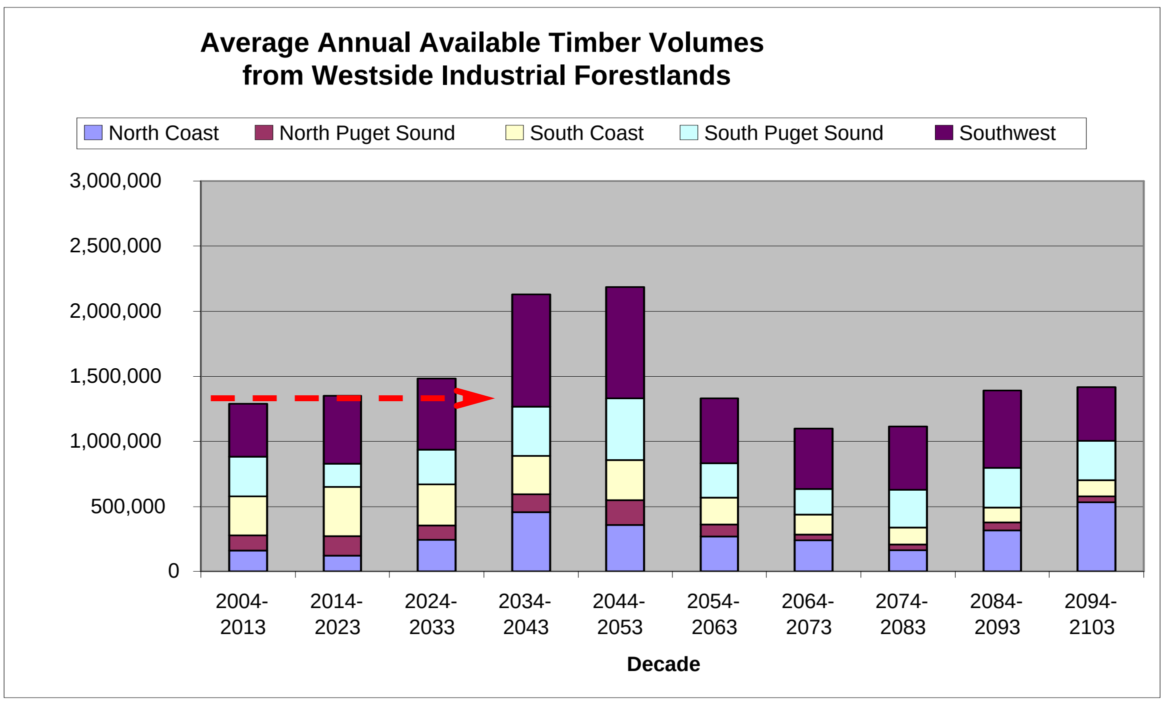


Figure 1.17: Westside industrial harvestable volume by timbershed.

We characterize volumes available for harvest rather than as a harvest forecast to caution readers that the precision of the input data coupled with unforeseeable mitigating factors such as market fluctuations and ownership changes is not sufficient to accurately predict the timing and magnitude of harvest volumes. Nevertheless, in the derivation of other measures, we simulate that which is harvestable as that which will likely be cut, consistent with an unconstrained optimal economic cutting cycle.

Figure 1.18 displays the average growth per managed acre ranging from a low of 450 BF/acre/yr for the North Puget Sound (Seattle to the Canadian boarder) to a high of 730 BF/acre/yr in the South West and an average of 640 BF/acre/yr for all Westside industrial forestlands. These estimates are comparable to the trend averages computed from the FIA sample (DP1). In effect, the management shift to shorter rotations, which would generally be expected to lower average growth, is being offset by productivity gains from intensive management, largely as a result of increased vegetation control. The vegetation control treatment produces approximately 25% more growth and the opportunity to manage on shorter rotations.

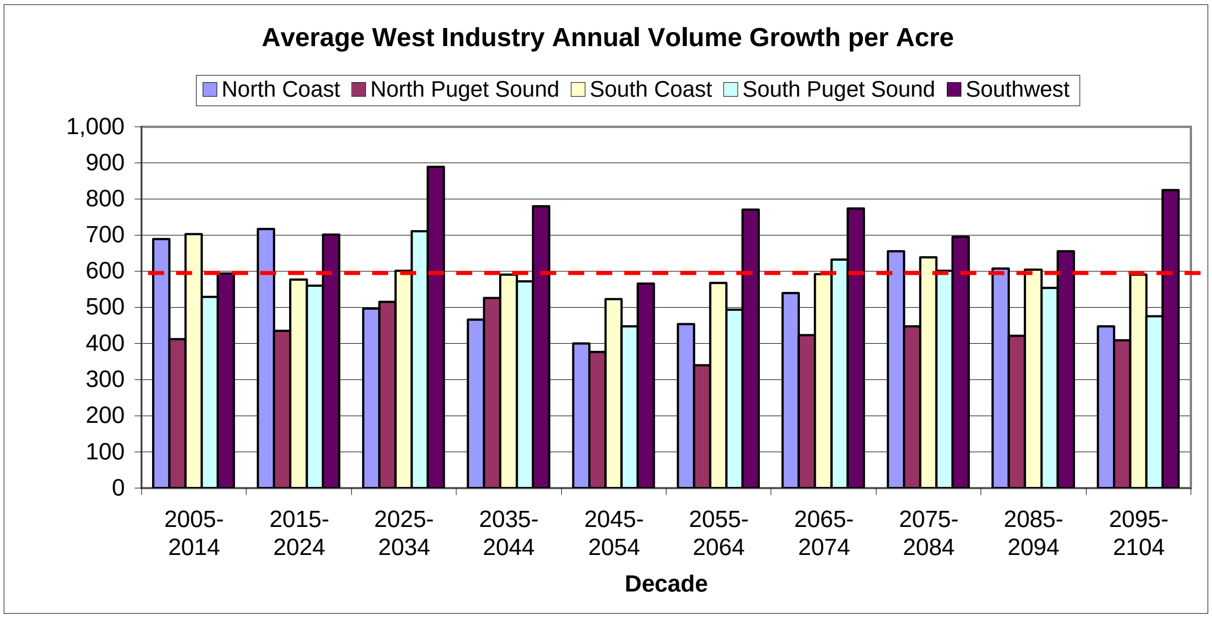


Figure 1.18: Westside annual industrial timber growth per acre by timbershed.

Declines in standing timber inventory directly reflect both the uneven age class distributions of the starting inventory and the reductions of the forestland base over time (Figure 1.19). Inventories climb to over 30 BBF in the third decade as a result of the growth of younger stands, but then decline with increased harvest of mature timber leveling off below 20 BBF. In addition to available harvestable timber volumes, these inventory changes affect the mix of forest structures and habitat.

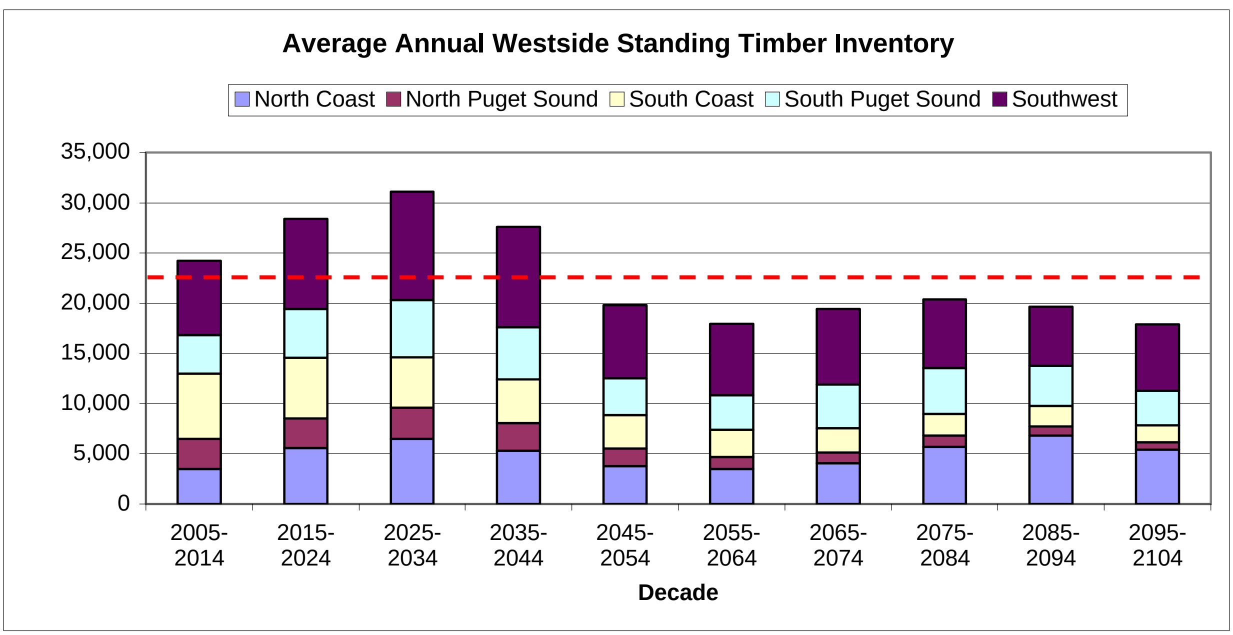


Figure 1.19: Westside industrial average annual timber inventory by timbershed.

The impact of forestland conversions would seem to be fairly certain during the first few decades and hence are included as a part of the baseline. The trend rate of industry conversion has been characterized at about -.9%/yr consistent with the trend of the last two decades (DP1). However even the distribution of this rate of conversion is heavily weighted to urban counties ranging from a high of -1.7% /yr for N. Puget Sound to some increase in industry forestland in N. Coast. Even assuming a constant percentage rate of decline for the long-term in the most urban areas, the number of acres being converted continues to decline as there is less and less timber remaining in the more populated counties. The impact of our assumption to continue the recent trend rate of conversions at the timbershed level therefore results in a decline in the conversion rate across all timbersheds from -.72%/yr in the first decade to -.27%/yr by the tenth decade for a -.5%/yr average over 10 decades. While there is little doubt that these patterns will change in the future, it is difficult to speculate on the degree. If the population dense regions spill over into adjacent timbersheds, the overall rate of conversions may over time be quite a bit higher than our baseline land conversion assumption albeit more likely beyond the first few decades.

Results for timberland returns and regional economic impacts:

Given the uncertainty in harvest timing we characterize the trend level of economic impacts by computing the Net Present Value (NPV) at a 5% cost of money. For an annual rate of revenue weighted to the early years we annualize the NPV at the 5% rate (Table 1.9). This logically emphasizes the performance during the early decades noting that projections for decade-to-decade differences are less reliable and becoming more so several decades out.

The cumulative industrial landowner net revenue return is estimated at approximately $446 million/yr and $8.9 billion NPV. Using the calibrated links between forest treatments and regional economic models discussed in DP3 we can also estimate the Forest Industry Labor Income which includes all the activities defined as occurring in forest sector businesses such as logging, processing, secondary manufacturing and pulp and paper production but not including retail activities such as lumber yards or box plants as these are not directly linked to the resource production activity. By including the inter-industry transactions represented by Economic Input/Outputs models we also estimate Total (direct and indirect) All-sector Labor Income in support of the industry's operations, a contribution to Gross State Product, and contributions to State & Local Taxes. These model links do not hold at the timbershed level as production facilities may be in other timbersheds, although the originating timbershed share of harvest is the critical resource activity driving all down stream activities wherever they occur. None of these measures include value-adding operations generated out of state from the resource once exported.

Table 1.9: Economic Impacts derived from timber harvests.

Economic impacts ($ millions)	**NPV**	**Ann Rev**
Landowner revenues net of cost	8,923	446
Forest Industry Labor Income	15,735	787
Total All-Sector Labor Income	39,235	1,962
Gross State Product	66,875	3,344
State &Local Taxes	7,527	376

It might be noted that the timber industry contribution to gross state product of $3.3 billion will understate industry's share of the gross business revenues reported by the state, which includes inter-industry transactions involving some double counting by firms involved in the same chain of processing.

The number of jobs contributing to these economic impacts is similarly estimated from job requirements to process logs that are entered into the state economic model to derive direct and indirect impacts. Projecting Job estimates forward in time are always problematic as to whether they adequately anticipate the impact of productivity gains that generally reduce the number of jobs for the same output over time. In this case the emphasis is weighted to the first few decades, not accounting for productivity, however, the labor income table is more robust in this regard as job losses associated with productivity gains are largely offset by real wage gains.

Table 1.10: Industry harvest impact on jobs.

	Total	Prim Wood	Sec Wood	Prim Paper
Forest Industry Employment (Jobs)	17,340	9,580	5,074	2,686
Total Employment (including other indirect Jobs)	51,098	27,031	12,385	11,681

To the degree that the Westside industry harvest is roughly 1/3 of the total these job estimates are consistent with a total forest sector industry employment of 50,000 and total direct and indirect jobs statewide of 150,000 prior to conversion losses.

Results for forest structure and habitat:

Industry lands are managed primarily for economic return, however, given the nature of such a long-term asset an essential degree of long-term stewardship is required for sustainability. Owners are required to meet regulatory standards for management targeted at protecting anadromous fish and other endangered species, such as the northern spotted owl (*Strix occidentalis caurina*) and the marbled murrelet (*Brachyramphus marmoratus*). In discussion paper DP7-W we develop estimates for the number of acres that are not being managed or are otherwise constrained to meet the Forest and Fish Rules. Forests withdrawn from management in favor of habitat protections and stream buffers are equal to approximately 13% of the total Westside industrial forestlands. As noted in the discussion paper, not managing dense stands that were previously managed for commercial purposes does not appear to offer either quick or reliable restoration of the old forest conditions generally regarded as the preferred habitat. To better understand habitat relative to industrial forests, we first provide an assessment of how many stands qualify as statistically similar to old forests considered as a Desired Future Condition (DFC) and then use a range of habitat suitability measures developed by Johnson and O'Neil's stand structure habitat matrix (O'Neil et al 2001) to test the degree to which forest structures support specific species.

In Figure 1.20 we note that the assessment for old forest conditions suggests only about 10 to 20% of the industrial stands are statistically similar to old forests. After 50 years between 8 and 16% are characterized as being in DFC, with the range across timbersheds most probably reflecting the range of acres devoted to the aging riparian buffers. The data suggest that during the first 50 years there is somewhat larger variability in the tree list structure driven from the FIA plot information than results from simulations of growth and harvest for those plots. It is probable that our simulations do not produce the variability in structure that results from natural aging so this difference in early vs. late DFC may well be a modeling error understating the DFC achievement. If there is value to be gained by increasing the DFC such as using thinning treatments for biodiversity pathways as noted in DP7-W, these differences will be reflected by treatment simulation impacts on forest structure but will not necessarily reflect the random variability of growth response across all inventory types.

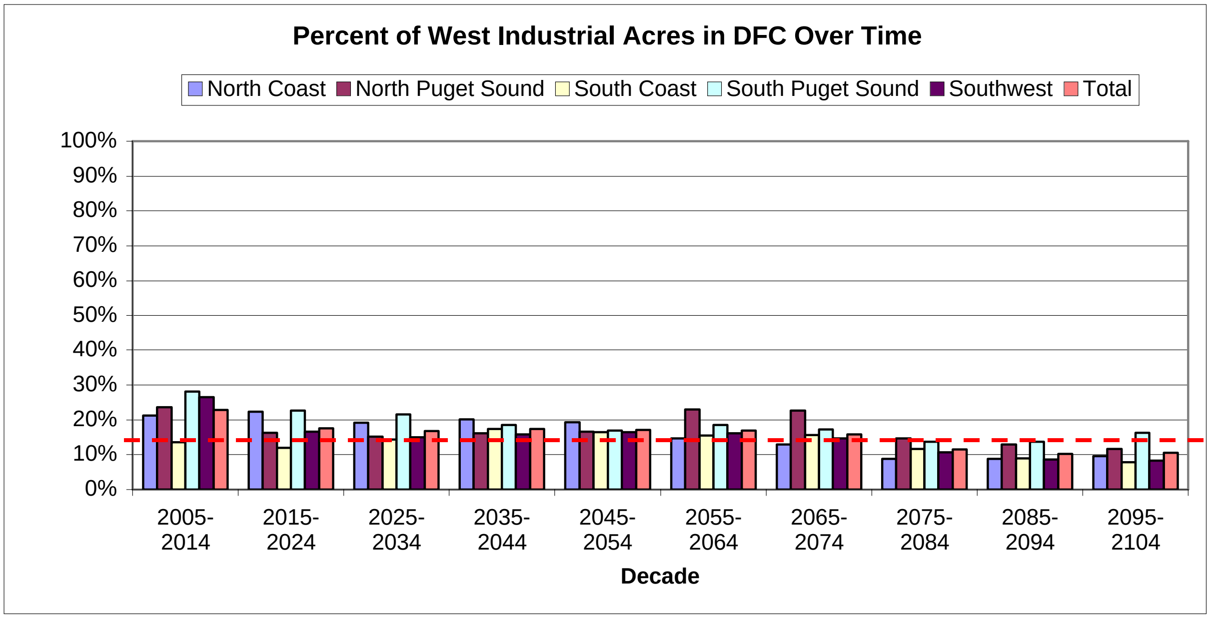


Figure 1.20: Percentage of industrial acres meeting a DFC statistical test over time.

As another means of assessing the impact of changing forest structure on habitat we use the habitat suitability measures developed in O'Neil et al. (2001). Figure 1.21 shows the total habitat for four species summing the acres (1) closely associated, (2) generally associated and (3) present or marginal support, as developed in DP4. The species selected include (1) the northern flying squirrel (*Glaucomys sabrinus*) with a preference for old forest structure; (2) the northern goshawk (*Accipiter gentilis*), a generalist in structure preference; (3) the red-tailed hawk (*Buteo jamaicensis*), closely associated with small to medium tree single story-open structures; and (4) the Pacific jumping mouse (*Zapus trinotatus*), closely associated with the grass/forb open structure stage.

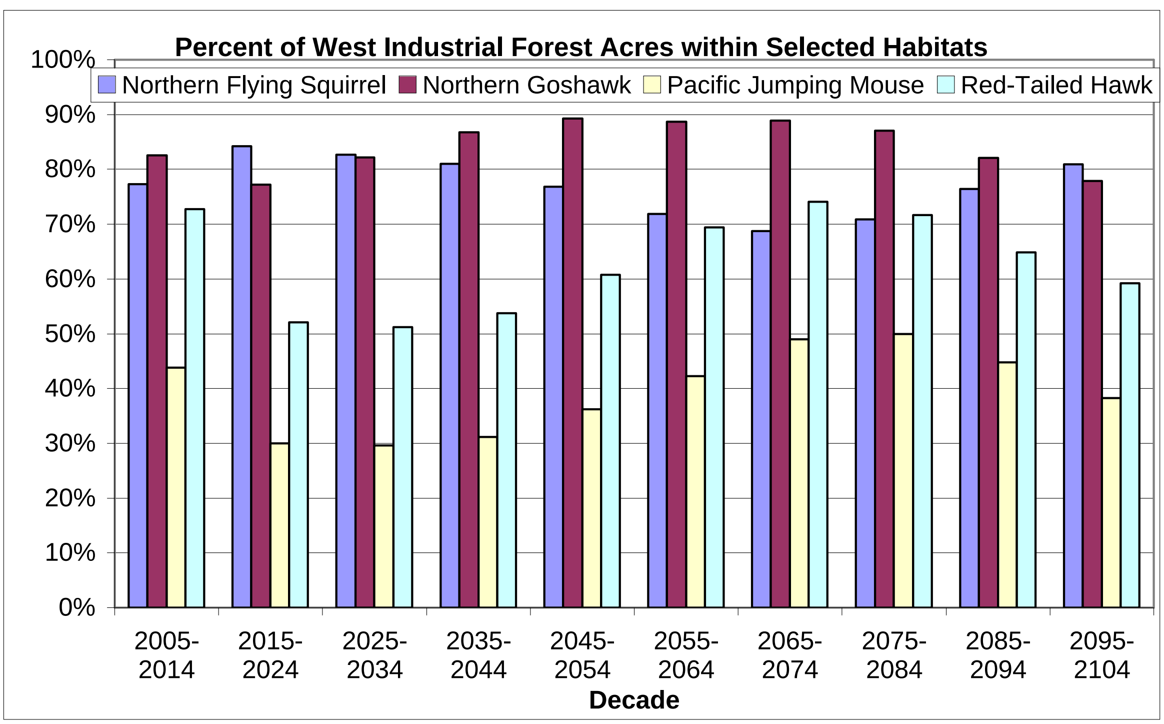


Figure 1.21: Percentage of acres within selected habitat.

While there is a large percentage of acres with some habitat for the northern flying squirrel only about 10% is identified as closely associated habitat. While the goshawk shows the most habitat, almost 60% is in the marginal category or occasional use category. The Pacific jumping mouse shows the least habitat with about 40% of this in the marginal category. Since the jumping mouse is most dependent upon open areas, it shows the greatest increase after a harvest or disturbance. Almost 50% of the red-tailed hawk habitat is in the marginal habitat category with a significant response to the harvest disturbance cycle but has more non-marginal habitat in later decades with dense forest conditions. For these four species, the northern flying squirrel habitat has the least amount of closely associated habitat although a substantial amount of generally associated habitat and is probably more dependent upon the oldest forest structures best characterized by the DFC assessment analysis. Old forest structures are in the shortest supply. This kind of stand-level statistical analysis relies on the principle that forest landscapes have always evolved as a moving mosaic created by multiple disturbances but this may understate the importance of particular spatial arrangements such as habitat corridors or connectedness. The smaller size of thinning treatments in relation to historic natural disturbances may also increase edge habitat but decrease interior habitat.

Alternative Biopathway Scenario for Industry

Land conversions would appear to provide the greatest uncertainty and undesirable impacts in these simulations and are also sensitive to economic returns. One opportunity to reduce the rate of conversions was developed in the Discussion Paper on regulatory impacts (DP7-W) noting that many small owners will have a disproportionate loss under the regulations, increasing their motivation to capitalize on conversion opportunities. The economic impacts per acre are the same for industry, as their only fundamental difference is having a large enough block of acres, not as overly burdened by the costs of stream buffers. Adopting biodiversity pathway treatments in the riparian zone was shown to improve both DFC and economics. We test the impact of managing about 20 % of the riparian buffers (77,000 acres) as biodiversity pathways split 50% toward a multiple thin ending in a 100 yr rotation and 50% with the final harvest replaced with a perpetual retention of 15 overstory trees instead of a final harvest. While this treatment would require regulatory approval of the treatments as Alternate Plans and only affects about 2% of the acres (which could be scaled up to approach 10% i.e.. the full buffer) it should have both economic and ecosystem appeal along with the impact of reducing the motivation for land conversions i.e.. it represents a potential win/win alternative. Harvest levels increase from the thinning by 31,000 bdft/yr, a 2.3% increase, but with a much larger impact for those owners with a large percentage of their land in buffers. Phasing in the treatments when stands are at the right age, and there are always some at that age, produces some DFC habitat within decades of the first treatment but growing over time. However the economic gains, which serve to reduce the motivation for land conversions, begin immediately.

Economic benefits: The $473 million NPV gain to landowners (Table 1.11) is substantial considering the small number of acres treated. The regional economic gains are roughly proportional to the number of acres treated. The increased number of jobs (Table 1.12) is somewhat higher in percentage terms than the regional economic impacts since thinnings are labor intensive.

Table 1.11: Economic Impacts from biodiversity pathway alternative on 20% of the stream buffers

Economic impacts ($ millions)	NPV	NPV-alt	%
Landowner revenues net of cost	8,923	9,396	5.3
Forest Industry Labor Income	15,735	16,098	2.3
Total All-Sector Labor Income	39,235	40,151	2.3
Gross State Product	66,875	68,436	2.3
State &Local Taxes	7,527	7,703	2.3

Table 1.12: Biopathway alternative impact on jobs

	Total	Prim Wood	Sec Wood	Prim Paper
Total Employment under biopath alternative	52,754	27,987	12,752	12,014
Total Employment (includes direct & indirect Jobs)	51,098	27,031	12,385	11,681

DFC and habitat Assessment: Of the 77,000 additional acres allocated initially to Biopathway, since the treatments were phased in and are subject to trend losses from conversion, only 10,000 net new acres reached DFC by 2034 (13%) and 20,000 by 2064 (30%). By 100 years, our growth model assumes enough natural mortality in the buffer that about the same number of acres have reached DFC without treatment as with treatment, albeit much later in time and probably less reliably. There were relatively smaller changes in the habitat suitability measures for the selected indicator species.

Cost Effectiveness: While this alternative could be considered an ecosystem service, in this situation the cost is negative because it reduces the cost of the riparian management buffer under the current practices that meet the requirements of the regulation. The $473 million savings will have a substantial impact, especially on some owners. Applied to 77,000 acres the benefit is $6,100 per acre treated, approximately the cost of protecting the riparian buffer acres by no harvest constraints developed in DP7-W. While the economic benefit begins immediately and is long lasting, the ecosystem benefit is accelerated by the treatment but in the long term with sufficient natural mortality, unmanaged stands may also reach the same level of DFC.

Alternative scenario without land conversion for industry

While the likelihood of substantially reducing land conversions seems low, we compare the Base scenario with a No Conversion Loss scenario to demonstrate the substantial impact of conversion.

Figure 1.22 compares the harvest levels of the Base case with No-Conversion Loss demonstrating the substantial loss from conversion even though the average rate of conversion was assumed to decline to only 1/3 of the rate for the prior decade by the 10th decade of the simulation. With no conversion losses harvest levels would return to almost 2 BBF/yr.

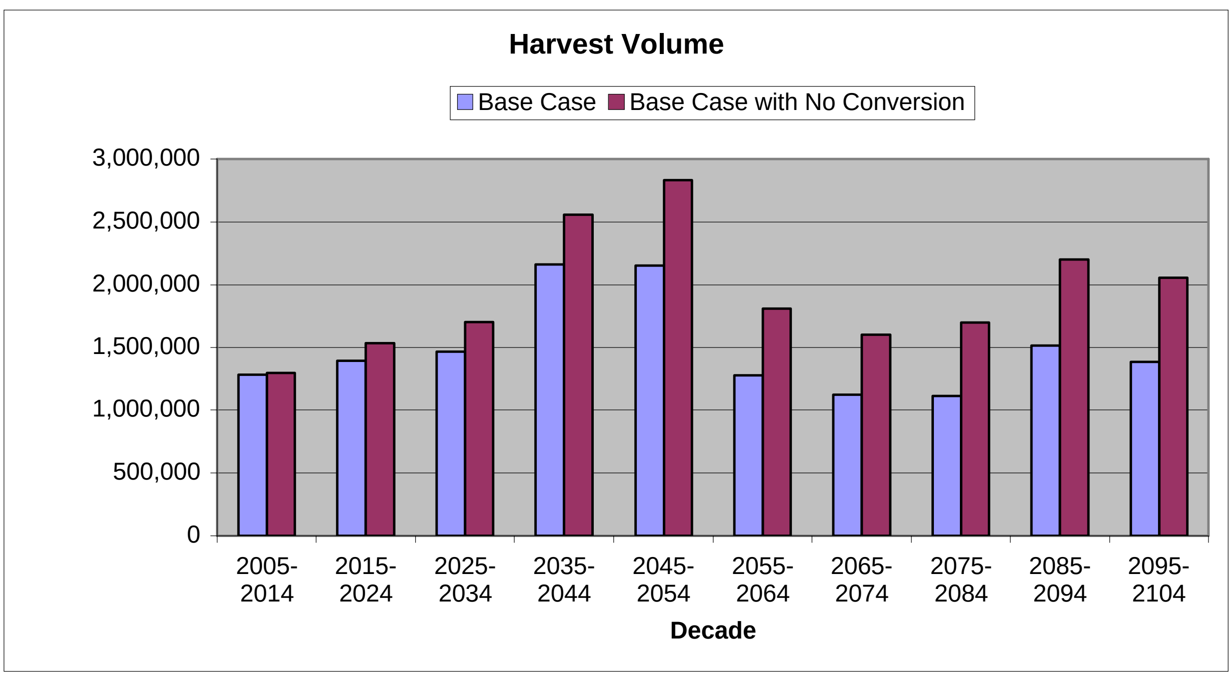


Figure 1.22: Impact of Conversion Loss on Westside Industrial Harvest

Suitable habitat is also substantially larger for each of the structure-dependent indicator species (Figure 1.23) and the total employment (direct and indirect) would be over 18,000 jobs higher.

Figure 1.23: Habitat suitability differences on industry land with no conversion losses

Concluding Summary for Industry-Managed Lands

In spite of the expectation for continued large Westside industry forestland conversion losses, the increasing management intensity on industry lands has the potential to largely offset at least a declining rate of conversion losses in terms of harvest volume and regional economics. The loss in acres of habitat however will not be offset. Opportunities are being lost to improve the habitat in no-management reserves (largely buffers) by not encouraging biodiversity pathway thinning treatments that can improve old forest habitat while at the same time provide a more viable economic return to encourage sustainable forest management. The lack of more up to date forestland plot information with greater coverage of sensitive areas substantially limits the precision that can be associated with projection levels however the comparisons between alternatives should be indicative of the impacts from policy or management alternatives.

Other Private Westside Management Stratification

Methodology Differences:

We use essentially the same methodology for stratifying the management plans of Other Private (includes small owners and Tribes) as we used for industry, however we omit several labor-intensive steps and provide less detailed outputs on habitat and regional economics but more insight on comparative management alternatives. We lack the detailed management intensification survey information that was collected for industry and substitute surveys of small forest landowners, loggers, forest consultants with Tribal interviews, data, and plans, and expert opinion. Small owners and Tribes dominate the category of Other Private on the Westside. Small owners with fewer than 20 acres have generally not been involved in thinning treatments but the dominant group owning from 20 to 99 acres thin extensively. Tribes manage more like industry but extend rotations, while generally avoiding thinnings and chemical treatments. However, since thinning on non-industrial lands was more intensive along streams prior to the Forest and Fish Regulations (FFR), anecdotal responses suggest thinning along streams is no longer practical which may mean less thinning overall. We use prior surveys to establish the percentage of thinning for each size group of small owners, and Small Forest Landowner Office (SFLO) data to determine their distribution by timbershed. Simulations of Tribal forests are included in the aggregate. Rotation ages as practiced by many small owners and Tribes are also longer than industry.. Net conversion losses for small owners have been small (and set to zero) as they have purchased from industry about the same number of acres as they have sold into land conversions. There have been gains by Tribes but these are small compared to the total other private ownership so are also set to zero (see DP1).

The base case, therefore, reflects a 100-year timbershed-dependent (1) update of the 1989 starting Forest Inventory Analysis (FIA) inventory, (2) estimates of unmanaged acres in stream buffers along streams and older forest areas, and (3) allocation of different management treatments as simulated for various stand types and age-classes to reflect the variability in other private owner management plans. In the base case 50% of the managed acres are on a short rotation without thinning with half of these a site dependent 5 to 10 year longer rotation than comparable industry lands. Of the 50% that are thinned, half receive a pre- and commercial thin, the other half just a commercial thin.

Westside Other Private Base Case Results

<u>Results for harvestable timber, inventory and growth:</u>

The age class distribution observed for the FIA data in the 1989 survey is provided in Figure 1.24 along side the resulting age class distribution for 2004 (Figure 1.25) as updated by interim harvest allocations and stand growth. It can be noted that Other Private unlike Industry maintains a significant inventory that would generally be considered mature and harvestable (50+years). It is possible that some of the older acres will be held indefinitely.

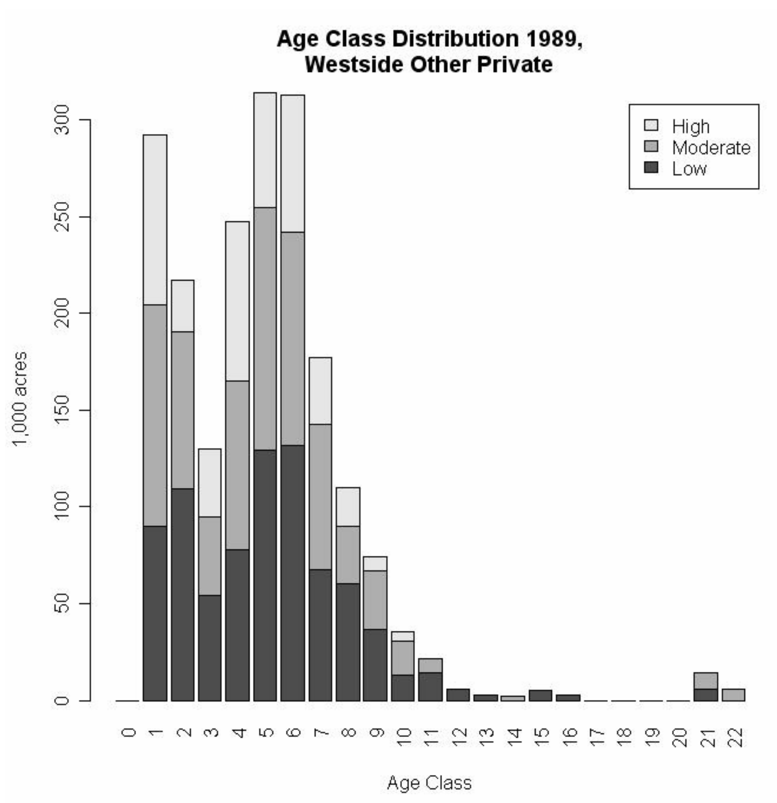


Figure 1.24: Westside Other Private age-class distribution 1989

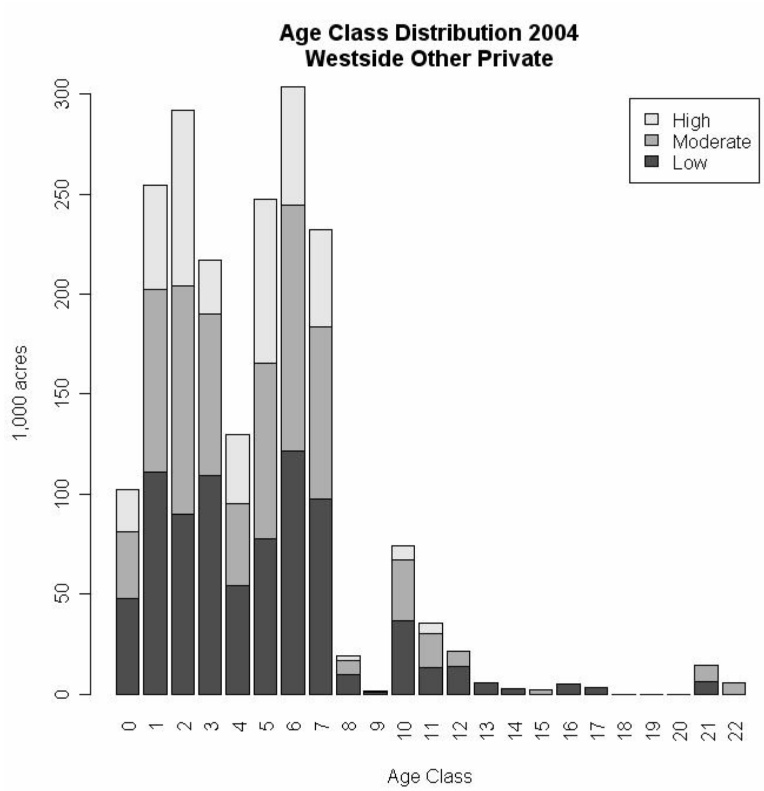


Figure 1.25: Westside Other Private age-class distribution updated to 2004

Timber volume of approximately 1.0 billion board feet scribner (BBF) per year for Westside Other Private lands is noted as available for the first 3 decades and approximately the same volume per year over 10 decades (Figure 1.26). However, the harvestable volume in the first decade is twice as high as the average but the excess inventory would be needed to maintain the harvestable average for the first 3 decades. There is a substantial bulge in the age class inventories for the fourth and fifth decades followed by a decline with the bulge occurring at least a decade later than for Industry owners.

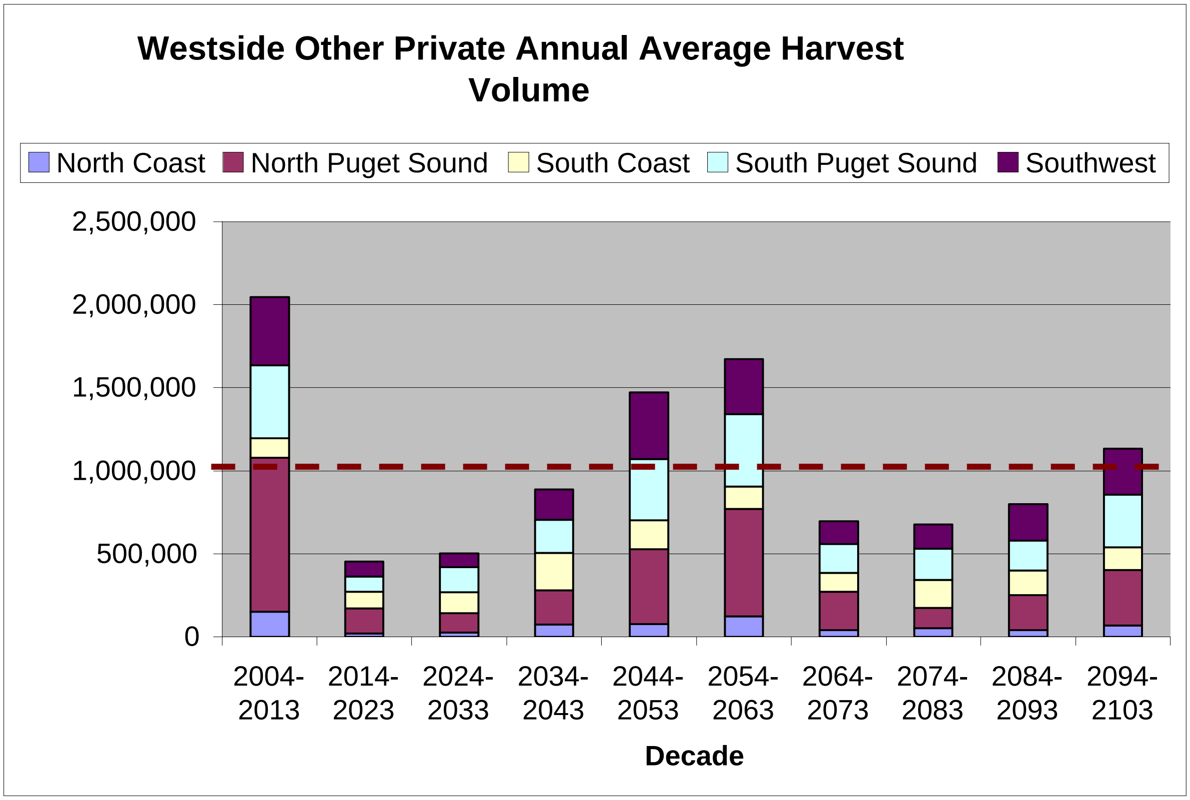


Figure1.26: Westside Other Private harvestable volume by timbershed.

Like our analysis of industry lands we simulate the harvest as that which is harvestable acknowledging that the timing may well be spread out more evenly over several decades especially since there exists an excess inventory of harvestable acres in the initial year.

Growth rate estimates are not substantially different than industry with longer rotations compensating for less intensive management. Unlike industry owners the standing inventory increases for four decades from 20 to 35 billion board feet (BBF) at much the same rate as it did in the prior decade (DP1) partially supported by the uneven age class inventory distribution, and in the future partially due to no-management stream buffers as well as no land conversions (Figure 1.27). A cyclic decline sets in after the peak harvest decades.

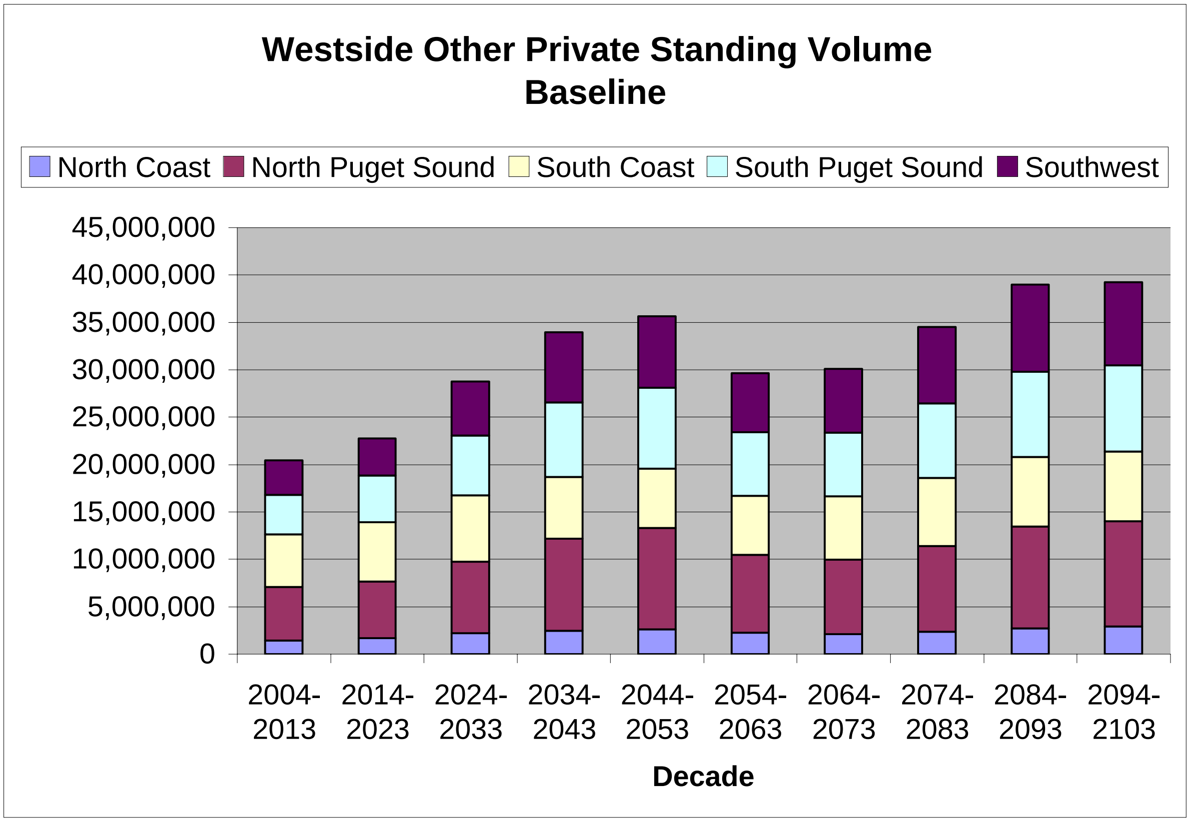


Figure 1.27: Westside Other Private standing timber volume (inventory) by timbershed.

<u>Results for timberland returns:</u>

The average annual net revenue rises from $306 million for the first 3 decades to $341 million over 10 decades. The Net Present Value (NPV) of $7.8 billion would produce a $389 million annuitized annual rate of revenue and is higher than the average given the excess revenue potential in the first decade.

The Other Private NPV per managed acre is $4,390 compared to $3,485 for Industry. This significant difference is largely related to the excess mature inventory for Other Private assuming it would be liquidated while the industry harvest level increases as large age classes reach maturity. For estimating regional economics we use the trend rate of activity without the first decade surge (Table 1.13).

Table 1.13: Economic Impacts derived from timber harvests.

Economic impacts ($ millions)	NPV	Annual Revenue
Landowner revenues net of cost	6,073	306
Forest Industry Labor Income	10,794	540
Total All-Sector Labor Income	26,919	1,346
Gross State Product	45,876	2,294
State & Local Taxes	5,163	258

The number of jobs contributing to these economic impacts is estimated (similarly to the industry analysis) from employment data and outputs from the state economic model to derive direct and indirect impacts (Table 1.14).

Table 1.14: Other Private harvest impact on jobs.

	Total	Prim Wood	Sec Wood	Prim Paper
Forest Industry Employment (Jobs)	11,994	6,572	3,480	1,842
Total Employment (including other indirect Jobs)	35,053	18,543	8,496	8,013

Results for forest structure and habitat:

We concluded from the industry analysis that in addition to appropriate streamside protection, only those species most sensitive to old forest structures are significantly impacted by the range of commercial practices being used. Additional research may provide greater sensitivity in habitat suitability models in the future but the assessment for acres in desired future conditions (DFC) comparable to old forest structures has been demonstrated to be most selective and indicative of habitat change and shown in Figure 1.28. We note that the assessment for old forest conditions on non-industrial private forests shows considerably more old forest habitat than on industry lands and remains between 18 and 29% when averaged across timbersheds by decade.

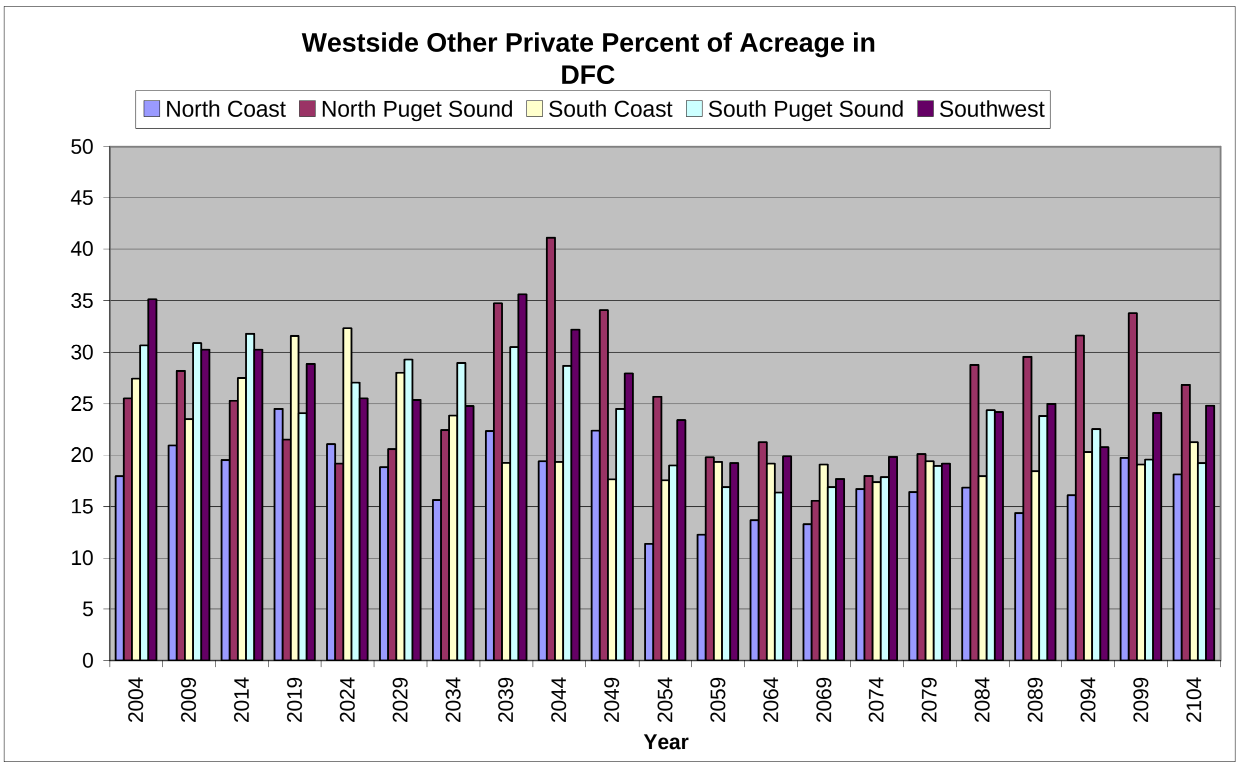


Figure 1.28: Percentage of Other Private acres meeting a DFC statistical test over time.

Alternative Commercial Thinning & Biopathway Scenario for Other Private

It was noted that the difference in economic return to the forest landowner for commercial thinning treatments (see DP2-W) was small suggesting that it should be possible to incentivize additional thinning by monetary or tax incentives if the benefits to habitat were considered to be important and of comparable value. We test the impacts of such a scenario by assuming 25% more of the managed acres are thinned, i.e.. half of the short rotation acres are replaced by the mix of thinning treatments included in the baseline. In addition, as a more aggressive restoration treatment, we put these same acres into a Biopathway in order to determine the impact on amounts of old forest structure (DFC) and the cost (lost revenue). Table 1.15

summarizes the cost of these treatment alternatives and the impact on DFC since old forests are the structure of greatest concern.

Table 1.15: Opportunity Cost to increase DFC by thinning and Biopathway treatments

DFC Opportunity Cost:			DFC acres (000)		DFC gain (acres 000)		$Cost/DFC acre	
	NPV ($Mills)	NPV gain	Dec 1-3	Dec 1-10	Dec 1-3	Dec 1-10	Dec 1-3	Dec 1-10
Base	7785	0	522	474				
CT Alt	7885	100	527	481	4.2	7.4	0	0
Biopath Alt	7322	-463	595	559	72.2	85.1	6410	5444

Base (50% no thin, 25% PT & CT)
CT Alt (252% no thin, 37.5% CT, 37.5% PT & CT)
Biopath Alt (25% no thin, 25% CT, 25% PT & CT, 25% BioP)

The commercial thinning alternative increases NPV suggesting the dollar cost to motivate even more conventional thinning should be very low. While thinning treatments are not extended to long enough rotations to produce much increase in DFC (old forest structures), they do produce a gain of a few thousand acres in DFC but at a no cost.

The biopath alternative produces an opportunity cost (NPV loss) of $463 million. There is a gain of 72,000 acres of DFC in the first three decades, rising from 100 to 110 thousand acres for the next four decades. The cost per additional DFC acre is $6,410/acre for the first three decades, dropping to about $4,400 for the next four decades, averaging $5,444 per DFC acre over the ten decades. There are many more acres dedicated to biopathways than are effectively producing DFC conditions at any given time. The NPV loss per dedicated biopathway acre is about $1,044/acre ranging from $500/acre to $2000/acre depending upon how soon there was an opportunity to initiate a biotreatment. Converted to an annuitized incentive contract at the time of regeneration, $23 per year per acre would provide equivalent compensation over a 100-year biopathway, although the compensation would necessarily increase if initiated later in the rotation. The biopathways examined were not pre-tested for best economics, and hence under a competitive contract bid system could be less costly.

The time path of these treatments is impacted by the starting inventory and the time it takes to progress through the several thinning treatments required by the biopathway. Figures 1.29 & 1.30 compare over time the base harvest levels to the treatment alternatives and Figures 1.31 & 1.32 the DFC.

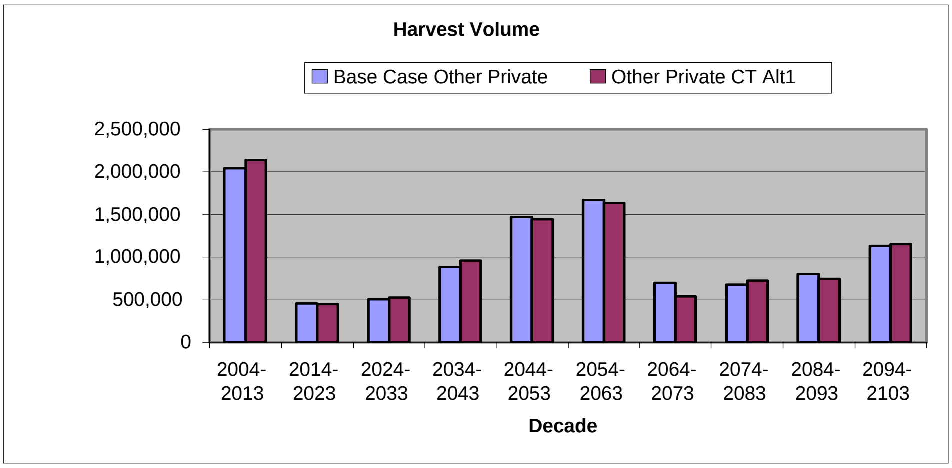


Figure 1.29: Harvest comparison base vs. increased commercial thin

Harvest levels remain fairly stable over the long term but the opportunity to commercially thin more acres early in the simulation period contributes to a small increase in NPV.

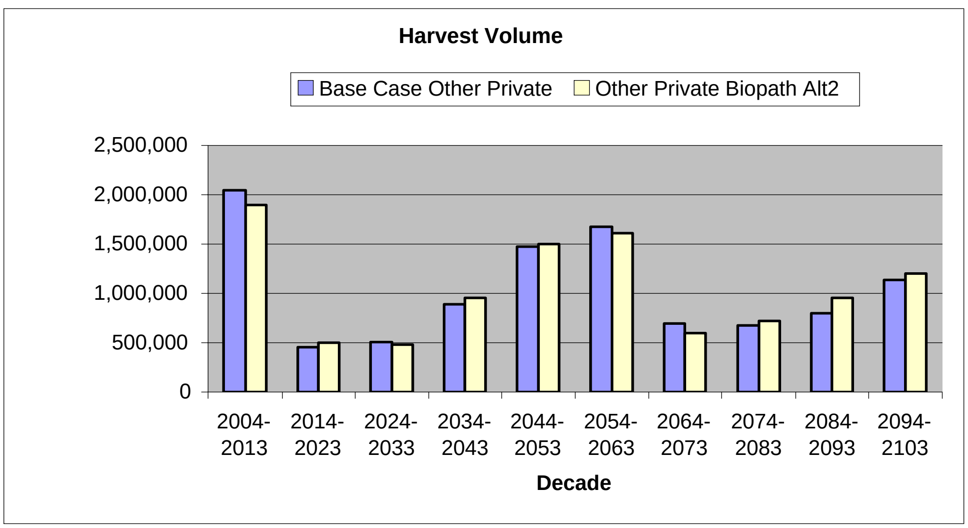


Figure 1.30: Harvest comparison base vs. increased biopathway thinning

For the biopathway alternative, early harvest levels are deferred by 150 million board feet (MMBF) (i.e.. when a thinning takes precedence over a final harvest) contributing to a significant decline in the NPV. Harvest levels are not significantly different over the 10-decade interval.

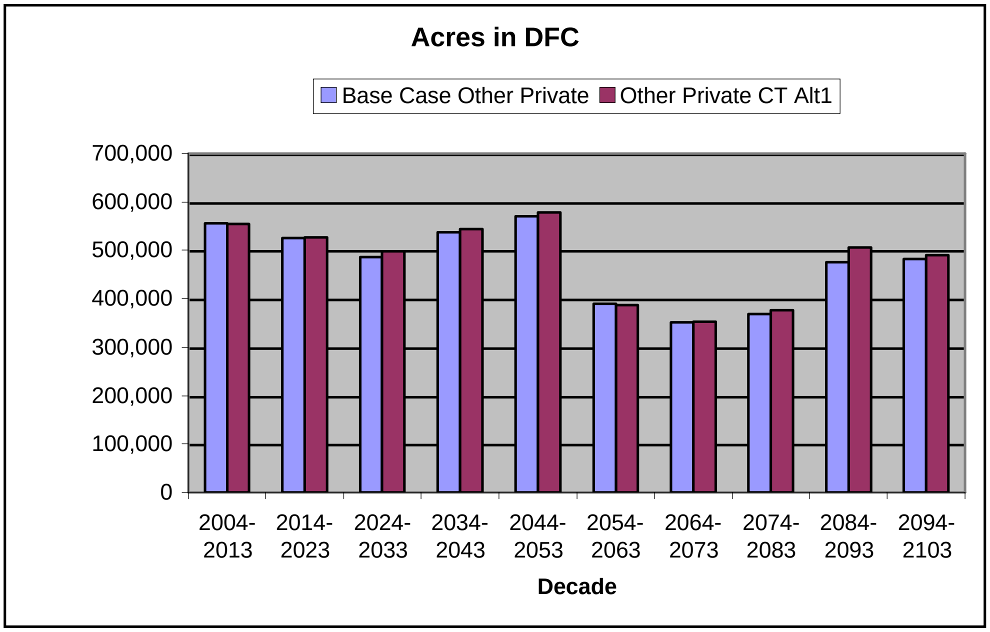


Figure 1.31: DFC comparison: base vs. increased commercial thinning

Commercial thinning contributes just a few thousand acres to DFC by the third decade.

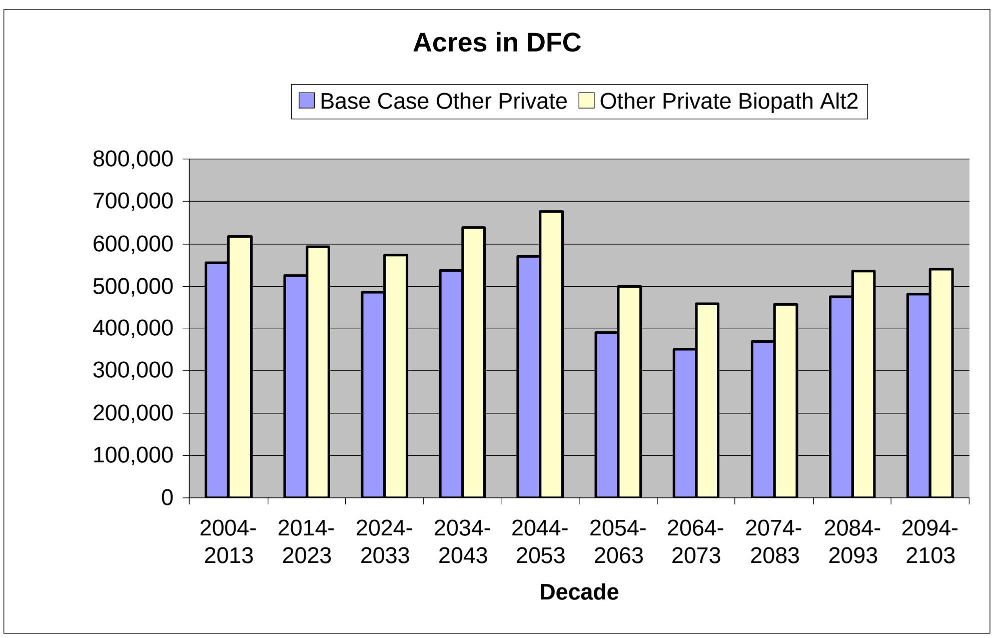


Figure 1.32: DFC comparison base vs. increased biopathway alternative

Acres in DFC continue to increase reaching the highest levels in decades four through seven. The decline in later years results from some stands with bigger but fewer trees that don't meet the old forest target criteria, even though the stands are much like very old forests with few residual overstory trees. Half of the biopathways examined the impacts of retaining 15 big trees in a final thin resulting in a reduced number of very large trees, but these stands were outside the 90% assessment limit of stands with trees too big and too few, albeit at the extreme end of the distribution typically characterized as old growth. Customizing the Biopathway to the target could substantially increase the DFC in the later years.

Concluding Summary for Other Private Management

Other Private owners are dominated by small owners and Tribes that manage their lands for a range of objectives and have as a consequence more stands beyond economic rotation providing increased habitat, with about 20% of the stands statistically similar to old forest structures. The excess of mature inventory provides other private forest owners with flexibility to harvest when they need the cash flow or to respond to favorable market conditions. This situation makes it difficult to predict short-term harvest behavior. Management treatments for this landowner group include thinnings (primary by small forest owners rather than Tribes) with about 50% of the land having been thinned in recent periods. The very small owners (fewer than 20 acres) are not as likely to thin but their share of the landbase is comparatively low. The 20 to 100 acre group manages the vast majority of the acres, is most likely to thin, and is known to be most likely to participate in forestry programs. Tribes employ professional forest managers. Since thinning has been very marginal from an economic standpoint in recent periods, the magnitude of incentive needed to increase thinnings should be low.

While increases in commercial thinning provide forest structure for some habitats, and provide a good start for the early phase of a biopathway, the rotations are not long enough to substantially increase the acreage in old forest structures. In forests dominated by western hemlock, such as those managed by Tribes, thinning might not be desirable. Following early thinnings with more biopathways can increase old forest structure by 110,000 acres in our biopathway simulation alternative from the fourth to seventh decade, with the rate of increase paced by the time it takes to introduce treatments and obtain a growth response. The opportunity cost per dedicated biopathway acre is about $1044, or as little as $500 if introduced at the time of regeneration. An annuitized payment of $25/year per biopath acre would seem to be sufficient to motivate biopathway management for some owners.

The biopath treatment was not optimized for different stand conditions so the cost could likely be lower under competitive bidding. However, the treatments demonstrated may also remove too many trees early for certain species such as the spotted owl. The biopathways that emphasize large but few trees appear to be more appropriate for riparian zones as they contribute larger woody debris, an important parameter for stream protection. Biopathways targeted for spotted owl habitat will require high canopy closure and retention of a greater number of trees in the overstory.

Westside Stratification Including Public

<u>Public Management Impacts</u>

The Department of Natural Resources (DNR) has been involved for several years in developing Sustainable Harvest Calculations for the Westside at a level of detail much greater than we are providing in the Timber Supply and Forest Structure Study. While there is a high degree of similarity in the methods and objectives their analysis was carried out spatially and in much greater depth and it would be unproductive as well as cost prohibitive to duplicate their efforts. We provide summaries of their analysis in order to provide complete coverage for some of the more important variables across all owners, the details of which are available in many documents from DNR (Brodie 2007). Given methodological differences, the comparisons cannot be considered exact but they are close enough for most inferences.

USFS Westside harvest levels have declined to the point of insignificance from an economic perspective but we include an alternative as analysis to demonstrate the impact of thinning half of the stands that are coming of age for such treatments.

DNR Sustainable Harvest Calculation and Plan: DNR generally manages on longer rotations than industry, and as a consequence has many acres of excess mature inventory from the standpoint of an optimal economic strategy and has gone to greater efforts to restore some old forest functionality for most areas under their management. They have upgraded their analysis methods to restore older forest functionality from that used in their initial Habit Conservation Plan (HCP) approval process using structural metrics rather than age as a surrogate for forest structure in order to better quantify when their managed forests are similar to older forests. They have modified their early Board-approved management plans in response to an out of court settlement focused essentially on additional considerations for the restoration of old forests.

DNR's management plans include both commercial and longer rotation thinnings in order to reach their objectives. The harvest strategy is evident in all timbersheds as noted in Figure 1.33.

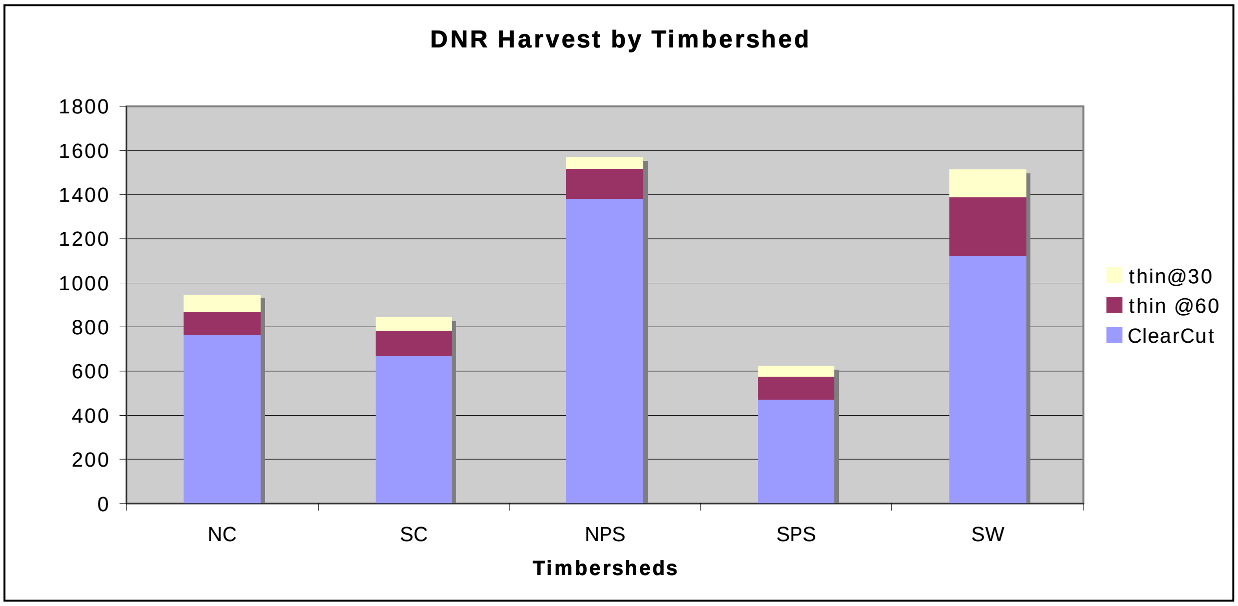


Figure 1.33: DNR's first decade clearcut, young and older thinning removals by timbershed

__Economic Impacts for DNR integrated with Industry and Other Private.__

We provide DNR, Industry and Other Private comparisons for harvest based on the first decade of their projections (assuming sustainability thereafter), the economic present value of harvest, the impact on regional economics, and old forest functionality. For industry we show both the land conversion scenario and the no-conversion scenario since the economic comparisons affecting jobs are more heavily impacted by conversions making that scenario somewhat more difficult to understand in comparison to recent experience.

We average the first three decades for industry and other private as representative of DNR's sustainable harvest calculation for the first decade. We generate Present Values (PV) for all revenue streams and quote the first decade as the annuitized annual revenue computed from the PV. This process takes out the fluctuations across decades with an emphasis on the first few decades. The Jobs numbers are not discounted but reflect only the first 30-year average for better comparisons with the revenues. We show industry first using the no-conversion assumption to avoid any misunderstanding of the consequence of conversion in lowering the number of jobs from current levels.

Table 1.16: Economic impacts from State & Private harvests with no conversions

State and Private Forest Sector Economic Impact (no land conversions)

	Industry	Oth Private	Total Private	DNR	St & Private
Acres Timberland (000s)	3,338	1,969	5,307	1,390	6,697
Harvest/yr (mmbf)	1,508	1,001	2,509	550	3,059
Vol/acre (bf/total acre)	452	508	473	396	457
Rev/yr ($ mils)	505	335	840	165	1,005
Rev/acre ($/total acre)	151	170	158	119	150
Present Val ($ mils)	10,092	6,703	16,795	3,307	20,102
PV /acre ($)	3,023	3,404	3,165	2,379	3,002
Forest Emp (30yr ave)	17,615	11,994	29,609	7,097	36,706
Total Emp (30 yr ave.)	51,596	35,053	86,649	20,638	107,287
Forest Labor Inc ($ mils)	899	540	1,439	282	1,720
Total Labor Inc ($ mils)	2,242	1,346	3,588	704	4,292
Gross State Prod ($mils)	3,821	2,294	6,115	1,199	7,314
St & Local Tax ($ mils)	430	258	688	135	823

While harvest levels are only 72 % of the level two decades ago and 89% of one decade ago, they are 104% of the harvest level data available for the last three years. The increase is largely a result of the DNR sustainable harvest calculation restoring some of the harvest lost with the initial version of their Habitat Conservation Plan. The projected harvest rates for Private are 70% of the 1980 to 1990 decade, 85% of the 1990 to 2000 decade, and 101% of the most recent three year period. *In effect, without land conversion losses we expect the sustained harvest level from State and Private lands for the next 3 decades to be similar to recent harvest levels.*

The economic impact on jobs is significantly less than the last impact study of the forest sector (Lippke & Conway 1994). The Forest Sector employment is down 28% (12,000 jobs) from 1992 due to the lower harvest, in addition to the impact of productivity gains of about 1.6% per year (10,000 jobs). The use of the static input-output model (Washington Input-Output NAICS) instead of the yet to be updated time dynamic econometric model linked to an input-output model (WPSM) produces indirect multipliers that are 25% lower. Forest Industry jobs are reduced by 22,000 largely unrelated to modeling differences. Total direct and indirect employment is reduced by 121,000 with about 60,000 likely explained by omissions in the static economic model framework. Contributions to Gross State Product and Tax Revenues are lower by about 40% from all of these impacts. The State & Local Tax receipts resulting from forest sector operations are estimated at $823 million/year (Table 1.16).

The Private harvest without conversion losses is essentially unchanged from recent harvest levels. However with conversions, the private harvest is expected to decline by 10% over the first several decades and continue to decline thereafter (Table 1.17).

Table 1.17: Economic impacts for State & Private harvests with continued industry land conversions

State and Private Forest Sector Economic Impact

	Industry	Oth Private	Total Private	DNR	St & Private
Acres Timberland (000s)	3,066	1,969	5,035	1,390	6,425
Harvest/yr (mmbf)	1,376	1,001	2,377	550	2,927
Vol/acre (bf/total acre)	449	508	472	396	456
Rev/yr ($ mils)	446	335	781	165	946
Rev/acre ($/total acre)	146	170	155	119	147
Present Val ($ mils)	8,923	6,703	15,626	3,307	18,933
PV /acre ($)	2,910	3,404	3,103	2,379	2,947
Forest Emp (100yr ave)	15,948	11,994	27,942	7,097	35,039
Total Emp (100 yr ave.)	46,794	35,053	81,847	20,638	102,485
Forest Labor Inc ($ mils)	787	540	1,327	282	1,608
Total Labor Inc ($ mils)	1,962	1,346	3,308	704	4,012
Gross State Prod ($mils)	3,344	2,294	5,638	1,199	6,837
St & Local Tax ($ mils)	376	258	634	135	769

Forest structure and habitat:

DNR has used a stand structure classification system to delineate forests that are providing characteristics fully functional with old forests. While the intent is similar to the Statistical assessment procedure used for other owners in this study and provides a measure of the impact of introducing Biopathway management alternatives, the metrics cannot be compared directly. There are many stands that will likely qualify as meeting the statistical parameters of an old forest under the assessment procedure since there is so much variability across old forests that will not be categorized as similar to old forest under the DNR structure classification. However we demonstrate the degree to which DNR is on a pathway to create more of the landscape as similar to older forest by comparing the private sector acres that were assessed as similar to old forests relative to the several classes of old forests categorized in DNR's analysis.

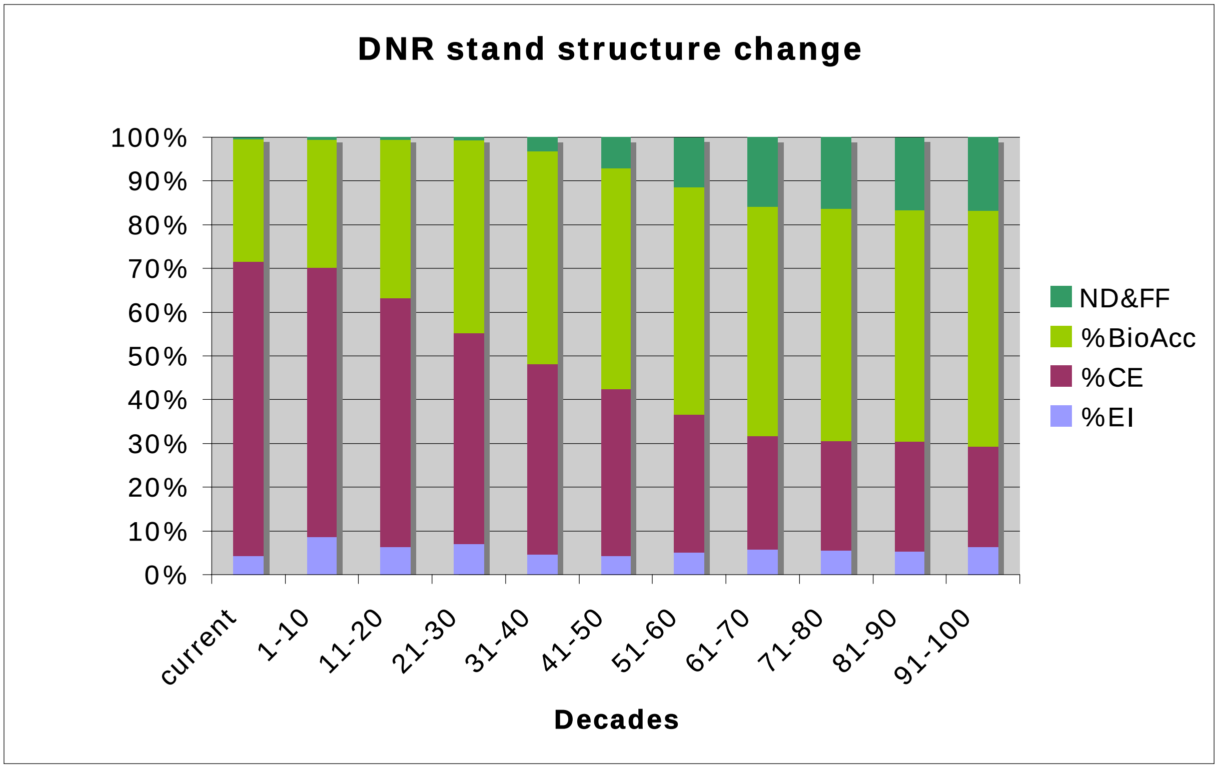


Figure 1.34: Stand Structure Distribution for DNR Westside over 10 decades

DNR's efforts to thin stands at a young age as well as a second thinning to enhance their biodiversity potential and similarity to old forest structures results in a substantial decline in Competitive Exclusion (CE) stands that are characterized as very dense with limited understory and hence provides the least support for habitat (Oliver et al. 1990, Carey et al. 1996). The structure most similar to old growth forests, Fully Functional (FF), and structure with significant diversity, Niche Diverse (ND), increase over time as a consequence of sustained thinnings with longer rotations (Figure 1.34). The statistical assessment test used in this study for other owners to measure the time stands are similar to old forests (time in DFC) will consider many of the stands in the Biomass Accumulation phase (BioAcc) as statistically similar to existing forests older than 80 years.

Comparing the acres in DFC for private owners with the percentage of stands in NV, FF, and BioAcc, demonstrates the aggressive efforts by DNR to move their stand structures away from Competitive Exclusion toward more diverse structures. DNR has committed a high percentage of their acres to these long rotation thinnings, while the private sector will maintain about 10-20 % of their land similar to old forests largely through riparian buffers, other set asides and long rotations by some small owners (Figure 1.35).

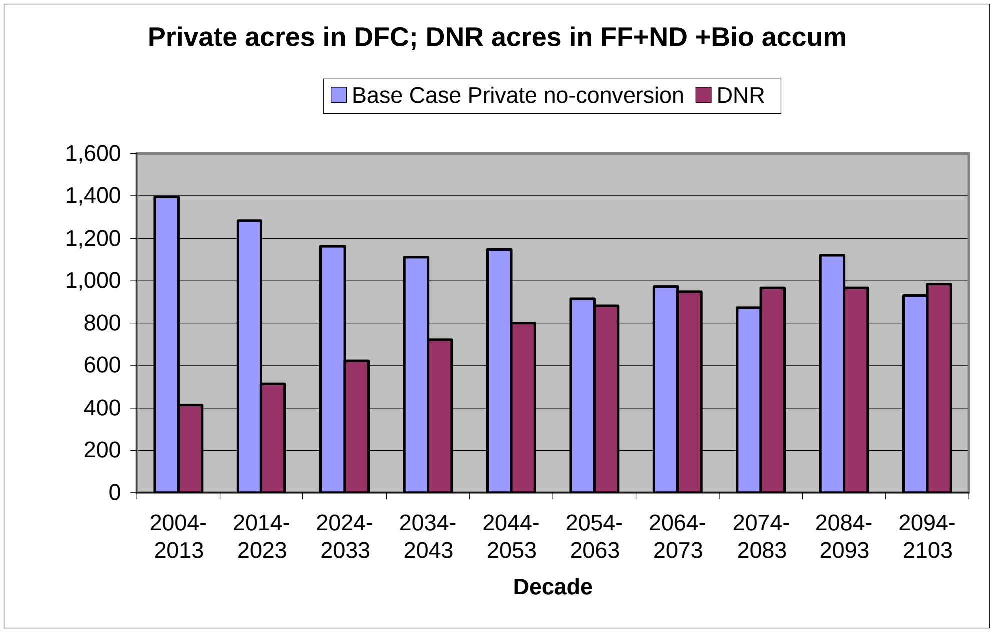


Figure 1.35: State vs. Private acres under management to promote old forest structures

Thinning & Biopathway Scenario for Federal Forests:

For each of the next four decades the Westside Federal Forests will experience 75 to 100,000 acres moving into age brackets with volumes that would be appropriate (15-35 mbf/acre) for thinning. These stands resulted from prior harvests and regeneration and have reached an overly dense Competitive Exclusion Structure, and can be expected to stay in this overly dense state for many decades if not subject to some disturbance. While we have not studied the character of these stands in any depth and recognize that with natural mortality they may eventually take on old forest characteristics, the opportunity exists to avoid many of these stands from becoming stagnant or acquire too much height to diameter ratio for wind resistance, and to lower fire and other health risks associated with dense stands, while improving stand resiliency to climatic stress. Targeting 5000 acres per year for a first thin and another 5000 acres per year for an older stand Biopathway thin would put half of these acres on an accelerated pathway to take on old forest conditions many decades sooner than by not thinning.

As noted in discussion paper DP4, multiple thinning biodiversity management pathways can increase the percent of time a managed stand is statistically similar to old forests from 5% to over 40% within 100 years of regeneration. The illustrated federal treatment would produce 200,000 acres similar to old forests in four decades with another 200,000 thereafter. The economic impacts are not huge since thinning volumes are much less than commercial harvesting but they are not insignificant. Using results similar but more conservative than DNR, removing 6mbf/acre in a first thin with a net value of $100/mbf and 14 mbf/acre in a second thin with a net value of $200/mbf produces total direct and indirect employment of about 4000 jobs, along with other regional economic benefits (Table 1.18).

Table 1.18: Economic impact of Forest Service thinning of dense regenerated stands

USFS Westside Thinning treatments	1st thin	2nd thin	total
Acres (000s)	5	5	10
Removals (mmbf)	30	70	100
Revenue (mils$)	3	14	17
Forest Emp (000s)	414	1,005	1,419
Total Emp (000s)	1,244	2,927	4,172
Forest Labor Inc (mil$)	17	39	56
Total Labor Inc(mil$)	43	99	142
Gross St Product(mil$)	73	169	243
St & Loc Tax(mil$)	8	19	27

Concluding Summary

In the absence of land conversions the all-owner harvestable timber appears to support a continuation of the most recent harvest levels for the next 3 decades. More intensive short rotation management on industry lands would lead to some increase by the fourth decade. Other Private lands include excess mature inventory which if cut over the next three decades would contribute to a stable harvest level. Small owners have flexibility in when they cut, leaving considerable uncertainty in the timing of their harvests levels from decade to decade. DNR harvest levels are sustainable at levels higher than recent cuts but substantially below pre-HCP levels as another stabilizing influence on harvests. Land conversions however, appear to be inevitable, and will induce a noticeable decline in otherwise stable projections.

Stream buffers and some longer rotations by smaller owners maintain between 10 to 20% of the private acreage in structures statistically assessed as similar to older forests. DNR is targeting a much higher share of their forests to take on old forest characteristics. The US Forest Service has the opportunity to thin many of its previously harvested and regenerated stands much like DNR is doing and could in the process restore more old forest structure while contributing modestly to the economy.

Stratification – East

Introduction

Throughout this study we have identified several issues that appear peripheral to timber supply, but in fact rely heavily on maintaining an adequate timber supply for their resolution. In particular, the issues associated with forest health, wildlife habitats, biofuel availability, climate change mitigation and processing infrastructure all depend on a consistent and adequate timber supply. Since harvest on Federal lands declined in the 1990's, private forests largely filled the timber supply gap but very recently four long established mills in Eastern Washington have closed. The focus of our analysis of the harvest potential on the Eastside is therefore to determine whether past harvest rates are sustainable and the degree to which a sustainable infrastructure or further mill closures might be indicated. In this section we first look at broad timber supply trends at a timbershed level (East Cascades, and Northeast and Southeast, which together make up the Inland Empire timbershed), and then focus on a more sub-regional analysis of timber availability from private forest lands. The regional analysis is tied back to timber availability from public lands in order to identify key opportunities and strategies that might alleviate infrastructure jeopardy which may otherwise pose a severe constraint to efforts to address forest health, emerging biofuel and carbon markets, climate change impacts, and community stability in Eastern Washington.

Methodology

Harvest Trends: Estimates of decadal harvest trends from the DNR timber harvest summary statistics (2006) are used as the target for a baseline harvest scenario. This publication provides the average harvest rate over the past 30 years by ownership and county allowing the calculation of harvest rates by FVS variant (Forest Vegetation Simulator) and ownership. Since National Forest harvests have declined substantially, recent harvest levels and National Forest plans provide the basis for harvest levels on federal forests. Calculating the averages by ownership and growth model variant provides the values and allocations in Table 1.19. These harvest rates became the target for the base harvest scenario. In instances where these rates required more intensive harvest activity than was suggested by management intensity survey information, the harvest rate target superseded management intensity information.

Table 1.19: Target harvest volume by region and owner group for Eastside forests

30 year average harvest rate with *NF at (1994-2003 rate)						
Owner group	Private		State		National Forest*	
FVS Variant	Average MBF/yr	Percent by Variant	Average MBF/yr	Percent by Variant	Average MBF/yr	Percent by Variant
North Idaho/Inland Empire variant	299,887	44.0%	26,927	22.4%	43,254	55.5%
East Cascades variant	365,317	53.6%	53,217	73.1%	27,511	35.3%
Blue Mountains variant	16,357	2.4%	1,363	4.5%	7,170	9.2%
Totals	681,562	100.0%	81,507	100.0%	71,326	100.0%

Inventory Updating: The 1991 FIA data were updated to reflect harvests that had occurred in the intervening period prior to simulating growth, harvest, and treatments to obtain the target harvest volumes in Table 1.19.. FVS models growth for Eastside variants on a 10 year period, hence the update for the first period relied on harvest information from 1991-2000. Harvest rates from 2001-2006 were also determined, but they fell within the likely bounds of the target harvest volume and were continued at the above targets.

Constraining simulation growth rates: Growth simulations were calibrated to obtain a weighted average net growth rate approximately equal to the growth rate derived from Gray et al.'s (2006) update of Eastern Washington non-National Forest inventories. The reported average growth rate for the private owners is 273 bf/ac/year. This measured rate is essentially equivalent to the average simulated growth rate of 274 bf/ac/yr for the first decade as indicated in Table 1.20.

Table 1.20: Growth Rate Calibration

Simulated Growth Rate for 1991-2001			
	Acres	**Net Growth**	
Region	**(1000's)**	**MBF per acre per decade**	**BF/ac/yr**
Wenatchee	305.9	2.68	268
Yakima	616.3	2.95	295
Okanogan	401.7	2.45	245
Tonasket	519.6	2.88	288
Southeast	146.3	2.28	228
Northeast	1199.7	2.75	275
	3189.5	2.74	274

Regulatory constraints: Because of the regulatory constraints on industrial, small private and state forests, and policy constraints on tribal forests, the harvests were targeted to occur on upland forests only (net of riparian areas). The private base case analysis accounted not only for riparian core zones that are reserved from harvest, but also accounted for acreage that became commercially unavailable as a result of riparian protection legislation (See DP 13 on regulatory impacts). Table 1.21 identifies the acreage reduction by region to account for riparian protection and those areas that became economically inoperable as a result of the stream crossing rule changes. These unmanaged acres account for policy-related reductions to allowable harvest in the riparian core zone, as well as the likelihood that the inner zones will not be treated because entry is no longer economically viable. The same percentage reductions were applied to tribal forests as an estimate of the potential impact of tribal forest management plans.

Table 1.21: Commercially available forested acres

Private forested acres by region			
Region	**forested acres**	**% riparian reserve**	**Commercially Available forested acres**
Okanogan	401,165	7.87%	**369,593**
Wenatchee	305,931	9.61%	**276,517**
Yakima	616,585	8.15%	**566,335**
Timbershed 6	1,323,681	9.02%	**1,204,285**
Northeast	1,201,555	7.20%	**1,115,092**
Southeast	146,329	9.96%	**131,748**
Tonasket	518,782	8.57%	**474,315**
Timbershed 7	1,866,666	8.23%	**1,713,040**
All regions	3,190,347	8.53%	**2,918,211**

Table 1.21 indicates that while the riparian rules apply across all of Eastern Washington, their impacts vary by region. There is substantial variability at the county level ranging from 19% of the acres in unmanaged buffers in Chelan to 7% in Pend Oreille. There is however, a much wider disparity of impacts and economic consequences across small owners as noted in Discussion Paper 13.

Sustainability of harvest targets: Growth and yield simulations of median stand data (an analysis of aggregate inventory data) covering all the conifer habitat types found on productive forest land in Eastern Washington indicated that growth would fall short of historic harvest rates in some regions. In effect the increase in private harvest that partially offset the federal harvest decline may not be sustainable. A significant shortfall could be expected within the next 10-15 years for the East Cascades (timbershed 6) and a less dramatic shortfall appears was imminent in the Northeast region (Table 1.22). The surplus in the SE may suggest other constraints such as economic viability.

Table 1.22: Base Case Analysis using aggregated data

		% of target attainable with State and Private Wood for the period ending 'X' years forward										
		State and Private Target	10*	20	30	40	50	60	70	80	90	100
Northeast	sawlog and hewsaw	317,928	81%	67%	87%	103%	130%	117%	133%	108%	129%	99%
	with pulp		101%	93%	94%	115%	152%	132%	149%	119%	158%	105%
East Cascades	sawlog and hewsaw	424,192	73%	103%	68%	14%	32%	99%	78%	56%	81%	11%
	with pulp		101%	140%	78%	23%	34%	153%	108%	82%	97%	63%
Southeast	sawlog and hewsaw	19,981	104%	123%	151%	117%	152%	110%	149%	257%	165%	277%
	with pulp		112%	123%	159%	123%	212%	128%	163%	266%	177%	297%

*First 10 year simulation period updates the inventory to 2001

Other considerations: The analysis did not consider any loss of available markets or inadequacy of the infrastructure, losses due to fire, insects, and disease, or conversion of forest land to other uses, although the results are expected to bear on the likelihood of these becoming critical issues. While a range of management alternatives have been evaluated, the dominant management regime practiced by private owners has been to cut volumes that become available when they are of scale to be economic, using retention practices for best regeneration which differ by forest type. Small owners have put greater emphasis on leaving trees that will respond to the more open canopy while industry has frequently put greater emphasis on underplanting. The public owners have put greater emphasis on retaining larger trees in the overstory. Because of the variability in pulp markets, the timber supply outcomes were identified both as a percentage of total volume and in terms of available sawlog quality material.

Private regional harvest scenarios

Given the substantial regional differences, all private FIA plots were grouped into regional portfolios that encompassed local variation in growth rates and distance to established or previously existing milling facilities. Sensitivity analysis was conducted on a regional basis to ascertain which areas and which time frames would most likely contribute to the timber supply shortfalls. The private FIA plots were grouped into six regions identified by the following labels: Yakima, Okanogan (OKA), Tonasket (TON) and Wenatchee (WEN) in the East Cascades FVS variant (EC), the Northeast for the North Idaho FVS variant (NI), and the Southeast for the Blue Mountains FVS variant (BM). This stratification was designed to reflect regional growth variation. The southeast counties are grouped into the FVS BM variant and Spokane, Stevens, Pend Oreille counties were grouped in the FVS NI variant. The Tonasket is Ferry County for the purposes of this analysis. Okanogan County is the Okanogan region, Chelan, Douglas and Kittitas make up the Wenatchee region and Yakima, Klickitat, and Benton make up the Yakima region. Acreage per plot was determined using the 1991 FIA data, with each plots scale factor and the acres summed for each region (Table 1.21).

Harvest reports were used to generate estimates of regional harvest volumes (Table 1.23) for inventory updates and long-term sustainable harvest targets. This simulated growth rate in conjunction with harvests equivalent to removals from 1991-2000 by owner group were used to update inventory to the current period. Simulation results for the first decade indicate a good agreement with the target volumes in all regions (Table 1.24).

Table 1.23: Target regional harvest volumes for private acres

Private and Tribal Harvest by Region and Timbershed			
MBF per decade per region			
Timbershed*	**Region**	**1991-2000**	**Long term average**
6	Okanogan	563,607	535,321
6	Wenatchee	1,072,501	1,227,066
6	Yakima	2,394,967	2,229,543
Timbershed 6		4,031,075	3,991,930
7	Northeast	2,972,774	2,427,302
7	Southeast	296,210	206,472
7	Tonasket	641,768	720,102
Timbershed 7		3,910,752	3,353,876
All Regions		7,941,827	7,345,805

* Timbershed 6=East Cascades; 7=Inland Empire

Table 1.24: Inventory update results

Inventory updates - first decade results						
Region	**total private acres**	**commercially available acres***	**standing MMBF**	**cut MMBF**	**cut: standing ratio**	**Simulation as % of target**
Okanogan	401,165	369,593	3269	570	17.4%	101.1%
Wenatchee	305,931	276,517	3507	1071	30.5%	99.8%
Yakima	616,585	566,335	6917	2476	35.8%	103.4%
East Cascades Timbershed 6	1,323,681	1,204,285	13693	4117	30.1%	102.1%
Northeast	1,201,555	1,115,092	9160	3002	32.8%	101.0%
Southeast	146,329	131,748	739	312	42.2%	100.4%
Tonasket	518,782	474,315	5334	643	12.1%	100.2%
Inland Empire Timbershed 7	1,866,666	1,713,040	15233	3957	26.0%	101.2%
Eastern WA	3,190,347	2,918,211	28926	8074	27.9%	101.7%

Projecting harvest removals forward based on the harvest rate target from 1980-2002 by owner group and region results in a net increase in standing volume for four of six regions indicating that more volume is obtainable in the future than would be removed under recent market and infrastructure conditions (Figure 1.36). When aggregated over the entire private forest, harvest volumes are largely attainable over the entire 100 year simulation period (Table 1.25), but the regional assessment identifies that these harvest rates are not sustainable in the Southeast and Wenatchee regions (Figure 1.37).

In both the Wenatchee and Southeast, in order to maintain target harvest volumes in the first two decades of the simulation period, there is a substantial draw down of standing inventory (See Appendix 2 – Eastside Data Summaries for regional simulation results). In subsequent decades, harvest volume availability fluctuates widely as merchantable stands are harvested as soon as they become available. The volume at stand entry declines from an average of 11 MBF/ac to an average of 9 MBF/ac as does average piece size, merchantable volume, and residual stand inventory. Initial analysis was conducted on gross acres, rather than commercially available acres. The target harvest volume could be met on the gross acreage, without the substantial decline in standing inventory and subsequent harvest volume fluctuations. This would infer that these regions were harvesting at a maximum sustainable rate given the available land base at the time, but as the land base was reduced primarily to provide riparian protection, the historic harvest rate was no longer sustainable. A rate that is reduced by the acreage associated with riparian reserves may be sustainable in the near term.

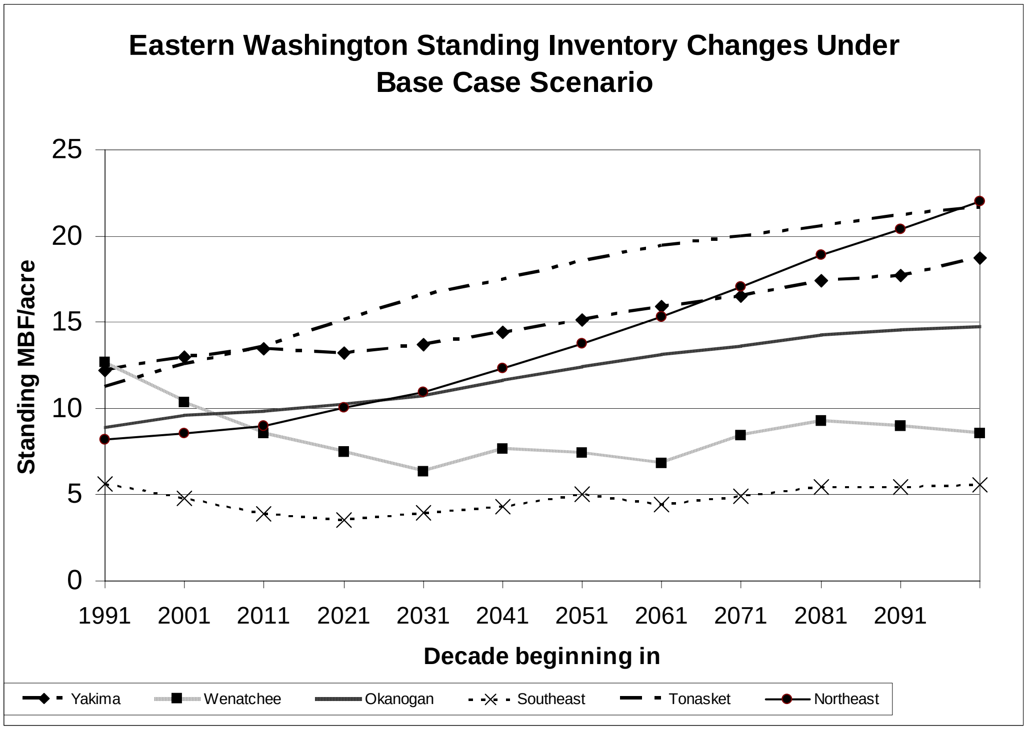


Figure 1.36: Changes in Standing Inventory by Region – Private Base Case

Table 1.25: Eastern Washington Base Case – Private Harvests

year	Standing MMBF	Cut MMBF	Target MMBF	% of target
1991	28926	8074	7957	101%
2001	29843	7546	7344	103%
2011	30585	7431	7344	101%
2021	32138	7362	7344	100%
2031	34094	7523	7344	102%
2041	37144	6950	7344	95%
2051	40005	7139	7344	97%
2061	42636	7495	7344	102%
2071	45805	6886	7344	94%
2081	49178	7035	7344	96%
2091	51444	7761	7344	106%
2101	53940	7324	7344	100%

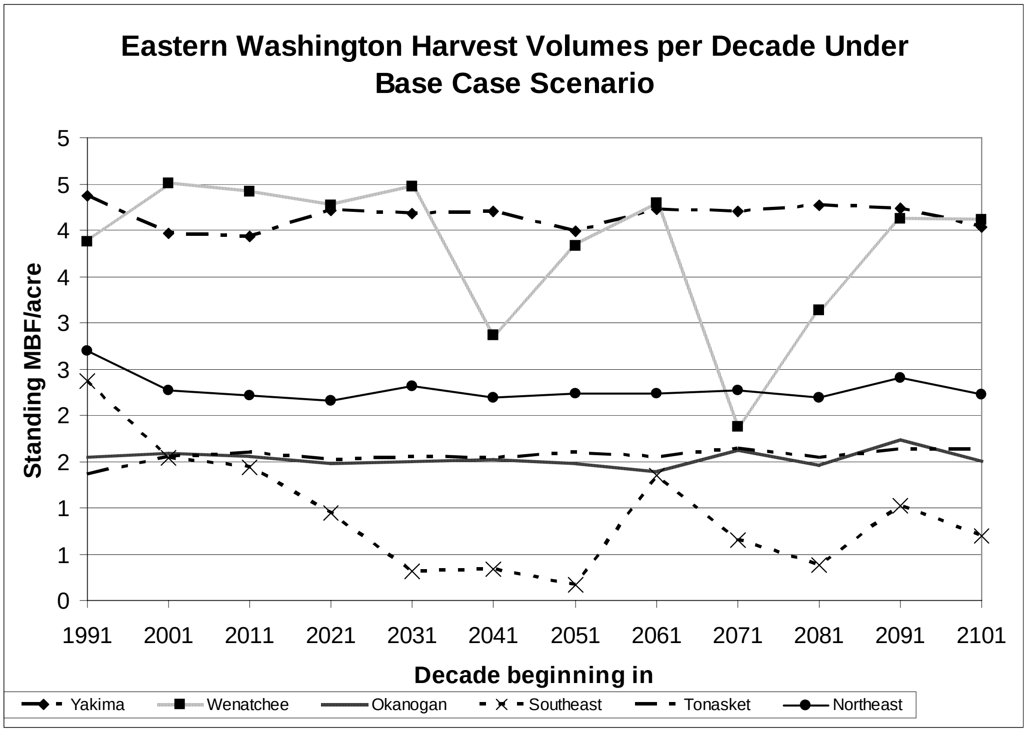


Figure 1.37: Harvest Volumes by Region – Private Base Case

In contrast, the Yakima, Tonasket, Northeast and Okanogan regions show a substantial gain in standing inventory with the base case harvest rates across the entire simulation period. Reasons for these regional differences may be a function of inherent growth rates, inventory age-class and volume characteristics and the level of inventory draw down in recent decades. As indicated in the Gray et al (2006) update of FIA inventory based on a sub-sample of plots, there has been a significant reduction of standing inventory on industrial acres. While as a cautionary note, the sample is small,, the simulations indicate that anywhere from 12.1% to 42.2% of the 1991 standing inventory was removed in one decade from 1991-2000. To substantiate the simulation results we examine DNR harvest data by owner group (Table 1.26) indicating that the draw down of standing inventory is regionally specific. The inventory drawdown is also not limited to industrial acres. The largest draw down of standing inventory per available acre is on Southeast region industrial ownerships, but it is also substantial on other private acres in the Wenatchee and Yakima regions.

Table 1.26: MBF harvested from 1991 to 2000 from Eastside private forests by owner group

MBF harvested from 1991 to 2000 from Eastside private forests						
Region	**Industry Harvest**	**Industrial Acres**	**cut/ available acre**	**Other Private Harvest**	**Other Private Acres**	**cut/ available acre**
Okanogan	86,597	37,015	2.3	477,010	364,149	1.3
Wenatchee	667,884	234,480	2.8	404,617	71,451	5.7
Yakima	634,203	188,890	3.4	1,760,764	427,695	4.1
Northeast	1,101,145	335,614	3.3	1,871,629	865,942	2.2
Southeast	81,620	11,629	7.0	214,590	134,700	1.6
Tonasket	86,018	51,581	1.7	555,750	467,201	1.2
all regions Eastern WA	2,657,467	859,209	3.1	5,284,360	2,331,139	2.3

In Table 1.26, the *cut/ available acre* column represents the average harvest across all available acres in the region by owner group, not just the acres that were harvested (harvested acres not available). In all regions but the Wenatchee and Yakima, the harvest per available acre is greater on industrial than on other private ownership. In the Wenatchee region the trend is significantly reversed. The large increase in harvest per available acre is concentrated in the small private ownership category. As Eastside harvesters in the small private category typically enter the stand when it has anywhere from 9-15 MBF and take approximately 3-8 MBF of merchantable volume, the trend in the Wenatchee region suggests the small private land owners did a substantial draw down of available timber during the 1990's. In the Yakima region the larger harvest per available acre on other private ownerships probably reflects the temporary increases in tribal harvest in response to a significant spruce budworm outbreak.

There are many causes for variations in harvest rates. Harvest volume per available acre reflects management differences, which vary regionally and by owner and may reflect markets, forest health challenges, and other opportunities. The volume harvested per available acre is very low in the Tonasket region despite a large and growing standing inventory base. That region had a mill closure that would have substantially altered the market conditions during the 1991-2000 decade. Changes in ownership pattern such as the sale of industrial lands to timber investment organizations and real estate investment trusts (TIMOs and REITs) may also impact management future timber supply.

As indicated in the discussion of harvest declines in the Southeast and Wenatchee regions, timber supply depends not only on volume, but also on log size. While technologies and markets may emerge to better use smaller diameter wood, the base case simulation assumed that current technologies, log sorts, and diameter limits applied for the entire simulation period. To determine the relative volume of different log sizes and qualities we used Department of Revenue (DOR) timber harvest figures, from Jan 1, 2002 to Dec 31, 2006 on private Eastside forests (Table 1.27) to estimate volume allocation by end use. The DOR tonnage conversion rate can be used to estimate the relative amounts of sawlog, hewsaw (small sawlog), and chipwood (pulp) wood that have been removed from private forests in each region. Table 1.27 indicates that the amount of wood sold as hewsaw is higher in the Northeast region, but the actual amount of small wood as a percentage of harvest is highest in the Wenatchee region.

Table 1.27: MBF harvested from 2002 to 2006 from Eastside private forests (excludes tribal)

Region	MBF sawlogs	MBF tonnage wood	Total Volume Harvested	Percent tonnage wood	MBF conversion ratio *
Yakima	497,241	17,174	514,415	3.5%	8.35
Okanogan	55,558	2,439	57,997	4.4%	7.57
Ferry	79,008	7,216	86,224	9.1%	7.00
Wenatchee	266,739	28,389	295,128	10.6%	7.83
Southeast	99,816	2,613	102,429	2.6%	8.42
Northeast	1,128,419	93,000	1,221,419	8.2%	7.17

* Lower numbers imply a larger percentage of small logs (hewsaw) in the estimated of tonnage to MBF conversion. A value of 7.75 is a 50/50 split of hewsaw to pulpwood, so Okanogan, Tonasket and Northeast Washington are merchandizing a lower percentage of pulp wood relative to other regions

The simulations assume that the relative percentages of sawlog, hewsaw, pulp, and available acres (net of riparian reserves) remain constant into the future. Land conversions may increase, small diameter log processing technology may continue to change, biofuel opportunities, forest health mitigation, fire risk reduction incentives, or climate make up a growing list of uncertainties to the outlook.

Also worthy of note has been the tribal response to insect infestations and fire hazard on Native American forestlands that has resulted in increased harvest activities to achieve needed density reductions. In Eastern Washington, tribal forest management contributes 1/3 of total harvest volume. Consideration of tribal forest health programs in Eastern Washington as a model for other ownerships was recommended by the Northwest Environmental Forum in 2006.

Eastside Private Base Case Harvest Outlook Scenario

We use the simulations of timber supply for the first three decades (2001-2030) as our most reliable projection in tables 1.28 through 1.30. Table 1.28 provides the gross standing and harvested volume for the entire region as well as the percentage of the harvest target attained. Only the Southeast region falls short of the target by 16%, but harvest volume is 50% of the standing inventory in the Wenatchee region indicating that the private timber supply would be under pressure. Yakima and the Southeast regions would need to cut 25% of their standing inventory to meet target harvest volumes. Table 1.29 provides average per acre estimates for the same time frame by region. The standing volume on harvested acres is very low in the Southeast relative to other regions reflecting a substantial draw down of mature inventory. The ratio of harvest to standing inventories on a per acre basis is almost identical to the total volume estimates for each region.

Table 1.28: Private Base Case – Inventory and Harvest by region and timbershed

Average Standing and cut volume: 2001-2030				
Region	Average Standing MMBF	Cut MMBF/ decade	Target harvest MMBF/decade	% of target
Okanogan	3,645	567	535	106%
Wenatchee	2,428	1,216	1,227	99%
Yakima	7,482	2,287	2,230	103%
Timbershed 6	13,555	4,071	3,992	102%
Northeast	10,239	2,465	2,427	102%
Tonasket	6,524	739	720	103%
Southeast	537	172	205	84%
Timbershed 7	17,300	3,376	3,352	101%

Table 1.29: Private Base Case – Per acre standing and cut by region and timbershed

Average Standing and cut volume per acre: 2001-2030				
Region	**Standing MBF/acre**	**Cut MBF/acre**	**Standing MBF/ harvested acre**	**Cut MBF/ harvested acre**
Okanogan	10,020	1,638	6,588	11,838
Wenatchee	8,691	4,344	5,358	21,371
Yakima	13,210	3,996	7,229	15,983
East Cascades Timbershed 6	11,283	3,379	6,652	16,056
Northeast	9,333	2,234	3,565	15,233
Tonasket	13,555	1,579	6,126	19,226
Southeast	4,038	1,360	2,300	7,435
Inland Empire Timbershed 7	8,235	1,952	3,429	13,453

Simulations were designed to meet green tree retention requirements, maximize volume and value removal, and promote regeneration potential. Table 1.30 reports average stand conditions after harvest for the 30 year period. Residual basal area, diameter, and stocking variables identify that the forest structure remaining post harvest is largely composed of understory trees with a cohort of trees greater than 10" dbh retained.

Table 1.30: Average Stand Metrics by Timbershed

2001-2030 - Residual Stand Metrics										
Timbershed	Region	Average SLOPE	Average BF/ac	Average QMD	Avg Height	Ave top height 40	Average TPA > 6"	Avg QMD for TPA > 6" dbh	Avg BA	Annual CUT (MMBF)
6	Okanogan	18	6,588	6.8	28	64	72	11.8	53	58
6	Wenatchee	37	5,358	6.4	32	67	91	11.0	53	120
6	Yakima	17	7,229	5.6	23	58	78	12.5	61	231
	Timbershed 6	22	6,683	6	26	61	80	12	58	409
7	Northeast	22	3,565	5.9	36	60	75	8.9	39	249
7	Southeast	23	2,263	6.2	29	56	58	10.2	36	17
7	Tonasket	29	6,127	6.3	30	64	76	11.3	56	72
	Timbershed 7	23	3,853	6.0	34	60	74	9.4	42	338
	All timbersheds	22	5,343	6.0	30	61	77	10.8	50	747

Table 1.31 provides estimates of the total acres that would need to be harvested to attain target volumes by region. Over the 30-year period, 1.4 million acres would need to be harvested. The average volume removed is 15,759 bf/ac and the estimated cash flow/acre is $3,439.

Table 1.31: Average Volume Requirements by Timbershed

2001-2030 private harvest statistics					
Timbershed	Region	Total Acres Harvested (1000's)	Average CUTBF/ac	Cashflow (1000's)	Cashflow/ Harvested Acre*
6	Okanogan	146.754	11,838	$372,863	$2,541
6	Wenatchee	168.386	21,371	$871,744	$5,177
6	Yakima	433.989	15,983	$1,729,630	$3,985
	Timbershed 6	749.129	16,382	$1,271,008	$3,970
7	Northeast	490.634	15,233	$1,053,914	$2,148
7	Southeast	71.108	7,365	$96,408	$1,356
7	Tonasket	111.974	19,226	$561,277	$5,013
	Timbershed 7	673.716	15,066	$1,828,950	$2,848
	All timbersheds	1422.845	15,759	$1,535,193	$3,439

Eastside Private Management Economic Impact

We estimate the economic contributions from the first three decade sustainable Eastside Private harvest and revenue information in Table 1.32 using the economic model described in Discussion Paper 3 based on the harvest and cash flows in tables 1.28 & 1.30. The Forest Products sector employment is estimated at 5,718, total direct and indirect employment at 17,281, Forest sector labor income of $236 million/yr and total labor income of $590 million per year. State and Local tax receipts for the projected average $114 million per year. Landowner revenues of $156 million per year suggest a present value estimate for land and timber of $3.1 billion before taxes. While the economic impacts shown originate from the timberland activity in each region, many of the jobs and economic impacts may be exported to other regions where the processing takes place.

Table 1.32: Eastside Private Timberland Economic Impact

Eastside Region	FP Emp Prim W	Sec W	Prim P	FP Emp Total	All Secor Emp Prim W	Sec W	Prim P	All Sector Emp Total	FP Labor Inc (mil$)	All Labor Inc (mil$)	Gross St Product (mil$)	St&Loc Tax Rec. (mil$)	Forest owner PV (mil$)	Annual owner Rev (mil$)	PV per Total acre
Okanogan	259	123	61	443	773	301	265	1339	18	46	79	9	234	12	583
Wenatchee	536	254	126	918	1601	624	548	2773	38	95	163	18	564	28	1845
Yakima	1034	490	243	1769	3087	1202	1057	5346	73	182	314	35	1110	55	1803
E. Cascade	1829	867	430	3129	5461	2127	1869	9458	129	323	556	63	1908	95	1442
Northeast	1114	528	262	1906	3326	1295	1139	5760	79	197	339	38	654	33	544
Southeast	78	37	18	134	233	91	80	404	6	14	24	3	57	3	391
Tonasket	321	152	75	549	958	373	328	1659	23	57	98	11	363	18	700
Inland	1512	717	355	2588	4517	1759	1546	7823	107	267	460	52	1212	61	649
E. WA	**3341**	**1585**	**785**	**5718**	**9978**	**3887**	**3416**	**17281**	**236**	**590**	**1017**	**114**	**3119**	**156**	**978**

It should be noted that economic activity tables such as this based on static I/O models capture the hands-on labor activity such as logging, processing, log hauling (in transportation) and indirect purchases driven by this activity but leave out the impact of profits that must be sustained to support the infrastructure. The $156 million revenue received by timberland owners is a dividend payment for all investments, since regeneration investment was at least 30 years prior, an accumulation of deferred dividends over many years that contributes to economic impacts not characterized in the economic model. It is possible the profits will flow to other regions if the investment climate becomes unattractive but if spent in the state revenues could generate another 3000 direct jobs and 9000 total jobs.

Carbon benefits

Simulations of management activities on private forests have been assessed using a carbon model to determine the relative contribution that these forests are making toward reducing carbon outputs (see Discussion Paper 11 for a full description of carbon tracking). Figure 1.38 identifies four major pools of carbon sequestration that emerge from management activities on private forests of Eastern Washington. Under the base case, an average of 24 metric tons/acre of carbon is sequestered in the forest for the entire period. However, when we consider the product, displacement, and substitution pools which account for the end use of the wood products through their entire life cycle, and the opportunity to use biofuels in the place of fossil fuels for displacement and substitution, an average of 60 metric tons/acre of carbon are sequestered as a by-product of the management process in ten decades. The life cycle analysis accounts for the embodied carbon in products as well as substitution and displacement, more than doubling the estimate of sequestered carbon that can be produced by managing forests for long-lived products. Utilizing by-products of the manufacturing process as bioenergy alternatives also serves to offset the use of fossil fuels, but as we discuss in DP#13, the need to maintain infrastructure and markets that can process higher value wood products is integral to the economic recovery of biomass for bioenergy uses.

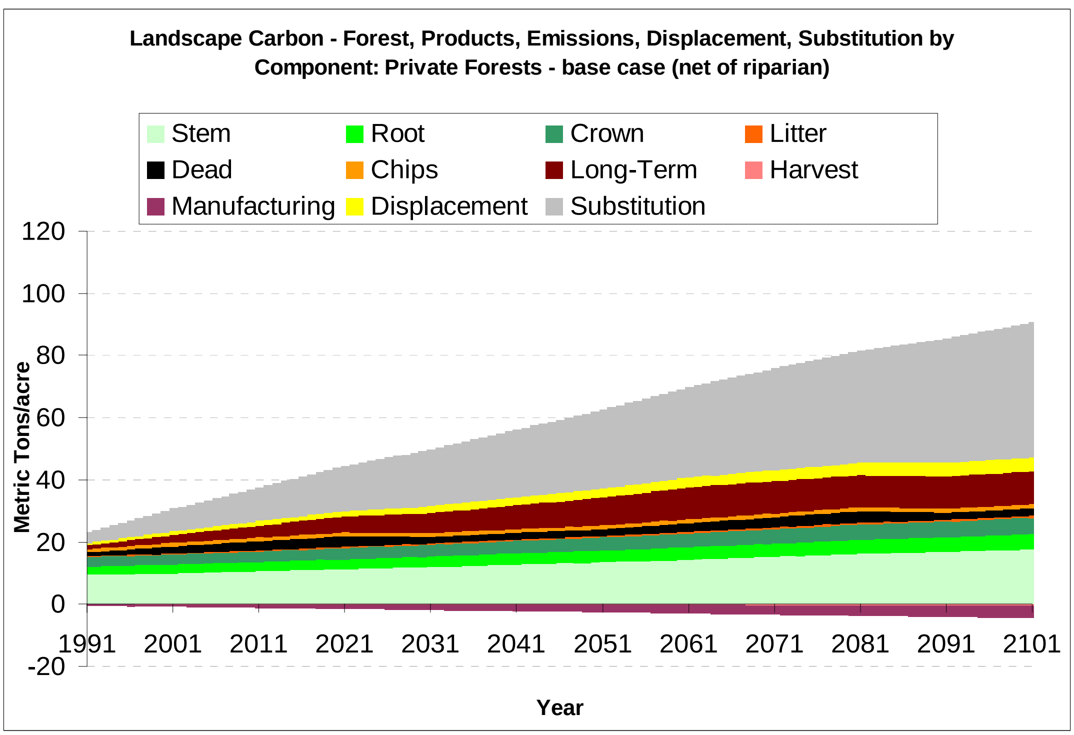


Figure 1.38: Life cycle analysis of carbon sequestration potential on private forest lands

Eastside State (DNR) Lands Harvest Scenario

The base case scenario assumes similar levels of management from DNR lands in the future as have occurred in the past. Table 1.33 shows the target harvest volumes by FVS variant for DNR managed lands in Eastern Washington. The North Idaho/Inland Empire variant is the DNR Northeast Region and the Blue Mountains variant is in the DNR Southeast Region. The East Cascades variant is used in both DNR Regions.

Base Case

As with the timbershed level analysis of private lands, median inventory values by habitat type were chosen to represent the available timber inventory on state forest lands. Table 1.33 provides estimates of gross acreage for forest lands capable of producing more than 20 cf/ac/year by FVS variant, habitat type, and leading tree species consistent with the definition of timberland. Commercially available acres have been determined by accounting for reserves associated with the DNR HCP, the Loomis Forest Natural Resources Conservation Area (NRCA), and for riparian reserves which have been adopted since the full FIA sample was conducted. Gray et al (2006) estimated that there were 714,000 acres of timberland under state, county, local government, and miscellaneous federal ownerships. Of that 714,000, 42,000 is federal, 659,000 is state, and 13,000 is county or local government. The FIA data provide inventory data for state, county, and local government as an aggregate for a total of 672,000 acres in these ownerships. Of that 672,000, we have identified 619,000 acres as potentially available timberland. The 619,000 acres are equivalent to approximately 92% of the total acres, which accounts for riparian reserves of 8.5% but does not account for other habitat reserves related to the Habitat Conservation Plan and the Loomis State Forest Reserve, that apply only to the East Cascades timbershed.

Table 1.33: DNR acres by FVS variant

Productive Forest Land		Forest Type										
FVS variant	Habitat Type	Unknown	ABLA	LAOC	PIAL	PICO	PIEN	PIPO	POTR5	PSME	THPL	Grand Total
BM	PSME									12,335		12,335
	PIPO											
BM Total										12,335		12,335
EC	LALY					6,021						6,021
	PSME							23,905		77,796		101,701
	ABLA		7,951			7,951	30,971		4,670			51,544
	ABAM									16,469		16,469
	TSHE									8,708		8,708
	PICO					6,361						6,361
	PIPO							41,653				41,653
	ABGR	6,361	6,716	6,361		6,361		65,061		79,775		170,635
EC Total		6,361	14,667	6,361		26,695	30,971	130,619	4,670	182,747		403,091
NI	PSME			6,597		13,501		20,405		68,885		109,387
	ABLA										6,597	6,597
	TSHE			6,597						6,597		13,194
	PIPO							20,405				20,405
	ABGR					6,904		6,904		34,115	6,597	54,519
NI Total				13,194		20,405		47,713		109,597	13,194	204,102
Grand Total		6,361	14,667	19,555		47,099	30,971	178,332	4,670	304,678	13,194	619,528

In response to the listing of the northern spotted owl, lynx, grizzly, and several species of salmon as threatened or endangered species, the DNR developed a statewide Habitat Conservation Plan (HCP) which came into effect in November 1996. In eastern Washington, the HCP covers three planning units along the East Cascade crest. Two of these planning units are located in the DNR Southeast Region while the Chelan unit is managed by the DNR Northeast Region (Table 1.34).

Table 1.34: Planning Units under the DNR HCP for eastern Washington

Planning Unit	Counties	DNR Acres
Chelan	Chelan and western Okanogan	15,000
Yakima	Kittitas and northwestern Yakima	81,000
Klickitat	Southwestern Yakima, western Klickitat and southeastern Skamania	132,000

In 2004, the HCP was amended for the Klickitat planning unit to address escalating forest health issues associated with overstocked stands (DNR 2004a). Changes to the HCP resulted in the identification of 58,482 acres of NRF (Nesting, Roosting and Forage) habitat across the three planning units (Table 1.35) as well as an additional 24,797 acres of Dispersal habitat. Density, diameter, and crown closure requirements for these acres were considered to render them commercially unavailable for harvest as part of the simulation exercise. The Loomis NRCA was removed from the FIA estimate of available productive timber land acreage in the EC variant.

Table 1.35: Commercially Unavailable Acres By Planning Unit

DNR Planning Unit	NRF and Reserved Acres	Spotted Owl Dispersal Habitat	Commercially Unavailable Acres
Loomis NRCA	25,000		25,000
Chelan	5,647		5,647
Yakima	13,567	8,332	21,899
Klickitat	39,268	16,465	55,733
Total	83,482	24,797	108,279

The net acreage after buffers and reserves (511,000 acres) was included in simulations. For an alternate case, increased management opportunities were identified and modeled. In the southeast region, approximately 600 MMBF of timber was identified that would need to be removed in order to restore a sustainable forest condition, including areas covered by the HCP. To restore the forests to a sustainable condition, the harvest rate would need to increase by 50% (Shelton, 2004). The ratio of harvested volume to standing inventory in the NI variant suggested that there were significant opportunities to increase harvest rates in that region as well. Simulations in the BM variant indicated very little, if any, opportunity to increase harvest volume and economic return to the trusts.

Table 1.36 provides volume and value estimates for the base case and Table 1.37 gives estimates for the alternate case. In the EC variant, the treatments between the base case and alternate case were identical, but the acres treated were increased for the alternate strategy. This approach ensured that cash flow/acre remained positive, even for the base case. By increasing the number of acres treated per year to a maximum estimated by growth rates, we estimated that harvest rates could potentially increase by 66% which is very similar to the estimate provided by Shelton (2004). This increase would shorten the average re-entry period between harvests from approximately 50 years to 30 years which would require periodic reassessments of the sustainable harvest rate.

Table 1.36: Base Case – Inventory and Harvest by variant

State Trust Lands		Base Case				Cash flow/Acre	
FVS variant	Unreserved Acres	Average Harvested Volume (BF/ac)	Average Standing Volume (BF/ac)	Acres treated/year - base case	Target MBF/yr	No site prep	With site prep
BM	12,335	4,482	4,907	304	1,363	$779	$594
EC	294,812	8,933	3,329	5,958	53,217	$552	$223
NI	204,102	7,228	1,781	3,725	26,927	$1,154	$1,069
Total	511,249	8,145	2,749	9,987	81,507	$783	$550

The NI variant alternate case had both an increase in the number of acres treated and an increase in management intensity. That increase in management intensity took the form of accelerated conversion of non-seral forests to seral species that were maintained at lower densities than is the case at present. Cash flow/acre was calculated for the first three decades of treatments for each variant and weighted across the entire Eastside. Cash flow varies substantially between the regions because of differences in volume removed and the piece size of harvested material. Site prep included costs associated with regeneration and any intermediate thinning treatments that might occur to bring understory trees to merchantable size. These costs varied by variant based on estimates dependent upon natural regeneration, density control, and species selection.

Table 1.37: Alternate Case – Inventory and Harvest by variant

State Trust Lands		Alternate Case				Cashflow/Acre	
FVS variant	Unreserved Acres	Average Harvested Volume (BF/ac)	Average Standing Volume (BF/ac)	Acres treated/year - alternate case	MBF/yr	No site prep	With site prep
BM	12,335	4,482	4,907	304	1,363	$779	$594
EC	294,812	8,933	3,329	9,917	88,585	$552	$223
NI	204,102	11,838	1,850	6,123	72,487	$1,143	$610
Total	511,249	9,985	2,777	16,344	163,199	$1,272	$613

Table 1.38 provides the average stand conditions post harvest for treatments that occurred within the first 30 years. On average the alternate case takes 78% of the merchantable volume, whereas the base case takes 75% of the merchantable volume. Residual overstory trees have an average QMD of 13.2 inches, but the QMD in the NI variant is substantially smaller than in the other two regions. This difference reflects the characteristics of the forest types, current inventory, and strategy for regeneration. In the NI alternate strategy, larger diameter trees are maintained as seed and shelter whereas in the base case, the understory is promoted for the next entry by removing overstory trees. In the EC and BM, these types of strategies were not favored because existing inventories were not conducive to such treatment simulations.

Table 1.38: Stand Statistics for harvested stand under Base and Alternate Scenarios

Variant	Scenario	Cut BF	Standing BF	Standing TPA	Standing QMD	Standing Height	Top Height	TPA>6"dbh	QMD>6"dbh
BM	Base	4,482	4,907	252	6.1	32	46	59	15.8
EC	Base	8,933	3,329	148	9.4	37	49	21	15.6
NI	Base	7,228	1,781	218	4.3	22	56	39	9.3
Total	Base	8,145	2,749	178	7.4	31	52	29	13.2
BM	Alternate	4,482	4,907	252	6.1	32	46	59	15.8
EC	Alternate	8,933	3,329	148	9.4	37	49	21	15.6
NI	Alternate	11,838	1,850	249	4.2	24	42	49	11.1
Total	Alternate	9,985	2,777	188	7.4	32	46	32	13.9

State Forest Management Economic Impact

We estimate the economic impact contributions for the Base Case and Alternate Scenario similar to the Private contributions (Table 1.39). Forest sector jobs total 624 in the base case and 1,884 including all sectors with direct and indirect impacts (DP3). The Alternative scenario nearly doubles the economic impact of jobs and economic activity levels, while increasing timber revenue to the state from $5 million to $10 million. The alternative also more directly addresses fire and insect risks and the rapidly increasing mortality reported for State forests.

Table 1.39: Eastside State Timberland Economic Impact

FVS variant	Unreserved Acres	Acres/yr treated	Stand + Cut vol/acre	Cut bdft per acre	Harvest mmbf per yr	Cashflow per acre with site prep ($)	Stump $/mbf	FP Emp Prim W	Sec W	Prim P	Total	Total Emp Prim W	Sec W	Prim P	Total	FP Labor Inc per yr	Tot Labor Inc per yr	GSP per yr	St & Loc Tax per yr
State Trust Land Scenarios																			
BM	12,335	304	9,389	4,482	1	594	132	6	3	1	10	18	7	6	32	0	1	2	0
EC	294,812	5,958	12,262	8,933	53	223	25	238	113	56	407	710	277	243	1,230	17	42	72	8
NI	204,102	3,725	9,009	7,228	27	1,069	148	120	57	28	206	359	140	123	623	9	21	37	4
Total	511,249	9,987	10,894	8,145	82	550	68	364	173	86	624	1,088	424	372	1,884	26	64	111	12
Alt Case FVS variants																			
BM	12,335	304	9,389	4,482	1	594	132	6	3	1	10	18	7	6	32	0	1	2	0
EC	294,812	9,917	12,262	8,933	89	223	25	396	188	93	678	1,183	461	405	2,048	28	70	120	14
NI	204,102	6,123	1,368	11,838	72	610	51	324	154	76	555	968	377	331	1,676	23	57	99	11
Total	511,249	16,344	12,737	9,931	162	613	62	726	344	170	1,242	2,167	844	742	3,753	51	128	221	25

Eastside Harvest Scenario for National Forests

Base Case:

The Department of Revenue (DOR) reports an average of 64,800 MBF/year is removed from Eastside Federal forests (2000-2002). According to representatives from the Colville and Okanogan-Wenatchee National Forests, approximately 12,000 acres are harvested or treated for fire resistance annually (Jahns, 2006). Based on Jahns (2006) estimate of acreage, an average of 5400 BF/acre of merchantable timber is removed. This volume/acre is slightly higher than we could produce when simulating thin from below harvest strategies on dry and moist forests that are assumed to be within the wildland – urban interface (WUI) and may therefore be more representative of the highest volume acres. We use the 12,000 acre estimate as a target for the base case describing the expectation for a continuation of what the Forest Service has been able to do within their budget constraints and legal challenges.

We also note that Congressional budgets largely dictate what can be harvested in conjunction with the complex approval process required by the courts. While these constraints have so far not allowed an increase in thinnings such as intended by the Healthy Forest Initiative the overriding objective is to improve forest health. To better understand the possibilities for stands needing treatment we simulated treatments on all available acres and then allocated the harvest on a per acre basis across the decades. To meet the Forest Service objective of reducing fire and insect risk and to also restore a fire resistant overstory the dominant treatment examined was to thin from below removing ladder fuels while leaving the larger trees with high canopies for an approximate Basal Area of 60sq ft and roughly 77 trees per acre over 6”dbh.

Forest Health Thinning Alternative:

While the FIA data indicate that approximately 3.3 million acres of National Forest is unreserved and available for timber harvest (Table 1.40), our thinning analysis looked at only those habitat types in dry and moist forests that were more likely to be in the WUI or would respond to restoration thinning treatments in ways that would reduce fire risk and insect and disease outbreaks. The acres included in the analysis were located in the ponderosa pine, grand fir and Douglas-fir habitat types for fire risk reduction. Control of mountain pine beetle (MPB) in the lodgepole pine habitat types was also considered as part of the analysis. The acreage associated with these habitat types by FVS variant is given as available acres in Table 1.40

Table 1.40: Available National Forest Acres

FVS variant	Unreserved Acres in National Forest	Acres available for treatment in dry and moist forests	Average cut BF/ac for the first entry	Average standing BF/ac for the first entry	Acres treated/year - base case	Acres treated/year - alternate case	Cost/acre to slash and leave*	Cashflow/acre with removal of merch vol	$/MBF
BM	181,339	152,728	6,638	13,052	1,140	4,559	-$300	-$9	-$1.30
EC	2,081,850	1,281,290	4,380	9,857	9,610	38,439	-$300	$265	$60.45
NI	1,014,344	481,901	2,985	10,275	3,424	13,698	-$300	$84	$28.11
Total	3,277,533	1,915,919	4,209	10,217	14,174	56,695	-$300	$198	$46.92

Treating all available acres on a 30-40 year re-entry period resulted in an estimated requirement to treat 56,695 acres per year as a restoration measure. This is more than four times the total acreage that is currently being treated. Thus harvest of 25% of total treatable acres was identified as a base case for the timber supply analysis allocated across all available National Forest acres (Table 1.40). The simulations indicate that for the first entry only, an average of 4,209 bf/ac could be removed when the harvest prescription is "thin from below" to 12" diameter strategy and then reducing the stocking further to a basal area of 60 ft^2/ac on all treatable acres. Subsequent entries on a 30-40 year rotation that are required to maintain these forests in a fire-safe condition reduce the average available bf/ac to 3571. Mason et al (2003) found that if stands had more than 200 TPA that were less than 6"dbh, an additional $300/acre was required to treat the stands in addition to harvesting costs. If we assume the forests were slashed and left to reduce ladder fuels and reduce stand competition, the treatment cost is estimated at $300/acre. If we assume that harvested merchantable wood is sold, then the estimated cash flow/acre is $198 for the first entry only. This cash flow value does not account for costs associated with sale preparation and any site preparation that may be required in addition to the slashing of small diameter wood.

Simulation of restoration thinnings on these candidate acres is described as an alternative management strategy for National Forest lands, more responsive to the Healthy Forest Initiative as well as reducing the risk on adjacent state and private lands. Thinning the available acres in Table 1.40 in 30 years requires 56,695 acres of thinning treatments per year followed by second and third entries to prevent fire and insect risks from returning by the end of ten decades.

USFS Management Economic Impact: Table 1.41 summarizes the volumes removed, job requirements and economic impacts from both the base level of activity that will likely more than break even and the additional treatments that will require stewardship activities with the positive impact from some stands returning revenues that offset costs in others.

Table 1.41: USFS economic impacts Base Case and Thinning Alternative

USFS Region & FVS variant dry& moist	Acres 1st thin/yr	Average CUTBF/a first entry	Harvest mmbf per yr	Cashflow per Treated Acre ($)	Stum-page$/ mbf	FP Emp Prim W	Sec W	Prim P	FP Emp Total	All Sector Emp Prim W	Sec W	Prim P	All Sector Emp Total	FP Labor Inc (mil$)	All Labor Inc (mil$)	Gross St Prod. (mil$)	St&Loc Tax Rec. (mil$)
FS BM	4,559	6,638	30	-$9	-1	189	41	23	253	540	123	97	760	10	26	44	5
FS EC	38,439	4,380	168	$265	61	1054	226	126	1406	3007	685	537	4229	56	143	244	27
FS NI	13,698	2,985	41	$84	28	256	55	31	341	730	166	130	1027	13	35	59	7
Alt Total	56,695	4,209	239	$199	27	1499	321	180	2000	4278	975	764	6017	79	204	348	39
Base activity total																	
USFS East	14,174	4,209	60	$198	47	267	126	63	456	796	310	273	1,379	19	47	81	9

While many of the thinning treatments are not necessarily economic, as noted in Discussion Paper 10 there are many costs avoided by these treatments that should justify the investment. The estimated revenue from the Alternative thinning case was $11million, excluding planning and approval costs which may be larger. Estimated revenues from the Base Case were $3 million, excluding planning costs. The fact that the USFS probably does not make money from market returns on some of these treatments is unavoidable. Both the economic impacts from the activity level and the reduction in fire and insect risk are major benefits to the state and all timber managers. Employment, labor income, and State & Local tax receipts increase by more than 300% in the alternative along with improved forest health. As noted in Discussion Paper 11, the reduction in fires will also contribute to reduced carbon emissions.

State Summary by Owner Group and Region

Each owner and region has different opportunities and is faced with different issues as demonstrated by the stratification of management alternative analysis. We sum the impacts across owners for both East and West to demonstrate the economic impacts on the state.

Table 1.42: Economic Impacts by Owner, East and West

Washington Forest Sector 's Economic Impact	West Private	West State	West Federal	West Total	East Private	East State	East Federal	East Total	**WA Total**
Acres Timberland (000s)	5,035	1,390	2,320	8,745	3,189	620	3,277	7,086	**15,831**
Harvest/yr (mmbf)	2,377	550	23	2,950	747	82	60	807	**3,757**
Vol/acre (bf/total acre)	472	396	10	337	234	132	18	114	**237**
Rev/yr ($ mils)	781	165	5	951	156	5.5	3.0	159	**1,110**
Rev/acre ($/total acre)	155	119	2	109	49	8.9	0.9	22	**70**
Present Val ($ mils)	15,626	3,307	92	19,018	3,120	110	60	3,180	**22,198**
PV /acre ($)	3,103	2,379	40	2,175	978	177	18	449	**1,402**
Forest Emp (100yr ave)	27,942	7,097	318	35,356	5,718	624	456	6,174	**41,530**
Total Emp (100 yr ave.)	81,847	20,638	954	103,439	17,281	1,884	1,379	18,660	**122,099**
Forest Labor Inc ($ mils)	1,327	282	13	1,621	236	26	19	255	**1,876**
Total Labor Inc ($ mils)	3,308	704	33	4,045	590	64	47	637	**4,682**
Gross State Prod ($mils)	5,638	1,199	56	6,893	1,017	111	81	1,098	**7,991**
St & Local Tax ($ mils)	634	135	6	776	114	12	9	123	**899**

Of the 16.6 million acres noted in our aggregate description of unreserved timberland (DP1) we have simulated the impact on 95%, with the remainder of marginal commercial contribution or classified as other public or other federal. Additional reserves for stream buffers and Habitat Conservation Plans reduce the operable acres by an additional 10 to 15% on Private owners and even more on public managers. This projection is representative of the Base Case conditions for the first three decades. Forest sector employment totals 42,000 jobs, with total direct and indirect employment based on the Washington Input-Output NAICS model of 122,000. State and Local Tax receipts related to state's forest sector economic activity level are estimated at $899 million. This estimate does not take into consideration specific forest sector taxes. As noted earlier in Discussion Paper 3, the indirect impacts as calculated by a dynamic econometric model would likely be larger.

Management alternatives on the Westside were largely focused on achieving more complex forests with better habitat rather than on alternatives that might boost or lower the harvest. The alternatives for the Eastside are largely related to reducing fire and insect risk, restoring forest health and improving resilience to climate change. Even though these alternatives were targeted toward forest health improvement and not timber production, they result in additional resources for the processing infrastructure thus contributing to local jobs.

Eastside Alternative Scenario

The Eastside alternatives on federal and state lands did not significantly increase revenues as they were directed at near break even forest health treatments. However, they resulted in a substantial increase in economic activity on the Eastside supportive of an infrastructure that has been declining. Jobs and economic activity levels initiated on the Eastside increased by over 40%. The increase in Forest Sector jobs was 2,782 and total direct and indirect jobs were 8,379. While some of these jobs may not stay on the Eastside, most would, especially those in the forest sector contributing to the local infrastructure.

While recent harvest levels on the Eastside were only 72% of the 1980 to 1990 decade and 80% of the 1990 to 2000 decade, the alternative scenario volumes restore the harvest level to earlier periods, albeit with a log mix heavily weighted to small but merchantable logs.

Table 1.43: Economic Impact of Eastside Forest Health Treatment Alternatives

Base vs Alt. Scenario	Base Case Eastside				Alternative Eastside Sceanrio				Difference	
Eastside	East Private	East State	East Federal	East Total	East Private	East State	East Federal	East Total	Alt % Dif	Alt Change
Acres Timberland (000s)	3,189	620	3,277	7,086	3,189	620	3,277	7,086	0%	0
Harvest/yr (mmbf)	747	82	60	807	747	162	238	1,147	42%	340
Vol/acre (bf/total acre)	234	132	18	125	234	261	73	162	42%	48
Rev/yr ($ mils)	156	5.5	3.0	159	156	10	11	177	11%	18
Rev/acre ($/total acre)	49	8.9	0.9	25	49	16	3	25	11%	3
Present Val ($ mils)	3,120	110	60	3,180	3,120	201	226	3,547	12%	367
PV /acre ($)	978	177	18	492	978	323	69	500	12%	52
Forest Emp (100yr ave)	5,718	624	456	6,174	5,718	1,242	1,996	8,956	45%	2,782
Total Emp (100 yr ave.)	17,281	1,884	1,379	18,660	17,281	3,753	6,005	27,039	45%	8,379
Forest Labor Inc ($ mils)	236	26	19	255	236	51	79	366	44%	111
Total Labor Inc ($ mils)	590	64	47	637	590	128	204	922	45%	285
Gross State Prod ($mils)	1,017	111	81	1,098	1,017	221	347	1,585	44%	487
St & Local Tax ($ mils)	114	12	9	123	114	25	39	178	45%	55

Ecosystem Service Opportunity Costs

Habitat, carbon storage, aesthetics and many other attributes qualify as ecosystem services that may be of value to the public. Markets for environmental goods have been around for a long time but payment for forest ecosystem services is relatively new and of growing interest. We have pointed out in other sections of this report that the habitat in greatest shortage is generally old forest habitat (Discussion Paper 4). Commercially regenerated forests begin with much higher densities than the more sporadic regeneration after natural disturbances that have historically resulted in multi-storied old forest conditions (Poage and Tappeiner 2002). An objective of commercial forest managers is to increase the yield from a managed plantation over that of natural regeneration. As a consequence, plantation forests are much more dense and homogeneous than natural forests and, if left unattended, are unlikely to develop old forest structural diversity. The method to intentionally alter commercial forests to achieve greater structural diversity similar to old forest conditions involves periodic thinnings with extended rotations combined with accommodations for understory and down-log retention that have become known as biodiversity management pathways (Carey et al. 1996). However, longer rotations to produce older forest structures or habitats result in revenue losses to forestland owners. These revenue losses are the opportunity cost for the landowner to produce the old forest structure as an ecosystem service.

Biodiversity Management Pathway Incentives

A recent study on the Olympic Experimental State Forest (OESF) examined a range of biodiversity pathway treatment alternatives that could produce forest structures statistically similar to old forest conditions (Lippke et al. 2007). The percentage of time the treated stand was within the target structure defined by old forest inventory data as the desired future conditions or DFC provided an ecological measure of success while the NPV landowner loss above a commercial rotation provide the measure of economic cost. Time to reach

DFC provided another measure of success. The cost of producing these structures is an opportunity cost i.e.. revenue loss to produce the ecosystem service benefit. Figure 1.39 demonstrates the characteristics of opportunity costs to produce the DFC i.e.. stands that are like old forest structures. A range of representative managed forest inventories from the OESF within the 30-year age-class was modeled with treatments designed to accelerate development of old forest conditions. The chart shows medium and high density stands for medium and high site classes with different costs to reach the same level of DFC over 100 years. A biodiversity pathway was found to often meet a DFC statistical test 50 out of 100 years. For medium density sites, the Net Present Value cost to the landowner is $3000 per acre for DFC 50% of the time or $60 for each one percent of time in DFC. This is the opportunity cost to the landowner to produce an ecosystem service. This cost estimate is derived by determining the loss in net present value (NPV) relative to commercial management on a shorter rotation at the time of the first commercial thinning window, a critical decision point for determining an alternate management pathway. There is no cost to produce zero DFC (the 0,0 origin in the figure). If compensated by either a one time payment of $3000 per acre or an annual payment thereafter of $150 per acre ($3000 PV equivalent) the landowner should be economically indifferent to managing for the biodiversity pathway producing 50% DFC vs. a commercial short rotation producing 0% DFC. However, some forest owners may actually prefer a cost-neutral biopathway because of the achieved environmental and aesthetic values. Some may need greater compensation preferring a nearer term payout while others may prefer annual compensation for sustainable revenue flow. Determining the opportunity cost to produce an environmental service measured by definable metrics can be an important step in informing forest management for broadened public values.

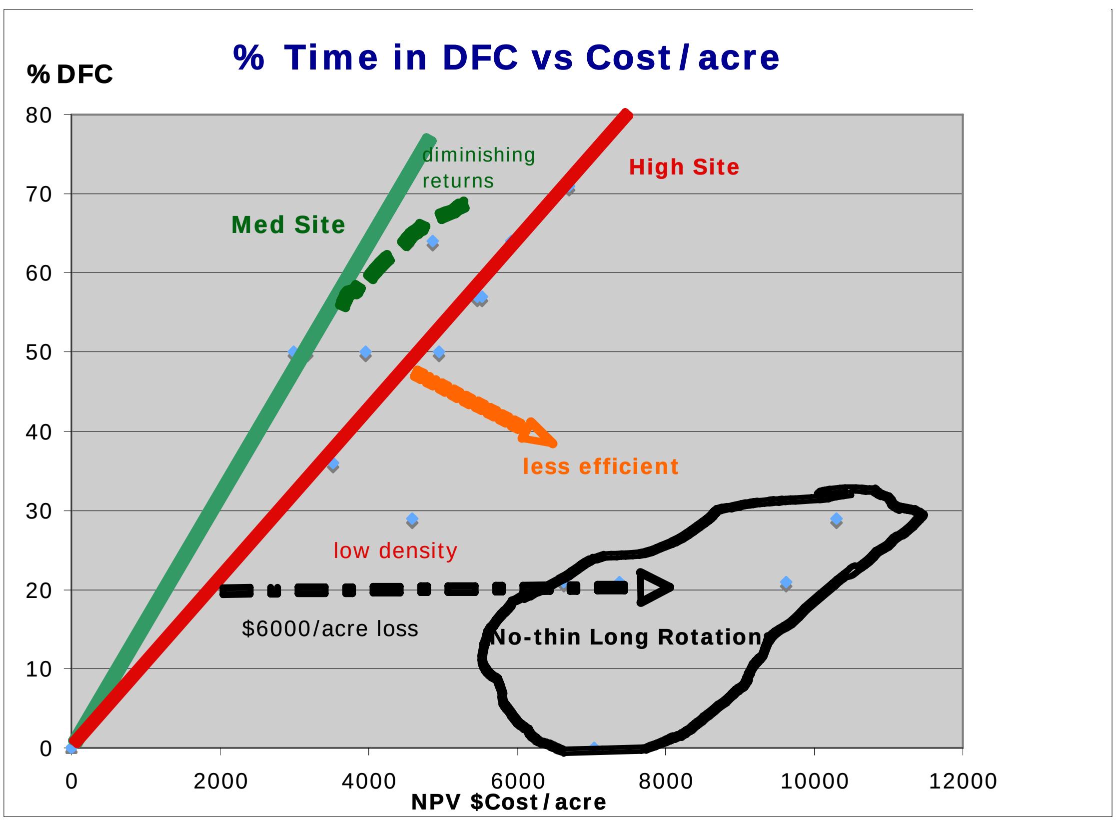


Figure 1.39: Estimated costs of biodiversity pathway treatment alternatives for previously managed forests in the OESF.

Figure 1.39 also demonstrates that higher density and higher site stands cost more to move towards DFC, largely because they produce a higher commercial value with greater losses when put on longer rotations. The $60 per acre for each one percent of time in DFC for medium site forests became $90, a 50% cost increase when applied to denser and faster growing sites. Figure 1.39 also demonstrates that no-thin long rotations may produce some DFC in 100 years but at a much higher cost of $500 or more per acre per percent DFC.

While the cost of these treatments may seem large, the main reason is that they are initiated some 30 years after the regeneration investment. Making the decision to manage on a biodiversity pathway at time of regeneration was discussed in Discussion Paper 4 and estimated to be about $500 per acre requiring only $25/yr/acre as the equivalent annual payment. These two options are not different in their economic valuation in that the time to reach DFC is about 30 years longer by starting at the time of regeneration. Restoration over a longer period of time is less expensive than trying to get there quickly. This is also demonstrated on Figure 1.39 as the cost goes up with diminishing marginal returns when trying to reach for higher percentages of time in DFC. It is impossible to reach DFC 100% of the time. To maximize benefits for the landscape at the least cost, targeting stands for 50% DFC appears to be about optimum.

So long as there are agreed upon metrics that can be estimated for ecosystem services it is possible to determine the opportunity cost to produce the service. As a recent example of such a purchase once the cost is identified such as the cost to purchase the harvesting rights on the Loomis Forest, the value of the service to public beneficiaries can be revealed by whether and how much they are willing to pay for the service which the market can help to determine by multiple bidders or by negotiation.

Regulatory relief or effectiveness improvement as an incentive

In cases where regulatory requirements have already created a legal mandate to produce an environmental service it may only be helpful to make the delivery of the ecosystem service more efficient (at less cost) thereby reducing the monetary incentive needed. In Discussion Paper 7 we note that the objectives behind forested riparian buffers are to produce DFC yet regulation prevents rather than motivates biopathway management to improve the habitat in streamside buffers. While the opportunity to manage riparian buffers as biopathways instead of no management reserves does not restore the total economic loss caused by the regulatory impact to the landowner, it does reduce the cost and hence provides motivation to thin the buffers for better habitat conditions, better economics, and more sustainable forestry. Our alternative management simulation of introducing biopathways in otherwise restricted riparian buffers on industrial forestland increased landowner revenue and produced more acres with old forest conditions along streams. This analysis identifies the high cost of the regulation as a negative cost incentive (disincentive) for meeting habitat goals. The same principle may hold true for addressing upland habitat needs. For previously-managed forests, consider spotted owl habitat. Thinning in the vicinity of spotted owl nest sites to produce the multi-layered habitat structures favored by owls may be considerably more effective than no-management reserves that are unlikely to meet DFC conditions.

In contrast, our biopathway management alternative for other private forest landowners, as an extension to thinning treatments on uplands, was quite expensive with a cost of about $4000/acre in DFC (about $2000 for each acre on a biopathway). The cost is high because there are many opportunities to thin maturing stands that can quickly reach DFC target conditions. The high cost and deferred harvest activity also has negative impacts on downstream economic activity so there would be less tax receipts to use for incentives. While first thinning treatments increase habitat quality for some species they also accelerate economic activity. However, deferred harvests for long rotations have the opposite effect.

Carbon as an Ecosystem Service

Not all ecosystem services are alike. Strategies to increase forest carbon storage provide a contrasting example to the discussion above. Carbon registries and accounting techniques are being considered to increase the incentive to reduce atmospheric carbon emissions but carbon accounting is very complex. Carbon emissions are in the air and impacted by all living plants and creatures as well as by the soil and the oceans. Also carbon storage verses release functions are linked to all products manufactured, their use, and disposal. Therefore, carbon must be viewed from a systems perspective across many boundaries.

A cap on the emissions from utilities has received considerable attention, as it would force utilities to purchase carbon offsets to their power plant emissions thereby creating an incentive to produce the offset source. Ironically, capping utilities' carbon emissions would not lower the carbon in the atmosphere; it would only serve to slow the rate of future atmospheric carbon increases. Given this limitation, the carbon credits that a utility would need to purchase could not come from existing carbon in a steady state condition such as the carbon in a sustainably managed forest, which cycles across treatments and disturbances around a long term neutral level. As a more effective alternative, the carbon offsets needed by utilities could come from the avoidance of existing uses of fossil fuels or fossil fuel intensive products. By expanding carbon storage accounting from a sustainably managed forest to the products that come from it, we have identified how carbon offsets could be measured against the displacement of fossil fuel intensive products and their emissions. Carbon credits could also come from net increases to the acres in forests if it can be assured that the new acres in one location are not merely offsets for deforestation elsewhere. If utility credits serve only to offset deforestation, new utility emissions will still represent an increase over a global cap.

Progress toward reducing carbon emissions will ultimately need to be bid back to all opportunities, essentially making all stored carbon more valuable relative to all sources for carbon emissions. **This is the link that identifies forest management, products manufacture, and use of residuals for energy as unique contributors in developing effective global carbon strategies.** If the goal is to reduce carbon emissions, all carbon sources and sinks need to be considered, not just emissions. This would operate like a tax on carbon emissions, which can be simplified to a tax on fossil carbon. Under the tax model the value of reducing carbon would be bid into all carbon including forest carbon, a quite different treatment approach than cap and trade, which attempts to isolate new sources of emissions and offset them.

Most registries to date are only designed for simplistic credit to additional carbon storage. If applied to carbon in the forest, the result would motivate land owners to extend their rotations resulting in less wood products with more fossil fuel intensive product substitution for less polluting wood alternatives, a counter productive impact. If applied to the harvest of wood, while there would be a short-term emission from the residuals decomposition, the immediate impact will be the substitution of carbon-sink wood products for carbon-source fossil fuel intensive products, reducing emissions while regeneration of the forest returns the forest carbon to its long term steady state. When the credit goes to the harvest it will be bid back to the landowner and ultimately into the land value as incentive to investment in sustainable forest management. However, with reduced harvest activity, the amount of carbon stored on the land will slow down with time and reach a steady state as forests reach their limits of growth.

An integrated system for atmospheric carbon reduction has to value the credit for the carbon stored in the forest, in wood products, and the value of displacement of fossil fuel intensive processes and products. Displacement is a multiplier over the carbon in the forest and wood products because it continues to grow over time. The real leverage and comparative advantage resides in replacing fossil fuel emission sources with net sink solar energy sources such as the wood from trees. Carbon registries to date, however, have not advanced beyond the boundaries of the forest, which limits the effectiveness of carbon credits and will instead produce unintended consequences such as increased market share for non-wood building products that are fossil fuel intensive in their manufacture.

Conclusion

Three examples of environmental services provided by forests and valued by the public have been discussed above to illustrate the potential for incentives to influence management choices and environmental outcomes while avoiding unintended consequences when the accounting of input and output variables are too narrowly defined. We have also demonstrated their impacts by planning alternatives implemented across ownerships. It is worth noting that the examples provided above also highlight the need for integrated approaches for multiple environmental services such that extended rotations favorable to old forest habitats are reconciled with wood products production needed to displace more polluting building product alternatives.

Summary of Issues

Westside Issues:

1. Declining Harvests: The 45% decline in harvest over the last two decades, although mostly unpredicted, has contributed to substantial structural change and can be traced to several factors when considering future impacts: (1) regulatory policy and effectiveness, (2) land conversions to non-forest use, and (3) management responses to harsher markets. Given projection errors of the past there may be little comfort in a new baseline projection that near-term projections for harvest levels can be sustained for several decades. However, it does suggest that our current models are not in conflict with current harvest rates. The uncertainties ahead will likely be dominated by these same factors but with new features such as incentives for ecosystem services such as habitat and carbon as an alternative to increased regulatory burdens.
2. Land Conversions: A continuation of land lost to conversion with small owners on the urban lowland fringe as intermediaries to real estate expansion seems inevitable. Working forests are declining more than 30,000 acres per year, diminishing not just the base for producing wood products for consumers but the landscape for the many ecosystem services that forests provide such as habitat, clean water, aesthetics, recreation, and carbon emission offsets.
3. Regulatory efficiency: While the objectives of protecting endangered species habitat and fish bearing streams have been widely supported, measures of effectiveness and the potential for improvement are notably absent. Neither upland or stream buffer habitat enhancement has been incentivized to improve their function; rather, the disparate negative economic impact on too many owners motivates selling into land conversions. Management alternatives that reduce forest density and promote habitat through structural diversity while providing more viable economics for sustainable forest management are foregone.
4. Management intensity: Declining markets and technology change have increased management intensity with shorter rotations producing more wood products, jobs, and even more carbon stored from fewer timbered acres. While intensive management does reduce the diversity of habitat in young forests, it appears that currently only old forest structures are in short supply, resulting in habitat concerns. The objectives of many small owners include more efforts to protect habitat but for others the complexities and costs of regulations impede their efforts.
5. Institutional response: Establishing regulations to achieve objectives prevails, yet there are many opportunities to improve habitat and economics that appear to have high potential but remain untested with no apparent institutional response capability. A more proactive management approach by some conservation organizations may contribute to greater effectiveness in the future.

Eastside Issues:

1. Forest Health: Increasing fires and record levels of Mountain Pine Beetle (MPB) infestations are symptomatic of declining forest health as a consequence of 100 years of fire suppression and management practices. Forests are overly dense with ladder fuels dominating the understory, compromising their ability to withstand climate stress or insects, with high risk of catastrophic crown fire. While thinning treatments can reduce stress, fire, and insect risk, the cost to remove fuel loads is an impediment. Federal managers have had neither the budget nor legal approval process to significantly improve forest health.
2. Climate Change: Record infestations and fires are being exacerbated by climate change with summer temperatures and moisture deficits outside of their 100-year dynamic range. Treatments that previously were thought to be effective to reduce stress and fire risk may now be in question. Better and more current forest data are needed as input into research protocols and models in order to design adaptive responses to continued climate change.

3. Habitat and Carbon Impacts: Thinning to restore forest health will affect high density forest habitat but is of less concern than the impact of uncontrolled fires. Fires emit large pulses of carbon that can be prevented by thinnings, while also capturing the carbon benefits of producing products and biofuel energy that can displace the carbon emissions of fossil fuel intensive products. Stream buffer regulations prevent thinning in the riparian zone, leaving the streams that need the most protection vulnerable to fires, erosion, and extensive restoration costs.
4. Infrastructure Decline: The decline in management on federal forests has contributed to accelerated private harvests and critical regional mill closures that will impede the ability to respond to the worsening forest health crisis and the development of biofuel processing capability.
5. Private harvests can not be sustained at the historic rates in some regions and the potential for increased private harvests in other regions may not be realized without improved market conditions and opportunities to remove small diameter wood with positive cashflow.
6. Institutional Response: There has not been an effective institutional response to the increasing health crisis in spite of many studies demonstrating the need. Passage of the Healthy Forest Initiative has yet to result in substantive increases in treatments on Federal lands and the State response to the Forest Health Working Group (FHWG) report of more than two years ago is at best only a beginning. The avoidable future costs of fighting fires, facility losses, fatalities, timber and habitat losses, restoration costs, water losses, carbon emissions and more have been shown to justify much larger investments in forest health activities. Thinning treatments are needed on a much larger scale by many owner groups. Better forest data, research and training are likely essential. Pilot projects as proposed by the FHWG to better demonstrate what can be done could accelerate the process.

References:

Adams, D.M., R.J. Alig, D.J. Anderson, J.A. Stevens, J.T. Chmelik. 1992. *Future prospects for Western Washington's timber supply.* College of Forest Resources, University of Washington. Seattle, WA. 201 p.

Agee, J. 1993. Fire ecology of Pacific Northwest forests. Washington D.C.: Island Press. 493 pp.

Agee, J., R. Edmonds. 1992. Forest protection guidelines for the northern spotted owl. In recovery plan for the northern spotted owl: app. F. Washington D.C.: USDI Fish and Wildlife Service.

Amman, G. D. and Anhold, J. A., 1989, Preliminary evaluation of hazard and risk rating variables for mountain pine beetle infestations in lodgepole pine stands, pp 22-27 in Proceedings – Symposium on the management of lodgepole pine to minimize losses to the mountain pine beetle held July 12-14, 1988 in Kalispell MT, USDA FS GTR-INT-262.

Arno, S.F. 2000. Fire in Western Forest Ecosystems. In: Brown, J.K., Smith, J.K., eds. Wildland Fire in Ecosystems: Effects of Fire on Flora. Gen.Tech. Rep. RMRS-GTR-42: vol. 2. USDA Forest Service: 97-120. http://www.fs.fed.us/rm/pubs/rmrs_gtr42_2.html.

Bailey, J.D. and J.C. Tappeiner. 1998. Effects of thinning on structural development in 40- to100-year-old Douglas-fir stands in western Oregon. *Forest Ecology and Management* 108:99-113.

Bailey, J.D., C. Mayrsohn, P.S. Doescher, E. St. Pierre, and J.C. Tappeiner. 1998. Understory vegetation in old and young Douglas-fir forests of western Oregon. *Forest Ecology and Management* 112:289-302.

Bare, B., B. Lippke, C. Oliver, S. Zens. 1995. Eastern Washington Timber Supply Analysis. CINTRFOR Special paper 18. Center for International Trade in Forest Products. University of Washington, College of Forest Resources. Seattle, WA. 191 p.

Bare, B.B., B.R. Lippke, W.Xu. 2000. Equitably Treating Individual Washington State Forest Trusts through Consolidated Management: A Proposed Conceptual Approach. Natural Resources Journal Summer 2000. 40(3): 479-497.

Bare, B. Bruce, B. R. Lippke, W. Xu. 2002. "Cost Impacts of Management Alternatives to Achieve Habitat Conservation Goals on State Forest Lands in Western Washington." Western Journal of Applied Forestry, 15(4) 2002. pp217-224.

Baumgartner, D.M., J.H. Creighton, and K.A. Blatner. 2003. Use and Effectiveness of Washington State's Extension Forest Stewardship Program. Small Scale Forest Economics, Management and Policy 1(2):49-61.

Berndt, G. 2004, WADNR Southeast Assistant Region Manager, in a presentation to the Forest Health Working Group, July 27, 2004, Spokane WA.

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

Briggs, D. and C. L. Mason. 2006. The Future of Wood Products and How This May Affect Small Woodland Owners. Northwest Woodlands. 22(2): 8-11.

Briggs, D., and J. Trobaugh. 2001. *Management practices on Pacific Northwest-side industrial forest lands: 1991–2000: With projections to 2005*. Stand Management Cooperative Working Paper No. 2. College of Forest Resources, University of Washington, Seattle, WA. 52 p.

Brodie, Angus. 2007. Personal communication providing post settlement Sustainable Harvest Caclulation adjustments.

Busing, R.T. and S.L. Garman. 2002. Promoting old-growth characteristics and long-term wood production in Douglas-fir forests. *Forest Ecology and Management* 160(1):161-175.

California Climate Action Registry. 2005. Forest Sector Protocol and Forest Project Protocol. California Climate Action Registry, Los Angeles, CA.

Carey, A.B. and R.O. Curtis. 1996. Conservation of biodiversity: a useful paradigm for forest ecosystem management. *Wildlife Society Bulletin* 24:610-620. 10 p.

Carey, A.B., B.R. Lippke, and J. Sessions. 1999. Intentional systems management: Managing forests for biodiversity. *Journal of Sustainable Forestry* 9(3/4):83-125.

Carey, A.B., C. Elliott, B.R. Lippke, J. Sessions, C.J. Chambers, C.D. Oliver, J.F. Franklin, and M.G. Raphael. 1996. *Washington Forest Landscape Management Project: A pragmatic, ecological approach to small-landscape management*. Washington Forest Landscape Management Project Report No. 2. Washington State Department of Natural Resources, Olympia, WA. 99 p.

Ceder, Kevin. 2004. Wildlife Habitat Modeling and Assessment using LMS. Rural Technology Initiative, College of Forest Resources, U. of Washington Fact Sheet #27.

Chan, S., P. Anderson, J. Cissel, L. Larsen, and C. Thompson. 2004. Variable density management in riparian reserves: Lessons learned from an operational study in managed forests of western Oregon, USA. *Forest Snow and Landscape Research* 78(1/2):151-172.

Curtis, R.O. 1997. The role of extended rotations. Pages 165-170 in K.A. Kohm and J.F. Franklin, eds. *Creating a forestry for the 21st century*. Island Press, Washington, DC.

DNR. 2004. A Desirable Forest Health Program for Washington's Forests. Forest Health Strategy Work Group Report. Olympia, WA. http://www.dnr.wa.gov/htdocs/rp/forhealth/fhswgc/foresthealthreport.pdf

DNR. 2004. Final Environmental Impact Statement on Alternatives for Sustainable Management of State Trust Lands in Western Washington. Olympia, WA. http://www.dnr.wa.gov/htdocs/fr/sales/sustainharvest/sustainharvest.html

DNR. 2006. http://www.dnr.wa.gov/htdocs/obe/obehome4.htm

DNR. 2007. http://www.dnr.wa.gov/htdocs/rp/forhealth/

(DNR, 2004a), Washington State Department of Natural Resources, 2004, HCP Amendment No. 1, Administrative Amendment to the Northern Spotted Owl Conservation Strategy for the Klickitat HCP Planning Unit, April 2004, Ellensburg, WA.

Douglas, Roger. 1993. Unfinished Business. Random House New Zealand Ltd. Auckland, New Zealand

Eng, M. et al. 2006. Provincial-level projection of the current mountain pine beetle outbreak: update of the infestation projection based on the 2005 Provincial overview of forest health. British Columbia Ministry of Forests Report. 7 p.

Garman, S.L., J.H. Cissel, and J.H. Mayo. 2003. *Accelerating development of late-successional conditions in young managed Douglas-fir stands: A simulation study*. General Technical Report PNW-GTR-557. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. 57p.

Gehringer, K.R. 2006. Structure-based nonparametric target definition and assessment procedures with an application to riparian forest management. *Forest Ecology and Management* 223(1-3):125-138

Graham, Russell T.; Harvey, Alan E.; Jain, Theresa B.; Tonn, Jonalea R. 1999. The effects of thinning and similar stand 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.

Graham, R., S. McCaffrey, T. Jain. (tech eds.) 2004. Science basis for changing forest structure to modify wildfire behavior and severity. Gen. Tech. Rep. RMRS-GTR-120. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 43 p.

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

Gray, Andrew N.; Fried, Jeremy S.; Christensen, Glenn; Potts, Larry. 2006. Timber resource statistics for forest land in eastern Washington, January 2002. Resource. Bulletin. PNW-RB-251. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 46 p.

Havari, B.A., and A.B. Carey. 2000. Forest management strategy, spatial heterogeneity, and winter birds in Washington. *Wildlife Society Bulletin* 28(3):643-652.

Hayes, J.P., J.M. Weikel, and M.M.P. Huso. 2003. Response of birds to thinning young Douglas fir forests. *Ecological Applications* 13(5):1222-1232.

http://www.for.gov.bc.ca/hre/bcmpb/BCMPB.v3.BeetleProjection.Update.pdf

Huff, M.H., M.G. Raphael, S.L. Miller, S.K. Nelson, J. Baldwin. (tech. coords.) 2006. Northwest Forest Plan—The first 10 years (1994-2003): status and trends of populations and nesting habitat for the marbled murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 149 p.

Jahns, P. 2006, Vegetation Management Team Leader, Okanogan/Wenatchee/Colville Plan Revision, USFS, personal communication March 8, 2006.

Lippke, B.R., K.W. Zobrist, and C.L. Mason. 2007. Templates for Forest Sustainability on the Olympic Experimental State Forest. RTI Working Paper No. 7. College of Forest Resources, University of Washington, Seattle, WA. 49 pp.

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. pages 8-19.

Lippke, B.R., J. Sessions, A.B. Carey. 1996. *Economic analysis of forest landscape management alternatives*. CINTRAFOR Special Paper 21. College of Forest Resources, University of Washington, Seattle, WA. 157 p.

Lippke, Bruce and R. S. Conway. 1994. Economic impact of alternative forest practices rules to protect northern spotted owl sites. Washington State Forest Practices Board, State of Washington, Olympia, WA. Approx. 200 pp.

Lippke, Bruce R. 1997 . The Role of Economics in Producing Non-Market Forest Amenities. Proceedings of IUFRO 1.14.00: The Uneven-Aged Management Symposium compiled by William Emmingham, Sept. 15-26, 1997, Oregon State University, Corvallis, OR.

Lippke, Bruce, B. B. Bare. 1998. Viability of the Non-Industrial Private Forest Sector in Washington State. Paper prepared for Washington Farm Forestry Association. CINTRAFOR, College of Forest Resources, Univ. of Washington, Seattle

Lippke, B.R., B. Bruce Bare, Weihuan Xu, Martin Mendoza. 2002. An Assessment of Forest Policy Changes in Western Washington. Journal of Sustainable Forestry Vol. 14(4) pp63-94

Marzluff, J.M., J.J. Millspaugh, K.R. Ceder, C.D. Oliver, J. Withey, J.B. McCarter, C.L. Mason, J. Comnick (2002). "Modeling changes in wildlife habitat and timber revenues in response to forest management" Forest Science 48 (2): pp. 191-202

Mason, C. L. 2006. *Red alder market implications for management; reasons for optimism. In Proceedings:* Red alder-a state of knowledge. Deal, R.L. and C.A. Harrington, eds. Gen. Tech. Rpt. PNW-GTR-669. Portland, OR: USDA Dept. of Ag., pacific Northwest Research Station. 150 p.: 133-136.

Mason, C.L. 2006. Sovereignty, Stewardship, and Sustainability. Evergreen Magazine. Winter 2005-2006: 26-31

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, WA. 78 p. plus appendices.

Mason, L., K. Ceder, H. Rogers, T. Bloxton, J. Comnick, B. Lippke, J. McCarter, K. Zobrist. 2006. Investments in Fuel Removals to Avoid Forest Fires Result in Substantial Benefits. Journal of Forestry. 104(1):27-31.

McComb, W.C., T.A. Spies, and W.H. Emmingham. 1993. Douglas-fir forests: Managing for timber and mature-forest habitat. *Journal of Forestry* 91(12): 31-42.

McKay, N., P.M. Bassett, C.D. MacLean. 1995. Timber Resource Statistics for Eastern Washington. Resource Bulletin PNW-RB-201. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. 47p.

McKenzie, D., Z. Gedalof, D. Peterson, and P. Mote. 2004. Climate Change, Wildfire, and Conservation. Conservation Biology.18:4. pages 890-902.

Michaelis, L. O. (2000). Assuring a future for private timber management. *In Proceedings:* Summit 2000, Washington Private Forests Forum. J. Agee, ed. Olympia, WA, University of Washington: 65-70.

Muir P.S., R.L. Mattingly, J.C. Tappeiner II, J.D. Bailey, W.E. Elliot, J.C. Hagar, J.C. Miller, E.B. Peterson, and E.E. Starkey. 2002. *Managing for biodiversity in young Douglas-fir forests of Western Oregon*. Biological Science Report USGS/BRD/BSR-2002-0006. U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Corvallis, OR. 76 p.

Northwest Environmental Forum. 2006. http://www.nwenvironmentalforum.org/documents/PPEastsideforesthealth.pdf

Oliver, C.D. and B.C. Larson. 1990. *Forest stand dynamics*. McGraw Hill, New York. 419 p.

Oliver, C.D., L.L. Irwin, W.H. Knapp. 1994. East Forest Management Practices: Historical overview, extent of their applications, and their effects on sustainability of ecosystems. Gen. Tech. Rep. PNW-GTR-324. Portland, OR.: USDA Forest Service, Pacific Northwest Research Station. 73 pp.

Omi, P. N. & E. J. Martinson. 2002. Effect of fuels treatment on wildfire severity. Joint Fire Sciences Program Report. 40 p. http://www.cnr.colostate.edu/frws/research/westfire/FinalReport.pdf

Oneil, E. 2005. The economics of forest health in eastern Washington. RTI Fact Sheet 35. Rural Technology Initiative. University of Washington, College of Forest Resources. Seattle, WA.

O'Neil, T. A., K. A. Bettinger, et al. (2001). Structural conditions and habitats of Oregon and Washington. Wildlife-habitat relationships in Oregon and Washington. D. H. Johnson and T. A. O'Neil. Corvallis OR, Oregon State University Press**:** 115-139.

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: p140-148Dec. 2005: p140-148

Perez-Garcia, J.M., J. Edelson, and K. Zobrist. 2000. *New proposed forest practices rules small business economic impact statement*. Washington State Department of Natural Resources, Olympia, WA.

Poage, N.J. & J.C. Tappeiner. (2002). Long-term patterns of diameter and basal area growth of old-growth Douglas-fir trees in Western Oregon. Canadian Journal of Forest Research 32 (7): 1232-1243.

Pyne, S.J. 1997. America's fires: Management on wildlands and forests. Durham, NC: Forest History Society. 54 p.

Reeves, G.H., Hohler, D.B, Larsen, D.P, Busch, D.e, Dratz, K., Reynolds, K., Stein, K.F., Atzet, T., Hays, P., and M. Tehan. 2004. *Effectiveness monitoring for the aquatic and riparian component of the Northwest Forest Plan: conceptual framework and options*. PNW-GTR-557 02-175. http://www.fs.fed.us/pnw/pugs/pnw_gtr577.pdf

Reeves, L.H. 2004. Comparing the value of leave tree buffers with a forest excise tax credit in Washington state. *Western Journal Applied Forestry* 19(3):165-170.

Ripley, Karen, 2006, personal communication with Washington DNR, Forest Health Program Manager

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

Sartwell C. and Stevens, R.E. 1975, Mountain Pine Beetle in Ponderosa Pine – prospects for silvicultural control in second growth stands, Journal of Forestry, 73:136-140.

Sartwell, C., 1971, Thinning ponderosa pine to prevent outbreaks of mountain pine beetle. In David M. Baumgartner (ed.) Pre-commercial thinning of coastal and intermountain forests in the Pacific Northwest, p 41-52, Washington State University Cooperative Extension Service, Pullman, WA.

Schenk, J. A., R. L. Mahoney, J. A. Moore, and D. L. Adams. 1980. A Model for Hazard Rating Lodgepole Pine Stands for Mortality by Mountain Pine-Beetle. Forest Ecology and Management 3:57-68.

Schmid, J.M. and S.A. Mata, 1992, Stand density and mountain pine beetle caused tree mortality in ponderosa pine stands, Research Note RM 515, USDA FS RM For and Rg Exp Stn

Shelton, G., 2004, Washington State Department of Natural Resources Southeast Region, presentation to the Forest Health Strategy Working Group, August 18, 2004, Seattle WA.

Shore, T. L., and L. Safranyik. 1992. Susceptibility and risk rating systems for the mountain pine beetle in lodgepole pine stands. Information Report BC-X-336., Forestry Canada, Pacific Forestry Centre, Victoria, BC.

Suzuki, N. and J.P. Hayes. 2003. Effects of thinning on small mammals in Oregon coastal forests. *Journal of Wildlife Management* 67(2):352-371.

Talbert, C. and D. Marshall. 2005. Plantation productivity in the Douglas-fir region under intensive silvicultural practices: Results from research and operations. *Journal of Forestry* 103(2):65-70.

Tappeiner, J.C., D. Huffman, D. Marshall, T.A. Spies, and J.D. Bailey. 1997. Density, ages, and growth rates in old-growth and young-growth forests in coastal Oregon. *Canadian Journal of Forest Research* 27:638-648.

The White House. 2003. President Bush signs the Healthy Forest Restoration Act into Law. http://www.whitehouse.gov/news/releases/2003/12/20031203-4.html

USDI. 1980. Habitat Evaluation Procedures. 102ESM. Washington DC, USDI Fish and Wildlife Service.

WADNR. 2002. Legislative Report on the Demographics on Non-Industrial Private Forests and Woodlands at http://www.dnr.wa.gov/sflo/publications/legrep02.pdf.

WADNR. 2004. A desirable forest health program for Washington's forests: forest health strategy work group report. Washington Dept. of Natural Resources. Olympia, WA. 63 p.

Western Governors Association. 2001 and 2002. Western Governors Association: A collaborative approach for reducing wildland fire risks to communities and the environment. The 10-Year Comprehensive Strategy Implementation Plan. http://www.westgov.org/

Wilson, J. and 21 others. 2005. Special Issue: CORRIM Reports on Environmental Performance of Wood Building Materials, Wood Fiber Sci. Vol. 37 Dec. 2005

Wilson, S.M. and A.B. Carey. 2000. Legacy retention versus thinning: influences on small mammals. *Northwest Science* 74(2):131-145.

Winistorfer, P., Z. Chen, B. Lippke, and N. Stevens. 2005. Energy Consumption and Greenhouse Gas Emissions Related to the Use, Maintenance and Disposal of a Residential Structure. Wood Fiber Sci. 37 Dec. 2005: p128-139

Zobrist, K. 2003. *Economic impacts of the Forests and Fish Rules on small, NIPF landowners: Ten Western Washington case studies*. RTI Working Paper 1, Revised Edition. Seattle, WA: Rural Technology Initiative, College of Forest Resources, University of Washington. 23 p.

Zobrist, K.W., K.R. Gehringer, and B.R. Lippke. 2005a. 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 Forest Service General Technical Report PNW- GTR-626.

Zobrist, K.W., K.R. Gehringer, and B.R. Lippke. 2004. Templates for Sustainable Riparian Management on Family Forest Ownerships. *Journal of Forestry* 102(7):19-25.

Zobrist, K.W., T.M. Hinckley, M.G. Andreu, K.R. Gehringer, C.W. Hedman, and B.R. Lippke. 2005b. *Templates for Forest Sustainability on Intensively Managed Private Forests*. RTI Working Paper 5. Seattle, WA: Rural Technology Initiative, College of Forest Resources, University of Washington. 106 p.

Appendix A - Westside

Table A-1.1.1: Industrial-West: Base Case Harvest & Inventory

Thinned Volume (Mbf/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	0	0	0	0	0	0	0	0	0	0	0	0
North Puget Sound	215	311	406	449	113	108	69	91	158	49	311	197
South Coast	8,317	37,699	11,453	11,814	5,707	6,056	7,640	5,734	5,001	3,092	19,156	10,251
South Puget Sound	11,398	17,316	24,985	27,255	5,488	12,716	21,787	28,470	14,006	11,699	17,899	17,512
Southwest	6,070	3,209	8,307	6,346	6,985	12,729	5,901	10,275	6,432	9,636	5,862	7,589
Total	26,001	58,534	45,151	45,863	18,292	31,610	35,397	44,570	25,597	24,476	43,229	35,549

Final Harvest Volume (Mbf/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	159,335	122,024	242,683	457,875	358,396	266,550	237,568	160,812	315,260	534,550	174,680	285,505
North Puget Sound	116,957	147,352	113,100	136,053	192,462	95,291	44,615	45,171	61,385	44,220	125,803	99,661
South Coast	292,930	345,241	302,705	283,200	301,594	201,021	148,367	129,400	109,605	121,323	313,625	223,539
South Puget Sound	292,948	159,071	242,578	352,372	466,720	249,708	177,041	258,167	291,709	289,933	231,532	278,025
Southwest	403,099	519,858	539,075	855,391	848,092	487,860	456,920	476,933	588,196	403,392	487,344	557,882
Total	1,265,268	1,293,546	1,440,140	2,084,891	2,167,265	1,300,430	1,064,512	1,070,482	1,366,155	1,393,418	1,332,985	1,444,611

Total Harvest Volume (Mbf/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	159,335	122,024	242,683	457,875	358,396	266,550	237,568	160,812	315,260	534,550	174,680	285,505
North Puget Sound	117,172	147,663	113,506	136,501	192,575	95,399	44,685	45,262	61,543	44,269	126,113	99,857
South Coast	301,247	382,940	314,157	295,014	307,301	207,078	156,007	135,134	114,607	124,415	332,781	233,790
South Puget Sound	304,346	176,387	267,563	379,627	472,207	262,424	198,828	286,637	305,715	301,632	249,432	295,537
Southwest	409,169	523,067	547,382	861,737	855,077	500,589	462,821	487,208	594,628	413,028	493,206	565,471
Total	1,291,269	1,352,080	1,485,290	2,130,754	2,185,557	1,332,040	1,099,909	1,115,052	1,391,751	1,417,894	1,376,213	1,480,160

Standing Volume (Mbf/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	3,515,492	5,561,917	6,506,087	5,289,436	3,756,022	3,495,092	4,041,271	5,704,047	6,807,866	5,401,764	5,194,499	5,007,899
North Puget Sound	2,979,152	2,975,967	3,048,818	2,768,219	1,770,021	1,186,899	1,114,749	1,103,317	923,122	755,563	3,001,312	1,862,583
South Coast	6,440,247	6,016,126	5,063,813	4,368,129	3,308,210	2,679,582	2,418,564	2,170,498	2,025,132	1,649,887	5,840,062	3,614,019
South Puget Sound	3,885,586	4,913,363	5,714,481	5,184,216	3,691,032	3,448,774	4,301,817	4,571,602	3,987,847	3,492,530	4,837,810	4,319,125
Southwest	7,436,461	8,936,050	10,786,401	9,987,240	7,308,667	7,092,299	7,574,215	6,856,832	5,944,688	6,564,218	9,052,971	7,848,707
Total	24,256,938	28,403,421	31,119,601	27,597,240	19,833,952	17,902,645	19,450,616	20,406,296	19,688,655	17,863,962	27,926,653	22,652,333

Standing and Cut Volume (Mbf/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	3,674,826	5,683,940	6,748,770	5,747,311	4,114,418	3,761,641	4,278,838	5,864,859	7,123,126	5,936,314	5,369,179	5,293,404
North Puget Sound	3,096,324	3,123,629	3,162,324	2,904,721	1,962,596	1,282,298	1,159,434	1,148,579	984,664	799,832	3,127,426	1,962,440
South Coast	6,741,494	6,399,066	5,377,970	4,663,143	3,615,512	2,886,660	2,574,571	2,305,631	2,139,739	1,774,302	6,172,843	3,847,809
South Puget Sound	4,189,932	5,089,749	5,982,044	5,563,842	4,163,240	3,711,198	4,500,645	4,858,240	4,293,562	3,794,162	5,087,242	4,614,661
Southwest	7,845,631	9,459,116	11,333,783	10,848,977	8,163,744	7,592,887	8,037,036	7,344,040	6,539,316	6,977,246	9,546,177	8,414,178
Total	25,548,207	29,755,501	32,604,891	29,727,994	22,019,510	19,234,685	20,550,524	21,521,348	21,080,406	19,281,856	29,302,866	24,132,492

Table A-1.1.2: Industrial-West: Base Case Acres

Managed Totals	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	361,271	376,734	392,859	409,675	427,210	445,496	464,564	484,449	505,184	526,808	376,955	439,425
North Puget Sound	436,783	367,587	309,352	260,343	219,099	184,388	155,177	130,593	109,904	92,492	371,241	226,572
South Coast	630,915	544,071	469,181	404,600	348,907	300,881	259,466	223,751	192,952	166,393	548,056	354,112
South Puget Sound	484,473	478,212	472,031	465,931	459,909	453,965	448,098	442,306	436,590	430,947	478,239	457,246
Southwest	930,354	883,092	838,231	795,649	755,230	716,865	680,448	645,881	613,071	581,927	883,893	744,075
Total	2,843,797	2,649,696	2,481,655	2,336,197	2,210,355	2,101,595	2,007,752	1,926,980	1,857,701	1,798,567	2,658,382	2,221,429

Overal Totals	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	432,178	450,676	469,966	490,082	511,059	532,934	555,745	579,532	604,338	630,205	450,940	525,672
North Puget Sound	499,556	420,414	353,811	297,758	250,586	210,888	177,478	149,361	125,699	105,785	424,594	259,134
South Coast	731,432	630,752	543,931	469,060	404,495	348,817	300,804	259,399	223,693	192,902	635,372	410,529
South Puget Sound	553,388	546,236	539,176	532,208	525,329	518,540	511,838	505,223	498,693	492,248	546,267	522,288
Southwest	1,061,870	1,007,927	956,725	908,123	861,991	818,202	776,637	737,184	699,735	664,188	1,008,841	849,258
Total	3,278,424	3,056,006	2,863,609	2,697,232	2,553,461	2,429,380	2,322,501	2,230,699	2,152,158	2,085,329	3,066,013	2,566,880

Unmanaged Totals	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	70,907	73,942	77,107	80,408	83,849	87,438	91,181	95,084	99,153	103,398	73,986	86,247
North Puget Sound	62,772	52,828	44,459	37,415	31,488	26,499	22,301	18,768	15,795	13,293	53,353	32,562
South Coast	100,517	86,681	74,750	64,461	55,588	47,936	41,338	35,648	30,741	26,510	87,316	56,417
South Puget Sound	68,915	68,024	67,145	66,277	65,420	64,575	63,740	62,917	62,103	61,301	68,028	65,042
Southwest	131,516	124,835	118,493	112,474	106,760	101,337	96,189	91,302	86,664	82,262	124,948	105,183
Total	434,627	406,310	381,954	361,034	343,105	327,786	314,749	303,719	294,457	286,762	407,630	345,450
Unmanaged %	13.3%	13.3%	13.3%	13.4%	13.4%	13.5%	13.6%	13.6%	13.7%	13.8%	13.3%	13.5%

Table A-1.1.3: Industrial-West: Base Case Harvest &Volume/acre

Annual Harvest Per Managed Acre (bf/ac/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	441	324	617	1,109	836	595	507	330	620	1,011	461	639
North Puget Sound	264	403	370	536	890	525	297	351	570	486	345	469
South Coast	472	711	669	730	892	700	621	614	600	753	618	676
South Puget Sound	628	369	567	815	1,027	579	445	650	701	700	521	648
Southwest	437	592	654	1,087	1,136	704	688	755	968	712	561	773
Total	451	511	599	916	992	637	553	581	751	790	521	678

Annual Standing and Cut Volume Per Total Acre (bf/ac/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	8,793	12,901	15,894	16,286	11,015	8,543	8,862	10,058	13,968	13,292	12,529	11,961
North Puget Sound	7,086	8,834	10,087	12,229	11,630	7,917	7,520	8,997	10,156	9,470	8,669	9,393
South Coast	10,541	13,077	12,513	12,741	12,400	10,446	10,851	11,043	11,954	12,329	12,044	11,789
South Puget Sound	9,307	10,065	13,110	13,943	11,836	8,569	9,640	11,948	11,502	10,085	10,827	11,000
Southwest	8,549	11,115	13,813	16,352	13,621	10,792	12,951	13,239	12,556	12,817	11,159	12,581
Total	8,927	11,287	13,316	14,781	12,342	9,525	10,557	11,585	12,512	12,095	11,177	11,693

Annual Volume Growth Per Total Acre (bf/ac/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	690	717	497	465	399	453	540	656	609	447	635	547
North Puget Sound	411	435	516	527	376	340	423	447	421	409	454	431
South Coast	704	577	602	592	524	569	593	638	606	591	628	599
South Puget Sound	530	561	711	573	446	495	632	602	555	474	601	558
Southwest	595	702	889	781	566	772	775	696	657	825	729	726
Total	593	623	700	625	480	574	635	643	607	584	639	606

Table A-1.1.4: Industrial-West: Base Case Desired Future Condition Assessment

Total Acres in DFC Target	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	106,357	95,263	74,938	100,948	103,999	75,176	118,207	70,393	77,058	55,538	36,435	56,923	47,184	53,296	65,621	74,503	118,008	41,755	51,863	52,341	56,140
North Puget Sound	127,138	112,744	101,061	70,229	56,065	50,903	53,312	45,384	78,252	36,685	30,647	24,112	20,702	16,524	17,556	20,212	25,453	12,441	13,123	9,752	9,515
South Coast	136,033	84,991	71,028	65,456	74,180	82,289	92,269	62,666	71,850	55,185	32,744	29,540	21,624	28,433	19,765	27,792	34,799	26,875	21,845	11,606	12,901
South Puget Sound	169,866	160,253	133,635	115,992	129,127	103,614	93,845	85,839	109,206	71,950	70,654	71,283	95,733	68,609	77,233	69,095	61,722	73,363	72,356	69,311	88,192
Southwest	299,649	281,198	253,784	173,166	151,777	135,326	158,777	139,202	144,911	109,425	70,654	70,659	60,837	84,521	100,326	79,406	91,376	97,824	92,185	77,333	83,061
Total	839,043	734,449	634,446	525,791	515,147	447,307	516,410	403,484	481,277	328,783	241,133	252,517	246,079	251,382	280,501	271,008	331,358	252,258	251,372	220,344	249,809

Percent Acres in DFC Target	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	25%	22%	17%	22%	22%	16%	24%	14%	15%	11%	7%	11%	9%	9%	11%	13%	20%	7%	8%	8%	9%
North Puget Sound	24%	24%	23%	17%	15%	15%	17%	16%	30%	15%	14%	12%	11%	10%	11%	14%	19%	10%	12%	10%	10%
South Coast	18%	12%	11%	11%	13%	16%	19%	14%	17%	14%	9%	9%	7%	10%	7%	11%	15%	12%	11%	6%	7%
South Puget Sound	31%	29%	24%	21%	24%	19%	18%	16%	21%	14%	14%	14%	19%	13%	15%	14%	12%	15%	15%	14%	18%
Southwest	28%	27%	25%	17%	16%	14%	17%	16%	17%	13%	9%	9%	8%	11%	13%	11%	13%	14%	14%	12%	13%
Total	25%	23%	20%	17%	18%	16%	19%	15%	19%	13%	10%	11%	10%	11%	12%	12%	15%	12%	12%	11%	12%

Table A-1.1.5: Industrial-West: Base Case Habitat Suitability Acres

Northern Flying Squirrel	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Present	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Generally Associated	2,290,810	2,286,136	2,496,343	2,412,348	2,317,760	2,193,799	2,099,692	1,841,671	1,720,669	1,578,201	1,733,721	1,767,373	1,863,962	1,808,857	1,725,590	1,690,531	1,635,248	1,455,275	1,494,841	1,346,545	1,440,909
Closely Associated	129,630	126,935	128,217	132,767	118,564	105,343	102,624	101,499	107,622	106,493	109,746	104,299	105,633	101,107	105,621	107,032	111,786	116,217	123,657	122,622	126,834
Total	2,420,440	2,413,072	2,624,560	2,545,114	2,436,324	2,299,142	2,202,316	1,943,170	1,828,291	1,684,694	1,843,467	1,871,671	1,969,595	1,909,964	1,831,211	1,797,563	1,747,034	1,571,492	1,618,498	1,469,167	1,567,743
North Coast	351,302	346,003	404,750	416,392	399,797	391,341	421,837	339,892	345,275	342,359	425,439	434,776	481,817	472,469	475,821	520,480	531,153	484,298	472,011	445,269	487,972
North Puget Sound	293,074	341,516	351,465	331,553	305,021	272,369	258,057	227,901	193,471	144,803	146,656	136,151	141,337	139,161	132,161	116,007	109,374	86,182	82,899	71,497	71,021
South Coast	582,690	527,312	570,798	506,712	465,565	431,472	390,998	349,393	320,560	281,029	279,213	266,678	264,264	237,759	211,993	204,147	187,909	171,266	159,100	137,663	134,382
South Puget Sound	370,601	394,239	435,719	469,233	450,882	431,768	407,064	388,549	385,189	356,962	367,625	378,364	425,117	429,991	430,112	378,871	381,425	352,068	366,812	341,132	374,096
Southwest	822,773	804,001	861,829	821,224	815,059	772,193	724,359	637,435	583,797	559,542	624,534	655,703	657,060	630,584	581,123	578,058	537,174	477,678	537,677	473,605	500,272
Total	2,420,440	2,413,072	2,624,560	2,545,114	2,436,324	2,299,142	2,202,316	1,943,170	1,828,291	1,684,694	1,843,467	1,871,671	1,969,595	1,909,964	1,831,211	1,797,563	1,747,034	1,571,492	1,618,498	1,469,167	1,567,743

Northern Goshawk	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Present	1,486,696	1,265,115	1,698,856	1,422,458	1,576,020	1,579,212	1,688,808	1,381,732	1,254,331	1,148,092	1,203,781	1,127,710	1,148,914	1,150,321	1,098,664	1,153,619	1,124,811	979,719	1,046,301	899,990	1,009,764
Generally Associated	1,393,375	1,261,299	882,039	797,702	768,841	779,885	768,946	977,747	1,037,669	1,098,747	882,039	778,028	642,644	637,859	682,764	684,722	712,655	837,942	823,311	890,239	772,763
Closely Associated	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2,880,070	2,526,414	2,580,895	2,220,160	2,344,862	2,359,097	2,457,754	2,359,480	2,292,000	2,246,839	2,085,820	1,905,738	1,791,559	1,788,180	1,781,428	1,838,342	1,837,467	1,817,661	1,869,612	1,790,230	1,782,527
North Coast	332,853	317,225	375,383	327,475	361,083	376,264	415,438	416,484	429,612	436,176	455,727	376,532	371,571	372,205	401,844	478,465	497,633	503,367	517,761	577,028	572,665
North Puget Sound	474,164	406,883	368,943	330,080	296,109	290,703	280,840	267,503	253,955	222,341	201,169	181,478	165,654	147,344	137,540	128,920	116,087	105,646	103,851	95,214	86,192
South Coast	549,447	467,324	515,737	406,185	427,065	402,153	411,297	380,078	346,126	310,939	297,351	265,449	227,251	217,299	194,765	201,912	201,002	169,330	162,341	147,981	142,047
South Puget Sound	535,497	479,892	462,321	415,905	429,930	473,061	488,986	478,090	480,600	486,038	432,000	409,333	408,718	405,346	418,883	414,708	438,297	444,088	453,809	417,047	397,885
Southwest	988,109	855,091	858,511	740,515	830,675	816,916	861,193	817,325	781,707	791,344	699,574	672,945	618,365	645,987	628,396	614,336	584,447	595,230	631,850	552,959	583,737
Total	2,880,070	2,526,414	2,580,895	2,220,160	2,344,862	2,359,097	2,457,754	2,359,480	2,292,000	2,246,839	2,085,820	1,905,738	1,791,559	1,788,180	1,781,428	1,838,342	1,837,467	1,817,661	1,869,612	1,790,230	1,782,527

Pacific Jumping Mouse	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Present	743,182	570,132	782,650	462,902	388,443	320,726	361,752	345,070	401,725	507,823	534,525	503,374	415,148	479,353	258,473	351,271	278,330	270,830	384,201	324,344	406,526
Generally Associated	908,794	453,290	335,629	360,651	295,413	392,699	350,420	573,695	492,273	616,649	301,251	411,493	178,200	368,744	212,248	409,857	201,519	503,200	190,352	490,137	375,831
Closely Associated	0	326,376	126,392	95,189	173,402	124,836	180,882	139,532	264,059	216,589	311,270	115,318	197,333	16,952	206,373	0	219,661	57,330	289,815	108,674	238,888
Total	1,651,976	1,349,799	1,244,671	918,742	857,258	838,261	893,054	1,058,297	1,158,056	1,341,061	1,147,046	1,030,186	790,681	865,048	677,095	761,129	699,510	831,360	864,367	923,154	1,021,245
North Coast	155,594	154,759	119,302	79,215	91,285	104,881	111,390	185,349	205,602	247,499	248,127	177,975	142,485	173,117	110,681	144,829	109,755	163,288	195,691	281,583	360,924
North Puget Sound	327,429	262,100	230,648	215,178	170,093	147,797	117,912	128,928	142,457	148,821	125,746	124,498	104,921	92,204	75,529	73,405	59,622	68,950	61,238	59,935	54,468
South Coast	317,756	263,729	246,887	186,663	160,372	155,423	170,671	154,658	151,660	174,189	144,286	132,667	81,913	105,919	72,013	87,662	80,083	71,046	71,640	68,511	88,876
South Puget Sound	308,116	274,011	225,277	167,279	163,005	172,271	191,524	223,248	266,163	301,708	264,220	250,113	213,763	218,765	160,262	192,670	195,308	251,492	259,612	248,812	258,448
Southwest	543,081	395,200	422,557	270,407	272,502	257,889	301,557	366,114	392,174	468,843	364,667	344,933	247,599	275,043	258,610	262,563	254,743	276,584	276,186	264,314	258,529
Total	1,651,976	1,349,799	1,244,671	918,742	857,258	838,261	893,054	1,058,297	1,158,056	1,341,061	1,147,046	1,030,186	790,681	865,048	677,095	761,129	699,510	831,360	864,367	923,154	1,021,245

Red-Tailed Hawk	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Present	1,340,538	1,050,720	1,137,880	786,784	659,396	564,881	630,059	648,763	787,122	864,091	871,365	743,108	732,685	634,677	520,414	645,982	610,862	668,276	577,388	692,111	640,142
Generally Associated	1,192,870	1,310,239	957,186	813,146	813,935	890,134	898,574	1,095,481	1,109,326	1,023,349	809,529	729,194	604,677	643,791	645,436	626,583	684,729	688,939	859,084	719,898	754,328
Closely Associated	18,699	17,154	12,316	5,605	5,341	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2,552,107	2,378,113	2,107,381	1,605,536	1,478,672	1,455,015	1,528,633	1,744,244	1,896,448	1,887,440	1,680,894	1,472,302	1,337,363	1,278,468	1,165,850	1,272,565	1,295,591	1,357,216	1,436,472	1,412,008	1,394,471
North Coast	271,109	308,832	271,588	222,124	235,630	203,608	209,454	307,232	358,410	362,503	375,908	283,559	277,478	270,580	236,862	278,185	344,185	361,011	435,116	450,956	456,363
North Puget Sound	449,273	392,312	330,194	281,526	229,379	209,788	178,942	197,349	214,803	189,894	163,667	150,990	136,950	117,990	100,613	100,272	87,935	90,770	79,495	76,293	67,219
South Coast	540,707	437,237	383,185	273,366	238,107	223,506	267,547	264,725	248,002	249,272	215,971	186,575	147,642	156,643	130,615	132,730	136,074	119,251	123,308	109,802	102,339
South Puget Sound	499,048	450,444	389,496	310,579	311,929	334,156	338,841	368,001	395,417	418,434	358,749	332,209	313,878	305,250	275,052	295,768	308,023	345,682	361,271	342,571	328,160
Southwest	791,970	789,288	732,918	517,941	463,628	483,958	533,849	606,937	679,816	667,338	566,599	518,969	461,414	428,005	422,709	465,610	419,374	440,502	437,282	432,386	440,390
Total	2,552,107	2,378,113	2,107,381	1,605,536	1,478,672	1,455,015	1,528,633	1,744,244	1,896,448	1,887,440	1,680,894	1,472,302	1,337,363	1,278,468	1,165,850	1,272,565	1,295,591	1,357,216	1,436,472	1,412,008	1,394,471

Table A-1.1.6: Industrial-West: Habitat as a Percent of Acres

	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Northern Flying Squirrel	73%	75%	84%	85%	84%	82%	80%	73%	71%	67%	75%	78%	84%	83%	81%	81%	80%	74%	77%	71%	77%
Northern Goshawk	86%	78%	83%	74%	81%	84%	90%	89%	89%	89%	85%	79%	76%	78%	79%	83%	85%	85%	89%	86%	87%
Pacific Jumping Mouse	49%	42%	40%	31%	29%	30%	33%	40%	45%	53%	47%	43%	34%	38%	30%	34%	32%	39%	41%	45%	50%
Red-Tailed Hawk	76%	74%	68%	53%	51%	52%	56%	66%	73%	75%	68%	61%	57%	56%	52%	58%	60%	64%	68%	68%	68%

Table A-1.2.1: Industrial - West: No-conversion Alt Harvest & Inventory

Thinned Volume (Mbf/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	0	0	0	0	0	0	0	0	0	0	0	0
North Puget Sound	231	370	601	774	238	277	208	324	648	238	401	391
South Coast	8,874	46,017	16,394	18,853	10,606	12,912	18,988	16,843	16,994	12,429	23,762	17,891
South Puget Sound	11,461	17,572	25,785	28,382	5,793	13,602	23,634	31,317	15,598	13,208	18,273	18,635
Southwest	6,226	3,466	9,453	7,435	8,619	16,554	8,130	14,969	9,981	15,808	6,381	10,064
Total	26,791	67,425	52,234	55,444	25,256	43,345	50,960	63,453	43,221	41,682	48,817	46,981

Final Harvest Volume (Mbf/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	157,779	115,658	220,646	396,475	298,724	212,757	181,130	118,032	221,463	361,427	164,694	228,409
North Puget Sound	119,918	183,083	167,774	243,343	405,452	238,780	135,117	159,623	258,941	221,018	156,925	213,305
South Coast	299,803	419,373	421,615	459,080	572,992	444,988	387,042	384,859	375,445	480,226	380,263	424,542
South Puget Sound	293,584	161,684	249,934	367,630	493,333	267,617	192,654	284,447	325,162	326,953	235,067	296,300
Southwest	406,002	554,654	606,756	1,017,482	1,061,746	646,648	640,617	696,157	902,129	655,703	522,471	718,789
Total	1,277,086	1,434,452	1,666,725	2,484,011	2,832,247	1,810,790	1,536,559	1,643,118	2,083,140	2,045,326	1,459,421	1,881,345

Total Harvest Volume (Mbf/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	157,779	115,658	220,646	396,475	298,724	212,757	181,130	118,032	221,463	361,427	164,694	228,409
North Puget Sound	120,149	183,453	168,376	244,117	405,690	239,056	135,324	159,947	259,589	221,256	157,326	213,696
South Coast	308,676	465,390	438,009	477,933	583,597	457,900	406,030	401,702	392,439	492,655	404,025	442,433
South Puget Sound	305,045	179,256	275,719	396,013	499,127	281,219	216,288	315,764	340,760	340,160	253,340	314,935
Southwest	412,228	558,120	616,209	1,024,917	1,070,365	663,202	648,747	711,126	912,110	671,510	528,852	728,854
Total	1,303,877	1,501,877	1,718,958	2,539,455	2,857,503	1,854,135	1,587,520	1,706,571	2,126,361	2,087,009	1,508,237	1,928,326

Standing Volume (Mbf/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	3,430,190	5,212,407	5,855,088	4,583,715	3,116,022	2,773,506	3,074,853	4,153,819	4,770,035	3,636,933	4,832,562	4,060,657
North Puget Sound	3,266,033	3,862,232	4,712,093	5,035,534	3,793,572	3,056,337	3,425,455	4,027,253	3,978,620	3,880,662	3,946,786	3,903,779
South Coast	6,987,837	7,478,622	7,322,153	7,322,819	6,399,875	6,055,287	6,311,664	6,590,562	7,120,599	6,704,241	7,262,871	6,829,366
South Puget Sound	3,912,917	5,012,707	5,903,852	5,423,107	3,910,961	3,706,317	4,683,678	5,038,944	4,451,825	3,952,032	4,943,159	4,599,634
Southwest	7,651,797	9,678,281	12,308,473	11,962,804	9,222,502	9,469,109	10,615,225	10,122,702	9,265,261	10,783,060	9,879,517	10,107,921
Total	25,248,774	31,244,249	36,101,659	34,327,979	26,442,931	25,060,557	28,110,874	29,933,279	29,586,339	28,956,928	30,864,894	29,501,357

Standing and Cut Volume (Mbf/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	3,587,969	5,328,065	6,075,734	4,980,190	3,414,746	2,986,264	3,255,982	4,271,852	4,991,498	3,998,360	4,997,256	4,289,066
North Puget Sound	3,386,181	4,045,686	4,880,469	5,279,651	4,199,262	3,295,393	3,560,779	4,187,199	4,238,208	4,101,917	4,104,112	4,117,475
South Coast	7,296,513	7,944,011	7,760,162	7,800,752	6,983,472	6,513,187	6,717,694	6,992,264	7,513,038	7,196,897	7,666,895	7,271,799
South Puget Sound	4,217,962	5,191,963	6,179,571	5,819,120	4,410,087	3,987,536	4,899,966	5,354,707	4,792,585	4,292,192	5,196,499	4,914,569
Southwest	8,064,026	10,236,401	12,924,682	12,987,721	10,292,867	10,132,311	11,263,972	10,833,828	10,177,371	11,454,570	10,408,369	10,836,775
Total	26,552,651	32,746,126	37,820,617	36,867,435	29,300,434	26,914,692	29,698,394	31,639,850	31,712,700	31,043,937	32,373,131	31,429,684

Table A-1.2.2: Industrial - West: No-Conversion Alt Acres

Managed Totals	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	357,485	357,485	357,485	357,485	357,485	357,485	357,485	357,485	357,485	357,485	357,485	357,485
North Puget Sound	455,606	455,606	455,606	455,606	455,606	455,606	455,606	455,606	455,606	455,606	455,606	455,606
South Coast	654,263	654,263	654,263	654,263	654,263	654,263	654,263	654,263	654,263	654,263	654,263	654,263
South Puget Sound	486,049	486,049	486,049	486,049	486,049	486,049	486,049	486,049	486,049	486,049	486,049	486,049
Southwest	942,480	942,480	942,480	942,480	942,480	942,480	942,480	942,480	942,480	942,480	942,480	942,480
Total	2,895,882	2,895,882	2,895,882	2,895,882	2,895,882	2,895,882	2,895,882	2,895,882	2,895,882	2,895,882	2,895,882	2,895,882

Overal Totals	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	427,650	427,650	427,650	427,650	427,650	427,650	427,650	427,650	427,650	427,650	427,650	427,650
North Puget Sound	521,083	521,083	521,083	521,083	521,083	521,083	521,083	521,083	521,083	521,083	521,083	521,083
South Coast	758,499	758,499	758,499	758,499	758,499	758,499	758,499	758,499	758,499	758,499	758,499	758,499
South Puget Sound	555,187	555,187	555,187	555,187	555,187	555,187	555,187	555,187	555,187	555,187	555,187	555,187
Southwest	1,075,710	1,075,710	1,075,710	1,075,710	1,075,710	1,075,710	1,075,710	1,075,710	1,075,710	1,075,710	1,075,710	1,075,710
Total	3,338,130	3,338,130	3,338,130	3,338,130	3,338,130	3,338,130	3,338,130	3,338,130	3,338,130	3,338,130	3,338,130	3,338,130

Unmanaged Totals	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	70,164	70,164	70,164	70,164	70,164	70,164	70,164	70,164	70,164	70,164	70,164	70,164
North Puget Sound	65,477	65,477	65,477	65,477	65,477	65,477	65,477	65,477	65,477	65,477	65,477	65,477
South Coast	104,237	104,237	104,237	104,237	104,237	104,237	104,237	104,237	104,237	104,237	104,237	104,237
South Puget Sound	69,139	69,139	69,139	69,139	69,139	69,139	69,139	69,139	69,139	69,139	69,139	69,139
Southwest	133,230	133,230	133,230	133,230	133,230	133,230	133,230	133,230	133,230	133,230	133,230	133,230
Total	442,247	442,247	442,247	442,247	442,247	442,247	442,247	442,247	442,247	442,247	442,247	442,247
Unmanaged %	13.2%	13.2%	13.2%	13.2%	13.2%	13.2%	13.2%	13.2%	13.2%	13.2%	13.2%	13.2%

Table A-1.2.3: Industrial - West: No-Conversion Alt Harvest &Volume/acre

Annual Harvest Per Managed Acre (bf/ac/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	441	324	617	1,109	836	595	507	330	620	1,011	461	639
North Puget Sound	264	403	370	536	890	525	297	351	570	486	345	469
South Coast	472	711	669	730	892	700	621	614	600	753	618	676
South Puget Sound	628	369	567	815	1,027	579	445	650	701	700	521	648
Southwest	437	592	654	1,087	1,136	704	688	755	968	712	561	773
Total	450	519	594	877	987	640	548	589	734	721	521	666

Annual Standing and Cut Volume Per Total Acre (bf/ac/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	8,793	12,901	15,894	16,286	11,015	8,543	8,862	10,058	13,968	13,292	12,529	11,961
North Puget Sound	7,086	8,834	10,087	12,229	11,630	7,917	7,520	8,997	10,156	9,470	8,669	9,393
South Coast	10,541	13,077	12,513	12,741	12,400	10,446	10,851	11,043	11,954	12,329	12,044	11,789
South Puget Sound	9,307	10,065	13,110	13,943	11,836	8,569	9,640	11,948	11,502	10,085	10,827	11,000
Southwest	8,549	11,115	13,813	16,352	13,621	10,792	12,951	13,239	12,556	12,817	11,159	12,581
Total	8,931	11,259	13,086	14,479	12,402	9,607	10,552	11,456	12,050	11,790	11,092	11,561

Annual Volume Growth Per Total Acre (bf/ac/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	690	717	497	465	399	453	540	656	609	447	635	547
North Puget Sound	411	435	516	527	376	340	423	447	421	409	454	431
South Coast	704	577	602	592	524	569	593	638	606	591	628	599
South Puget Sound	530	561	711	573	446	495	632	602	555	474	601	558
Southwest	595	702	889	781	566	772	775	696	657	825	729	726
Total	592	611	686	623	486	571	625	623	585	600	630	600

Table A-1.2.4: Industrial - West: No-Conversion Alt Desired Future Condition Assessment

Total Acres in DFC Target	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	106,357	93,288	71,862	94,797	95,637	67,697	104,241	60,789	65,164	45,992	29,546	45,204	36,693	40,586	48,936	54,408	84,391	29,241	35,566	35,150	36,919
North Puget Sound	127,138	122,899	120,085	90,966	79,159	78,344	89,442	83,000	155,998	79,720	72,596	62,260	58,270	50,699	58,719	73,691	101,157	53,897	61,971	50,202	53,389
South Coast	136,033	91,523	82,366	81,737	99,750	119,160	143,880	105,228	129,924	107,459	68,661	66,702	52,580	74,451	55,732	84,388	113,786	94,631	82,831	47,390	56,726
South Puget Sound	169,866	161,298	135,385	118,277	132,531	107,039	97,580	89,838	115,039	76,288	75,402	76,570	103,504	74,662	84,595	76,175	68,491	81,940	81,343	78,428	100,444
Southwest	299,649	288,625	267,366	187,252	168,457	154,165	185,658	167,069	178,513	138,358	91,696	94,124	83,181	118,614	144,514	117,400	138,665	152,371	147,381	126,902	139,901
Total	839,043	757,633	677,063	573,030	575,534	526,405	620,801	505,923	644,638	447,817	337,901	344,861	334,228	359,013	392,496	406,063	506,491	412,080	409,092	338,071	387,380

Percent Acres in DFC Target	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	25%	22%	17%	22%	22%	16%	24%	14%	15%	11%	7%	11%	9%	9%	11%	13%	20%	7%	8%	8%	9%
North Puget Sound	24%	24%	23%	17%	15%	15%	17%	16%	30%	15%	14%	12%	11%	10%	11%	14%	19%	10%	12%	10%	10%
South Coast	18%	12%	11%	11%	13%	16%	19%	14%	17%	14%	9%	9%	7%	10%	7%	11%	15%	12%	11%	6%	7%
South Puget Sound	31%	29%	24%	21%	24%	19%	18%	16%	21%	14%	14%	14%	19%	13%	15%	14%	12%	15%	15%	14%	18%
Southwest	28%	27%	25%	17%	16%	14%	17%	16%	17%	13%	9%	9%	8%	11%	13%	11%	13%	14%	14%	12%	13%
Total	25%	23%	20%	17%	17%	16%	19%	15%	19%	13%	10%	10%	10%	11%	12%	12%	15%	12%	12%	10%	12%

Table A-1.2.5: Industrial - West: No Conversion Alt Habitat Suitability Acres

Northern Flying Squirrel	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Present	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Generally Associated	2,290,810	2,371,467	2,683,030	2,677,649	2,660,276	2,598,284	2,561,504	2,343,169	2,242,377	2,092,413	2,336,249	2,436,610	2,627,291	2,617,604	2,548,194	2,538,054	2,504,035	2,281,666	2,406,430	2,204,722	2,377,747
Closely Associated	129,630	129,523	134,018	142,078	131,497	123,862	123,404	125,529	139,885	138,975	144,496	142,273	145,810	144,622	154,623	157,209	163,345	171,156	183,986	187,620	201,230

Northern Flying Squirrel	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	351,302	338,828	388,136	391,021	367,651	352,411	371,996	293,517	291,982	283,512	345,006	345,266	374,687	359,799	354,837	380,091	379,841	339,152	323,692	299,021	320,902
North Puget Sound	293,074	372,276	417,627	429,450	430,669	419,203	432,948	416,792	385,694	314,672	347,403	351,567	397,827	426,984	442,029	422,947	434,677	373,357	391,479	368,047	398,521
South Coast	582,690	567,839	661,908	632,752	626,053	624,800	609,706	586,701	579,655	547,229	585,478	602,173	642,582	622,566	597,762	619,879	614,425	603,047	603,263	562,097	590,873
South Puget Sound	370,601	396,812	441,424	478,479	462,766	446,040	423,264	406,649	405,762	378,482	392,331	406,426	459,627	467,930	471,116	417,698	423,258	393,230	412,372	386,005	426,067
Southwest	822,773	825,235	907,953	888,024	904,635	879,693	846,995	765,039	719,169	707,494	810,527	873,452	898,377	884,947	837,073	854,649	815,178	744,036	859,610	777,173	842,614
Total	2,420,440	2,500,989	2,817,048	2,819,727	2,791,773	2,722,147	2,684,908	2,468,698	2,382,262	2,231,388	2,480,745	2,578,884	2,773,101	2,762,226	2,702,817	2,695,264	2,667,380	2,452,822	2,590,416	2,392,343	2,578,977

Northern Goshawk	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Present	1,486,696	1,307,510	1,818,868	1,576,134	1,803,560	1,865,907	2,054,677	1,760,153	1,642,976	1,519,174	1,627,519	1,610,367	1,667,286	1,719,859	1,659,397	1,757,705	1,748,984	1,526,347	1,747,620	1,461,592	1,708,359
Generally Associated	1,393,375	1,310,604	950,392	891,001	884,085	922,032	939,647	1,208,252	1,321,722	1,446,599	1,211,040	1,092,766	927,892	932,342	1,013,457	1,040,316	1,098,765	1,303,211	1,233,765	1,399,570	1,212,826
Closely Associated	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Northern Goshawk	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	332,853	310,646	359,975	307,521	332,050	338,834	366,353	359,659	363,302	361,203	369,567	299,013	288,954	283,444	299,670	349,409	355,870	352,506	355,066	387,504	376,599
North Puget Sound	474,164	443,530	438,395	427,543	418,085	447,421	471,171	489,218	506,271	483,170	476,533	468,610	466,276	452,090	460,017	470,025	461,355	457,677	490,423	490,133	483,655
South Coast	549,447	503,241	598,058	507,220	574,281	582,343	641,359	638,227	625,885	605,472	623,512	599,398	552,582	568,992	549,183	613,093	657,238	596,229	615,553	604,229	624,576
South Puget Sound	535,497	483,024	468,374	424,100	441,262	488,699	508,446	500,361	506,270	515,339	461,032	439,693	441,896	441,110	458,817	457,208	486,368	496,009	510,174	471,906	453,161
Southwest	988,109	877,674	904,457	800,750	921,967	930,643	1,006,995	980,941	962,971	1,000,588	907,914	896,421	845,470	906,564	905,167	908,286	886,918	927,137	1,010,169	907,390	983,195
Total	2,880,070	2,618,114	2,769,260	2,467,135	2,687,645	2,787,940	2,994,324	2,968,405	2,964,699	2,965,773	2,838,560	2,703,134	2,595,178	2,652,201	2,672,854	2,798,021	2,847,749	2,829,558	2,981,385	2,861,162	2,921,185

Pacific Jumping Mouse	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Present	743,182	593,144	850,613	534,575	466,757	405,139	463,107	461,551	542,109	675,897	701,881	733,658	612,313	742,620	453,331	599,693	512,236	491,993	683,103	549,229	691,127
Generally Associated	908,794	472,295	363,277	408,195	336,587	467,403	430,802	688,712	644,361	815,519	428,030	592,629	274,236	542,607	331,475	640,484	321,428	796,522	297,237	779,629	625,093
Closely Associated	0	337,251	134,275	106,404	206,168	146,198	220,038	178,338	309,125	288,842	426,973	164,235	288,411	30,915	301,456	0	346,940	86,404	448,095	163,777	347,350

Pacific Jumping Mouse	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	155,594	151,550	114,405	74,388	83,945	94,448	98,229	160,060	173,867	204,957	201,216	141,334	110,804	131,834	82,539	105,764	78,489	114,350	134,200	189,098	237,353
North Puget Sound	327,429	285,706	274,067	278,713	240,160	227,474	197,823	235,788	283,995	323,403	297,871	321,477	295,328	282,905	252,614	267,623	236,953	298,703	289,188	308,525	305,639
South Coast	317,756	283,998	286,295	233,094	215,654	225,063	266,137	259,703	274,241	339,186	302,552	299,568	199,178	277,346	203,056	266,180	261,854	250,160	271,638	279,738	390,782
South Puget Sound	308,116	275,799	228,227	170,575	167,302	177,966	199,146	233,647	280,380	319,897	281,976	268,663	231,115	238,067	175,540	212,415	216,728	280,895	291,857	281,541	294,353
Southwest	543,081	405,638	445,172	292,403	302,451	293,791	352,611	439,404	483,112	592,813	473,269	459,481	338,534	385,990	372,512	388,196	386,580	430,811	441,552	433,732	435,444
Total	1,651,976	1,402,690	1,348,165	1,049,173	1,009,512	1,018,741	1,113,947	1,328,601	1,495,595	1,780,257	1,556,884	1,490,523	1,174,959	1,316,142	1,086,262	1,240,178	1,180,604	1,374,919	1,428,435	1,492,634	1,663,570

Red-Tailed Hawk	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Present	1,340,538	1,092,151	1,225,539	882,248	758,927	678,664	788,983	816,483	1,016,644	1,127,798	1,151,116	1,070,223	1,067,878	981,470	834,345	1,045,661	945,266	1,084,694	961,233	1,119,983	1,030,390
Generally Associated	1,192,870	1,353,582	1,023,707	903,109	930,725	1,047,758	1,089,696	1,367,853	1,417,107	1,357,898	1,112,486	1,014,296	862,624	929,610	957,262	940,569	1,073,499	1,053,477	1,285,357	1,121,095	1,212,397
Closely Associated	18,699	18,699	14,634	6,018	5,815	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Red-Tailed Hawk	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	271,109	302,428	260,440	208,590	216,683	183,353	184,706	265,314	303,090	300,193	304,839	225,181	215,782	206,054	176,636	203,150	246,136	252,814	298,391	302,840	300,116
North Puget Sound	449,273	427,646	392,352	364,652	323,867	322,884	300,215	360,918	428,220	412,659	387,698	389,883	385,480	362,024	336,514	365,579	349,476	393,232	375,404	392,736	377,189
South Coast	540,707	470,841	444,349	341,363	320,186	323,651	417,202	444,527	448,452	485,392	452,869	421,295	359,006	410,165	368,297	403,026	444,934	419,896	467,549	448,335	449,979
South Puget Sound	499,048	453,383	394,596	316,698	320,151	345,202	352,326	385,143	416,537	443,659	382,859	356,848	339,358	332,184	301,274	326,079	341,806	386,098	406,142	387,633	373,750
Southwest	791,970	810,134	772,143	560,071	514,581	551,332	624,231	728,436	837,452	843,792	735,338	691,311	630,877	600,653	608,887	688,397	636,413	686,130	699,104	709,534	741,753
Total	2,552,107	2,464,432	2,263,880	1,791,375	1,695,468	1,726,423	1,878,679	2,184,337	2,433,751	2,485,696	2,263,602	2,084,519	1,930,502	1,911,080	1,791,608	1,986,230	2,018,765	2,138,171	2,246,590	2,241,078	2,242,787

Table A-1.2.6: Industrial - West: No Conversion Loss Habitat as a Percent of Acres

Total Habitat as a % of Total Acres	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Northern Flying Squirrel	73%	75%	84%	84%	84%	82%	80%	74%	71%	67%	74%	77%	83%	83%	81%	81%	80%	73%	78%	72%	77%
Northern Goshawk	86%	78%	83%	74%	81%	84%	90%	89%	89%	89%	85%	81%	78%	79%	80%	84%	85%	85%	89%	86%	88%
Pacific Jumping Mouse	49%	42%	40%	31%	30%	31%	33%	40%	45%	53%	47%	45%	35%	39%	33%	37%	35%	41%	43%	45%	50%
Red-Tailed Hawk	76%	74%	68%	54%	51%	52%	56%	65%	73%	74%	68%	62%	58%	57%	54%	60%	60%	64%	67%	67%	67%

Table A-1.3.1: Industrial - West: Riparian Alt Harvest & Inventory

Thinned Volume (Mbf/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	34,811	164,042	144,372	210,767	179,411	129,094	70,075	23,447	8,623	18,191	114,408	98,283
North Puget Sound	1,584	3,822	3,673	3,948	2,333	2,415	626	516	232	107	3,026	1,926
South Coast	10,922	43,741	15,830	17,297	8,702	8,437	8,918	6,013	5,146	3,265	23,498	12,827
South Puget Sound	13,111	21,147	27,808	33,530	8,822	17,235	23,056	29,533	14,261	12,264	20,689	20,077
Southwest	8,087	9,417	18,465	15,087	18,543	18,548	8,813	11,350	6,779	10,136	11,989	12,522
Total	37,186	94,531	80,213	90,939	56,341	59,544	48,420	49,757	27,280	27,591	70,643	57,180

Final Harvest Volume (Mbf/yr	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	160,402	124,253	243,294	459,668	361,159	281,060	261,168	170,570	362,752	569,487	175,983	299,381
North Puget Sound	118,295	147,386	113,254	136,406	193,149	96,649	46,348	47,976	62,584	46,805	126,312	100,885
South Coast	299,016	345,401	302,868	283,810	302,613	203,213	151,559	133,616	112,571	123,367	315,761	225,803
South Puget Sound	293,446	159,873	242,994	352,985	470,342	253,214	179,172	263,610	300,081	297,533	232,104	281,325
Southwest	403,605	520,107	539,402	856,422	850,453	492,500	465,789	491,536	599,149	414,374	487,705	563,334
Total	1,274,764	1,297,019	1,441,812	2,089,291	2,177,715	1,326,637	1,104,036	1,107,309	1,437,137	1,451,567	1,337,865	1,470,729

Total Harvest Volume (Mbf/yr	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	163,883	140,657	257,732	480,744	379,100	293,969	268,175	172,915	363,614	571,306	187,424	309,210
North Puget Sound	119,880	151,208	116,927	140,354	195,482	99,064	46,974	48,493	62,816	46,913	129,338	102,811
South Coast	309,938	389,142	318,697	301,107	311,314	211,651	160,477	139,628	117,717	126,632	339,259	238,630
South Puget Sound	306,557	181,020	270,802	386,515	479,164	270,449	202,228	293,143	314,343	309,796	252,793	301,402
Southwest	411,692	529,524	557,866	871,509	868,996	511,048	474,601	502,886	605,928	424,510	499,694	575,856
Total	1,311,950	1,391,551	1,522,025	2,180,230	2,234,056	1,386,181	1,152,456	1,157,065	1,464,417	1,479,158	1,408,508	1,527,909

Standing Volume (Mbf/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	3,835,998	6,075,647	7,147,242	6,019,697	4,573,424	4,385,195	4,982,490	6,694,474	7,744,032	6,313,493	5,686,296	5,777,169
North Puget Sound	3,075,538	3,087,555	3,177,911	2,900,229	1,892,315	1,293,784	1,209,206	1,183,003	990,345	808,552	3,113,668	1,961,844
South Coast	6,680,138	6,266,698	5,309,062	4,603,010	3,532,929	2,887,649	2,597,765	2,316,870	2,149,039	1,759,966	6,085,299	3,810,312
South Puget Sound	3,980,043	5,037,377	5,867,885	5,339,451	3,835,568	3,602,934	4,466,552	4,721,856	4,115,704	3,609,646	4,961,768	4,457,702
Southwest	7,597,007	9,152,518	11,054,890	10,274,619	7,584,036	7,375,442	7,848,360	7,082,871	6,127,448	6,730,956	9,268,138	8,082,815
Total	25,168,724	29,619,795	32,556,990	29,137,006	21,418,272	19,545,003	21,104,374	21,999,073	21,126,568	19,222,612	29,115,170	24,089,842

Standing and Cut Volume (Mb	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	3,999,881	6,216,304	7,404,974	6,500,441	4,952,524	4,679,164	5,250,665	6,867,390	8,107,646	6,884,799	5,873,720	6,086,379
North Puget Sound	3,195,418	3,238,763	3,294,838	3,040,583	2,087,797	1,392,848	1,256,181	1,231,496	1,053,161	855,464	3,243,006	2,064,655
South Coast	6,990,076	6,655,840	5,627,759	4,904,117	3,844,243	3,099,300	2,758,242	2,456,498	2,266,756	1,886,598	6,424,558	4,048,943
South Puget Sound	4,286,600	5,218,397	6,138,687	5,725,966	4,314,732	3,873,383	4,668,780	5,014,999	4,430,046	3,919,443	5,214,561	4,759,103
Southwest	8,008,699	9,682,041	11,612,756	11,146,128	8,453,032	7,886,490	8,322,962	7,585,757	6,733,375	7,155,466	9,767,832	8,658,671
Total	26,480,674	31,011,346	34,079,014	31,317,235	23,652,327	20,931,184	22,256,830	23,156,139	22,590,985	20,701,770	30,523,678	25,617,751

Table A-1.3.2: Industrial - West: Riparian Alt Acres

Managed Totals	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	385,753	402,265	419,483	437,438	456,161	475,686	496,047	517,279	539,420	562,509	402,500	469,204
North Puget Sound	449,650	378,415	318,465	268,012	225,553	189,820	159,748	134,440	113,141	95,217	382,177	233,246
South Coast	643,764	555,151	478,736	412,839	356,013	307,009	264,750	228,308	196,882	169,781	559,217	361,323
South Puget Sound	492,919	486,548	480,260	474,053	467,926	461,879	455,909	450,017	444,201	438,460	486,576	465,217
Southwest	947,374	899,247	853,566	810,205	769,046	729,979	692,896	657,697	624,286	592,572	900,062	757,687
Total	2,919,460	2,721,626	2,550,509	2,402,547	2,274,699	2,164,372	2,069,349	1,987,740	1,917,930	1,858,539	2,730,532	2,286,677

Overal Totals	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	432,178	450,676	469,966	490,082	511,059	532,934	555,745	579,532	604,338	630,205	450,940	525,672
North Puget Sound	499,556	420,414	353,811	297,758	250,586	210,888	177,478	149,361	125,699	105,785	424,594	259,134
South Coast	731,432	630,752	543,931	469,060	404,495	348,817	300,804	259,399	223,693	192,902	635,372	410,529
South Puget Sound	553,388	546,236	539,176	532,208	525,329	518,540	511,838	505,223	498,693	492,248	546,267	522,288
Southwest	1,061,870	1,007,927	956,725	908,123	861,991	818,202	776,637	737,184	699,735	664,188	1,008,841	849,258
Total	3,278,424	3,056,006	2,863,609	2,697,232	2,553,461	2,429,380	2,322,501	2,230,699	2,152,158	2,085,329	3,066,013	2,566,880

Unmanaged Totals	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	46,425	48,412	50,484	52,645	54,898	57,248	59,698	62,253	64,918	67,697	48,440	56,468
North Puget Sound	49,906	41,999	35,346	29,746	25,034	21,068	17,730	14,921	12,557	10,568	42,417	25,887
South Coast	87,668	75,601	65,195	56,221	48,482	41,809	36,054	31,091	26,812	23,121	76,155	49,205
South Puget Sound	60,469	59,688	58,916	58,155	57,403	56,661	55,929	55,206	54,493	53,788	59,691	57,071
Southwest	114,496	108,680	103,159	97,919	92,944	88,223	83,741	79,487	75,449	71,616	108,778	91,571
Total	358,964	334,380	313,099	294,685	278,761	265,008	253,152	242,959	234,228	226,790	335,481	280,203
Unmanaged %	10.9%	10.9%	10.9%	10.9%	10.9%	10.9%	10.9%	10.9%	10.9%	10.9%	10.9%	10.9%

Table A-1.3.3: Industrial - West: Riparian Alt Harvest &Volume/acre

Annual Harvest Per Managed Acre (bf/ac/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	425	349	614	1,091	828	615	536	333	670	1,013	463	647
North Puget Sound	262	400	370	535	878	529	303	365	565	500	344	471
South Coast	476	709	666	731	886	701	625	621	603	751	617	677
South Puget Sound	621	372	564	815	1,024	586	445	653	708	706	519	650
Southwest	432	589	654	1,080	1,133	705	693	765	968	719	558	774
Total	447	512	598	912	985	644	562	584	765	797	519	681

Annual Standing and Cut Volume Per Total Acre (bf/ac/y	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	9,457	14,170	17,344	17,968	12,765	10,446	10,799	11,901	15,962	15,008	13,657	13,582
North Puget Sound	7,302	9,129	10,494	12,741	12,189	8,526	8,138	9,663	10,765	10,130	8,975	9,908
South Coast	10,921	13,527	13,011	13,310	13,014	11,124	11,549	11,726	12,593	12,971	12,486	12,375
South Puget Sound	9,479	10,324	13,412	14,307	12,175	8,930	9,997	12,331	11,854	10,412	11,072	11,322
Southwest	8,701	11,345	14,140	16,721	14,022	11,193	13,400	13,671	12,915	13,156	11,395	12,926
Total	9,211	11,731	13,866	15,439	13,049	10,306	11,387	12,417	13,372	12,892	11,603	12,367

Annual Volume Growth Per Total Acre (bf/ac/yr)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	755	788	550	524	452	515	586	706	661	479	698	602
North Puget Sound	425	451	541	543	397	356	444	461	435	428	472	448
South Coast	727	593	619	609	542	586	607	653	615	602	646	615
South Puget Sound	543	573	727	583	463	511	642	614	567	487	614	571
Southwest	606	716	908	795	584	793	789	706	672	840	743	741
Total	615	647	726	649	507	604	658	668	634	605	663	631

Table A-1.3.4: Industrial - West: Riparian Alt Acres In DFC

Total Acres in DFC Target	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	106,307	95,860	74,877	100,707	108,437	79,427	120,727	73,930	81,028	61,712	50,244	68,105	58,090	62,790	72,269	79,195	115,388	39,018	49,997	49,094	52,340
North Puget Sound	126,988	112,727	101,437	70,711	56,206	51,660	54,353	46,294	78,608	36,983	31,373	24,775	21,758	17,454	18,015	20,930	26,012	12,774	13,453	9,706	9,486
South Coast	135,980	84,981	71,509	66,963	75,557	83,725	93,054	65,765	73,580	57,751	35,448	32,300	24,331	31,077	22,143	29,450	35,878	27,908	22,744	12,200	13,290
South Puget Sound	169,782	160,313	133,197	116,092	129,447	104,143	95,658	87,841	110,407	73,423	72,984	73,129	97,140	69,871	77,766	69,064	60,355	72,123	71,474	69,042	88,446
Southwest	299,738	281,729	254,560	173,944	153,025	139,516	162,984	144,836	149,964	115,604	74,874	75,488	64,788	88,358	103,697	81,891	93,311	98,321	92,678	77,518	82,798
Total	838,795	735,611	635,580	528,417	522,672	458,471	526,776	418,666	493,588	345,472	264,922	273,797	266,106	269,549	293,890	280,531	330,945	250,145	250,346	217,559	246,361

Percent Acres in DFC Target	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	25%	22%	17%	22%	23%	17%	25%	15%	16%	12%	10%	13%	11%	11%	13%	14%	19%	6%	8%	8%	8%
North Puget Sound	24%	24%	23%	18%	15%	15%	17%	16%	30%	15%	14%	12%	12%	10%	12%	15%	20%	11%	12%	10%	10%
South Coast	18%	12%	11%	11%	13%	16%	19%	15%	18%	15%	10%	10%	8%	11%	8%	12%	15%	13%	11%	7%	8%
South Puget Sound	31%	29%	24%	21%	24%	19%	18%	17%	21%	14%	14%	14%	19%	14%	15%	14%	12%	15%	14%	14%	18%
Southwest	28%	27%	25%	17%	16%	15%	18%	16%	17%	14%	9%	9%	8%	12%	14%	11%	13%	14%	14%	12%	13%
Total	25%	23%	20%	18%	18%	16%	19%	16%	19%	14%	11%	11%	11%	12%	13%	13%	15%	12%	12%	10%	12%

Table A-1.3.5: Industrial - West: Riparian Alt Habitat Suitability Acres

Northern Flying Squirre	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Present	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Generally Associated	2,291,114	2,288,101	2,497,492	2,411,145	2,319,249	2,190,366	2,092,396	1,826,858	1,711,794	1,559,228	1,705,464	1,746,047	1,842,444	1,787,347	1,706,160	1,669,892	1,614,883	1,442,561	1,486,721	1,347,652	1,446,435
Closely Associated	128,638	122,875	124,491	129,557	114,520	105,532	106,813	106,424	113,985	117,990	129,197	118,582	120,637	116,830	118,911	122,649	122,461	118,715	119,384	112,180	113,243

Northern Flying Squirre	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	351,074	345,373	404,156	414,991	398,722	391,065	421,547	334,597	344,941	339,294	421,805	431,736	478,809	469,755	473,454	519,010	525,346	477,606	463,469	439,659	483,473
North Puget Sound	292,881	341,239	350,999	330,026	304,273	271,039	256,683	226,167	192,097	143,663	144,945	134,733	139,846	138,514	131,559	115,153	108,705	85,892	82,506	71,080	70,528
South Coast	582,412	526,322	569,935	506,327	465,313	430,955	390,328	348,085	320,163	280,498	278,696	265,834	263,693	237,252	211,391	203,503	187,096	170,693	158,624	137,240	134,008
South Puget Sound	370,466	393,982	435,278	468,357	450,334	430,905	406,354	387,140	384,662	356,184	366,006	376,985	424,363	429,592	429,466	378,113	380,165	350,790	365,724	340,267	372,910
Southwest	822,918	804,060	861,615	821,000	815,127	771,933	724,298	637,292	583,916	557,578	623,210	655,340	656,370	629,065	579,201	576,762	536,031	476,295	535,780	471,585	498,760
Total	2,419,751	2,410,976	2,621,983	2,540,702	2,433,769	2,295,898	2,199,210	1,933,282	1,825,779	1,677,217	1,834,661	1,864,629	1,963,081	1,904,177	1,825,071	1,792,542	1,737,344	1,561,276	1,606,104	1,459,832	1,559,678

Northern Goshawk	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Present	1,486,949	1,267,844	1,702,602	1,425,613	1,578,698	1,580,709	1,687,291	1,379,540	1,248,543	1,143,617	1,194,566	1,123,759	1,138,051	1,140,731	1,092,217	1,147,814	1,118,549	977,867	1,048,994	911,351	1,025,030
Generally Associated	1,392,985	1,258,801	878,506	794,515	765,610	778,238	769,949	979,261	1,042,805	1,102,914	890,942	781,469	652,947	646,109	687,075	687,685	714,528	835,544	816,455	875,967	750,219
Closely Associated	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Northern Goshawk	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	332,667	317,014	375,117	327,185	360,839	375,901	414,797	415,922	429,034	435,872	455,411	376,161	371,207	371,458	400,394	476,627	494,174	500,624	515,242	575,595	567,384
North Puget Sound	474,237	406,952	369,224	330,340	296,290	291,509	281,576	267,495	253,987	222,367	201,192	181,498	165,670	147,313	137,515	128,829	116,006	105,499	103,654	94,942	85,978
South Coast	549,231	467,530	515,527	406,001	426,408	401,541	410,711	379,885	345,946	310,769	297,191	265,282	227,086	217,099	194,506	201,596	200,680	169,030	161,772	147,453	141,457
South Puget Sound	535,499	479,894	462,568	415,907	429,932	472,979	488,855	478,042	480,550	486,028	431,992	409,196	408,551	405,019	418,518	414,478	438,221	443,743	453,471	416,880	397,173
Southwest	988,301	855,255	858,673	740,696	830,840	817,017	861,301	817,458	781,831	791,494	699,722	673,091	618,483	645,952	628,358	613,969	583,995	594,515	631,310	552,448	583,256
Total	2,879,934	2,526,644	2,581,109	2,220,128	2,344,308	2,358,948	2,457,240	2,358,801	2,291,348	2,246,531	2,085,508	1,905,228	1,790,998	1,786,841	1,779,292	1,835,499	1,833,076	1,813,411	1,865,449	1,787,318	1,775,249

Pacific Jumping Mouse	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Present	744,858	572,275	785,734	471,392	399,786	326,533	370,416	349,101	403,814	508,808	535,440	503,753	416,725	480,666	260,889	353,999	280,931	273,403	388,970	333,545	415,090
Generally Associated	909,135	454,067	336,489	362,673	296,417	394,532	351,319	574,868	493,223	617,563	302,295	413,251	181,009	370,595	215,533	411,612	209,189	506,623	199,789	494,314	339,618
Closely Associated	0	326,656	127,022	95,543	173,403	124,847	180,897	139,568	264,106	216,820	311,622	116,314	198,469	19,400	207,670	2,370	221,026	63,835	292,348	113,532	239,610

Pacific Jumping Mouse	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	157,213	155,441	119,856	84,942	98,174	106,906	113,512	185,850	206,094	247,751	248,751	179,221	145,021	176,253	113,794	147,566	115,394	170,480	206,006	293,381	345,202
North Puget Sound	327,686	262,389	231,710	216,382	170,793	149,300	120,558	130,951	144,031	149,919	126,295	125,141	105,615	92,910	76,295	74,239	60,571	69,737	62,120	60,582	53,401
South Coast	317,652	264,602	247,923	189,119	161,990	156,764	171,861	155,011	152,001	174,514	144,575	132,950	82,298	106,347	72,626	88,394	81,120	71,935	72,346	69,255	86,647
South Puget Sound	308,202	274,814	226,372	168,404	164,058	172,877	191,822	223,856	266,770	302,102	264,787	250,652	214,664	219,247	161,028	193,590	197,240	253,275	261,452	250,988	254,906
Southwest	543,240	395,751	423,383	270,761	274,591	260,064	304,879	367,869	392,247	468,904	364,950	345,354	248,605	275,904	260,350	264,191	256,821	278,433	279,182	267,185	254,162
Total	1,653,993	1,352,998	1,249,245	929,609	869,607	845,912	902,632	1,063,537	1,161,143	1,343,191	1,149,357	1,033,317	796,204	870,662	684,093	767,980	711,146	843,861	881,107	941,391	994,318

Red-Tailed Hawk	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Present	1,340,465	1,057,532	1,143,125	789,683	659,774	578,241	630,060	649,609	791,835	855,378	858,889	736,616	721,175	622,526	509,790	631,864	599,496	662,223	574,932	694,385	637,302
Generally Associated	1,192,873	1,303,269	953,547	810,763	819,132	886,075	910,329	1,089,519	1,107,352	1,028,373	817,676	733,104	615,100	655,246	654,325	637,196	691,376	688,709	855,692	710,418	746,379
Closely Associated	18,746	17,951	13,071	8,490	5,734	1,815	1,512	8,720	878	5,775	5,764	3,251	1,609	0	79	303	164	0	130	0	391

Red-Tailed Hawk	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
North Coast	271,082	308,632	271,581	222,099	237,227	209,963	215,986	307,066	357,997	362,651	375,678	282,867	277,106	269,813	235,339	275,882	340,237	356,855	431,266	446,718	448,383
North Puget Sound	449,346	392,381	331,097	282,585	229,869	211,079	181,579	199,391	216,767	191,417	164,648	151,782	137,627	118,354	100,952	100,510	88,171	90,646	79,329	75,923	66,987
South Coast	540,496	437,456	383,608	274,799	239,251	224,504	268,646	265,052	248,490	248,942	216,179	186,748	147,678	156,618	130,349	132,399	135,696	118,785	122,593	109,125	101,671
South Puget Sound	499,050	450,852	390,147	311,119	312,540	334,389	338,464	367,540	395,637	418,850	359,165	332,464	313,941	305,019	274,898	295,488	308,017	345,389	361,049	341,963	327,448
Southwest	792,110	789,431	733,309	518,335	465,753	486,195	537,226	608,800	681,173	667,666	566,660	519,109	461,532	427,968	422,657	465,083	418,914	439,256	436,517	431,074	439,582
Total	2,552,084	2,378,752	2,109,743	1,608,937	1,484,640	1,466,131	1,541,902	1,747,848	1,900,065	1,889,526	1,682,329	1,472,970	1,337,884	1,277,772	1,164,194	1,269,362	1,291,036	1,350,931	1,430,754	1,404,803	1,384,071

Table A-1.3.6: Industrial - West: Riparian Alt Habitat as a Percent of Acres

Total Habitat as a Percent of Total Acres	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059	2064	2069	2074	2079	2084	2089	2094	2099	2104
Northern Flying Squirrel	72%	75%	84%	85%	84%	81%	80%	73%	71%	67%	75%	78%	84%	83%	81%	81%	80%	73%	76%	71%	76%
Northern Goshawk	86%	78%	83%	74%	81%	84%	90%	89%	89%	89%	85%	79%	76%	78%	79%	83%	84%	85%	89%	86%	87%
Pacific Jumping Mouse	50%	42%	40%	31%	30%	30%	33%	40%	45%	53%	47%	43%	34%	38%	30%	35%	33%	40%	42%	45%	49%
Red-Tailed Hawk	76%	74%	68%	54%	51%	52%	56%	66%	73%	75%	68%	61%	57%	56%	52%	57%	59%	63%	68%	68%	68%

Table A-2.1.1: Other Private - West: Base Case Harvest

Harvest (MBF)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	1,525,719	189,247	262,701	737,847	760,910	1,240,187	411,962	505,366	401,172	689,679	659,223	672,479
North Puget Sound	9,250,075	1,528,779	1,158,861	2,064,742	4,517,915	6,479,058	2,292,583	1,242,706	2,120,317	3,346,733	3,979,238	3,400,177
South Coast	1,177,578	985,418	1,268,736	2,239,244	1,743,176	1,335,165	1,143,876	1,672,140	1,483,289	1,357,478	1,143,911	1,440,610
South Puget Sound	4,390,504	913,103	1,496,628	2,018,862	3,685,616	4,358,185	1,742,167	1,892,044	1,802,161	3,159,970	2,266,745	2,545,924
Southwest	4,125,473	928,092	849,855	1,803,409	4,007,642	3,321,865	1,366,855	1,458,073	2,171,192	2,787,102	1,967,806	2,281,956
Total	20,469,349	4,544,639	5,036,780	8,864,104	14,715,260	16,734,460	6,957,443	6,770,329	7,978,131	11,340,961	10,016,923	10,341,146
Annual Average	2,046,935	454,464	503,678	886,410	1,471,526	1,673,446	695,744	677,033	797,813	1,134,096	1,001,692	1,034,115

Table A-2.1.2: Other Private - West: Base Case Inventory & Acres

Inventory (MBF)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10	No conversons	Acres Managed	Buffers etc.	Total
North Coast	1,426,332	1,714,753	2,192,089	2,467,815	2,640,112	2,267,831	2,116,937	2,385,863	2,745,649	2,928,425	1,777,724	2,288,580	**NC**	136,423	16,861	153,284
North Puget Sound	5,645,733	5,941,592	7,574,190	9,729,738	10,656,861	8,225,963	7,833,323	9,017,806	10,714,277	11,111,555	6,387,172	8,645,104	**NPS**	567,277	42,698	609,975
South Coast	5,570,507	6,277,830	6,966,141	6,477,118	6,267,150	6,194,631	6,669,381	7,208,957	7,343,786	7,343,097	6,271,493	6,631,860	**SC**	270,556	47,745	318,301
South Puget Sound	4,130,702	4,916,025	6,358,020	7,879,241	8,544,384	6,741,532	6,752,467	7,830,472	8,995,762	9,076,650	5,134,916	7,122,525	**SPS**	419,988	36,521	456,509
Southwest	3,656,865	3,919,463	5,699,481	7,390,144	7,566,644	6,231,116	6,731,791	8,074,072	9,182,804	8,785,680	4,425,270	6,723,806	**SW**	379,209	51,494	430,704
Total	20,430,138	22,769,664	28,789,921	33,944,056	35,675,151	29,661,072	30,103,898	34,517,170	38,982,277	39,245,407	23,996,574	31,411,875	**Total**	1,773,453	195,319	1,968,773

Table A-2.1.3: Other Private - West: Base Case Acres in DFC

Acres in DFC	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	29,805	33,745	30,558	29,127	32,028	18,115	20,660	25,366	23,917	27,490	31,369	27,081
North Puget Sound	163,784	142,645	121,229	174,456	229,303	138,674	112,316	116,146	177,814	199,377	142,553	157,574
South Coast	81,037	93,987	96,002	68,625	58,810	58,755	60,916	58,508	57,897	62,727	90,342	69,727
South Puget Sound	140,428	127,518	128,536	135,571	121,395	81,874	75,881	83,976	109,865	96,052	132,161	110,110
Southwest	140,790	127,320	109,590	129,969	129,406	91,763	80,912	84,005	105,854	96,557	125,900	109,617
Total	555,844	525,214	485,916	537,748	570,942	389,182	350,685	368,001	475,347	482,204	522,325	474,108

Table A-2.1.4: Other Private - West: Base Case Percent Acres in DFC

Percent Acres in DFC	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	19	22	20	19	21	12	13	17	16	18	20	18
North Puget Sound	27	23	20	29	38	23	18	19	29	33	23	26
South Coast	25	30	30	22	18	18	19	18	18	20	28	22
South Puget Sound	31	28	28	30	27	18	17	18	24	21	29	24
Southwest	33	30	25	30	30	21	19	20	25	22	29	25
Total	28	27	25	27	29	20	18	19	24	24	27	24

Table A-2.1.5: Other Private - West: Base Case Ave. Annual Net Revenue and NPV in $ Millions

(in $ millions)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	NPV
North Coast	54	5	9	22	25	43	14	16	13	24	588
North Puget Sound	269	43	31	69	154	199	62	39	67	104	2,891
South Coast	36	30	43	84	62	41	36	58	51	46	848
South Puget Sound	171	32	56	78	140	176	68	76	71	124	2,147
Southwest	104	16	19	62	125	94	36	44	74	89	1,312
Total	634	126	158	316	506	553	217	234	276	387	7,785

Table A-2.2.1: Other Private - West: Alt 25% More Commercial Thin Total Harvest

Harvest(MBF)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	1,604,265	198,745	333,900	798,357	623,192	1,307,748	261,288	436,855	503,245	575,921	712,303	664,351
North Puget Sound	9,467,454	1,542,317	1,227,115	2,310,799	4,397,840	6,452,075	1,600,625	1,298,667	2,005,621	3,510,264	4,078,962	3,381,278
South Coast	1,376,960	1,113,358	1,261,053	2,372,513	1,679,477	1,275,787	1,065,172	1,758,818	1,413,200	1,223,144	1,250,457	1,453,948
South Puget Sound	4,605,136	891,416	1,561,781	2,123,133	3,654,269	4,331,924	1,346,776	2,206,259	1,650,435	3,138,942	2,352,778	2,551,007
Southwest	4,325,006	764,392	841,794	1,973,739	4,077,741	3,033,890	1,114,280	1,582,204	1,918,557	3,056,611	1,977,064	2,268,821
Total	21,378,821	4,510,229	5,225,644	9,578,540	14,432,519	16,401,423	5,388,141	7,282,804	7,491,057	11,504,883	10,371,564	10,319,406
Annual Average	2,137,882	451,023	522,564	957,854	1,443,252	1,640,142	538,814	728,280	749,106	1,150,488	1,037,156	1,031,941

Table A-2.2.2: Other Private - West: Alt 25% More Commercial Thin Standing Inventory

Inventory MBF	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10	No conversons	Acres Managed	Buffers etc.	Total
North Coast	1,426,332	1,714,753	2,192,089	2,467,815	2,640,112	2,267,831	2,116,937	2,385,863	2,745,649	2,928,425	1,777,724	2,288,580	**NC**	136,423	16,861	153,284
North Puget Sound	5,645,733	5,941,592	7,574,190	9,729,738	10,656,861	8,225,963	7,833,323	9,017,806	10,714,277	11,111,555	6,387,172	8,645,104	**NPS**	567,277	42,698	609,975
South Coast	5,570,507	6,277,830	6,966,141	6,477,118	6,267,150	6,194,631	6,669,381	7,208,957	7,343,786	7,343,097	6,271,493	6,631,860	**SC**	270,556	47,745	318,301
South Puget Sound	4,130,702	4,916,025	6,358,020	7,879,241	8,544,384	6,741,532	6,752,467	7,830,472	8,995,762	9,076,650	5,134,916	7,122,525	**SPS**	419,988	36,521	456,509
Southwest	3,656,865	3,919,463	5,699,481	7,390,144	7,566,644	6,231,116	6,731,791	8,074,072	9,182,804	8,785,680	4,425,270	6,723,806	**SW**	379,209	51,494	430,704
Total	20,430,138	22,769,664	28,789,921	33,944,056	35,675,151	29,661,072	30,103,898	34,517,170	38,982,277	39,245,407	23,996,574	31,411,875	**Total**	1,773,453	195,319	1,968,773

Table A-2.2.3: Other Private - West: Alt 25% More Commercial Thin with Acres in DFC

Acres	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	29,251	33,696	30,151	27,962	33,092	17,682	21,123	26,949	23,482	28,910	31,033	27,230
North Puget Sound	170,447	147,008	129,400	184,879	238,495	139,957	114,384	122,740	195,030	208,237	148,952	165,058
South Coast	79,154	91,758	98,170	66,633	58,870	58,054	61,686	60,279	58,931	63,662	89,694	69,720
South Puget Sound	138,352	128,763	128,577	136,800	120,687	80,324	77,049	85,449	115,973	95,984	131,897	110,796
Southwest	136,869	125,680	112,255	128,390	127,290	90,740	78,582	80,772	112,626	93,729	124,935	108,693
Total	554,073	526,906	498,553	544,665	578,434	386,756	352,824	376,189	506,041	490,522	526,510	481,496

Table A-2.2.4: Other Private - West: Alt 25% More Commercial Thin with Percent Acres in DFC

% of Acres in DFC	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	19	22	20	18	22	12	14	18	15	19	20	18
North Puget Sound	28	24	21	30	39	23	19	20	32	34	24	27
South Coast	25	29	31	21	18	18	19	19	19	20	28	22
South Puget Sound	30	28	28	30	26	18	17	19	25	21	29	24
Southwest	32	29	26	30	30	21	18	19	26	22	29	25
Total	28	27	25	28	29	20	18	19	26	25	27	24

Table A-2.2.5: Other Private - West: Alt 25% More Commercial Thin Ave. Annual Net Revenue and NPV in $ Thousands

Average annual net revenue ($ thousands)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	NPV
North Coast	57	3	10	11	13	39	7	11	7	13	560
North Puget Sound	265	43	29	75	146	199	43	41	58	106	2,854
South Coast	42	33	43	90	58	38	33	61	48	41	910
South Puget Sound	179	30	58	81	139	178	50	89	64	123	2,203
Southwest	111	13	16	69	130	92	25	54	66	99	1,359
Total	654	121	157	325	486	546	157	256	243	382	7,885

Table A-2.3.1: Other Private - West: Alt 25% More BioPath Total Harvest

Harvest(MBF)	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	1,226,537	163,056	366,400	755,634	784,360	1,112,902	249,322	428,765	533,887	671,136	585,331	629,200
North Puget Sound	8,674,520	1,697,485	1,189,841	2,449,980	4,826,304	6,061,875	1,957,411	1,399,667	2,239,153	3,671,466	3,853,949	3,416,770
South Coast	1,165,036	1,186,735	1,087,583	2,178,028	1,574,263	1,359,038	1,007,455	1,694,282	2,354,184	1,296,832	1,146,452	1,490,344
South Puget Sound	4,098,064	1,048,956	1,351,092	2,272,755	3,724,795	4,269,818	1,512,180	2,198,942	1,984,285	3,204,150	2,166,037	2,566,504
Southwest	3,825,407	926,911	798,186	1,905,046	4,063,505	3,276,526	1,225,394	1,480,931	2,428,763	3,170,334	1,850,168	2,310,100
Total	18,989,565	5,023,143	4,793,102	9,561,444	14,973,227	16,080,158	5,951,761	7,202,588	9,540,272	12,013,919	9,601,937	10,412,918
Annual Average	1,898,957	502,314	479,310	956,144	1,497,323	1,608,016	595,176	720,259	954,027	1,201,392	960,194	1,041,292

Table A-2.3.2: Other Private - West: Alt 25% More BioPath Staending Inventory

Inventory MBF	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10	No conversons	Acres Managed	Buffers etc.	Total
North Coast	1,420,192	1,763,430	2,166,789	2,346,988	2,375,303	2,027,052	2,023,100	2,343,783	2,631,703	2,677,747	1,783,470	2,177,609	**NC**	136,423	16,861	153,284
North Puget Sound	6,416,285	6,802,094	8,516,608	10,430,418	10,974,107	8,854,021	8,816,965	10,127,088	11,728,774	12,002,860	7,244,996	9,466,922	**NPS**	567,277	42,698	609,975
South Coast	5,591,963	6,190,164	6,975,394	6,745,660	6,764,067	6,773,714	7,445,555	7,955,641	7,275,589	7,164,204	6,252,507	6,888,195	**SC**	270,556	47,745	318,301
South Puget Sound	4,512,918	5,221,241	6,840,680	8,144,864	8,640,487	6,842,550	7,092,234	8,126,968	9,015,914	9,035,566	5,524,946	7,347,342	**SPS**	419,988	36,521	456,509
Southwest	4,024,961	4,404,085	6,234,050	7,806,271	7,910,764	6,708,095	7,210,274	8,576,194	9,380,940	8,687,252	4,887,698	7,094,289	**SW**	379,209	51,494	430,704
Total	21,966,318	24,381,014	30,733,519	35,474,200	36,664,728	31,205,433	32,588,128	37,129,674	40,032,921	39,567,629	25,693,617	32,974,357	**Total**	1,773,453	195,319	1,968,773

Table A-2.3.3: Other Private - West: Alt 25% More BioPath with Acres in DFC

Acres	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	35,027	39,017	36,239	31,757	36,341	24,775	28,948	31,723	28,494	31,320	36,761	32,364
North Puget Sound	185,906	166,234	146,497	201,242	245,129	158,166	133,258	133,647	194,343	216,554	166,213	178,098
South Coast	83,663	97,892	108,076	89,772	96,415	97,689	101,686	90,154	69,531	69,265	96,544	90,414
South Puget Sound	157,415	144,822	151,024	160,732	145,011	103,365	95,712	100,156	126,065	114,784	151,087	129,909
Southwest	154,619	144,884	132,364	155,053	153,414	116,072	99,340	101,623	117,601	108,739	143,956	128,371
Total	616,630	592,849	574,201	638,556	676,310	500,066	458,943	457,303	536,034	540,662	594,560	559,155

Table A-2.3.4: Other Private - West: Alt 25% More BipPath with Percent Acres in DFC

% of Acres	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	Avg Decade 1-3	Avg Decade 1-10
North Coast	23	25	24	21	24	16	19	21	19	20	24	21
North Puget Sound	30	27	24	33	40	26	22	22	32	36	27	29
South Coast	26	31	34	28	30	31	32	28	22	22	30	28
South Puget Sound	34	32	33	35	32	23	21	22	28	25	33	28
Southwest	36	34	31	36	36	27	23	24	27	25	33	30
Total	31	30	29	32	34	25	23	23	27	27	30	28

Table A-2.3.5: Other Private - West: Alt 25% More BioPath Ave. Annual Net Revenue and NPV in $ Thousands

Average annual net revenue $ thousands	2004-2013	2014-2023	2024-2033	2034-2043	2044-2053	2054-2063	2064-2073	2074-2083	2084-2093	2094-2103	NPV
North Coast	43	4	12	24	26	38	8	14	18	23	505
North Puget Sound	242	46	29	81	156	184	56	44	67	116	2,705
South Coast	35	34	38	81	55	43	31	60	87	44	834
South Puget Sound	158	36	49	89	142	174	57	90	78	124	2,067
Southwest	91	15	15	67	129	93	30	42	84	106	1,210
Total	570	136	144	341	507	532	183	251	335	413	7,322

Appendix B – Eastside

Data were simulated forward from the survey period to 2001 to update the FIA inventories to the current period. Inventory updates used growth rate and harvest volume data by owner group to estimate the starting inventory in 2001. Timber supply projections for the next 100 years were then simulated using historic harvest levels by timbershed and region as a projection target. Tabular estimates of standing and cut volume (in million board feet/region) are provided along with an estimate of the % of the target volume (historic rate) that was attained in any given decade. The standing volume estimates cover the acreage that is estimated to be commercially available at this time and therefore exclude riparian zones and economically inaccessible areas for private simulations, HCP and NRCA designated reserves on state simulations, and all cold forest habitat types on federal simulations.

Table B-1: Northeast Region Base Case – Private and Tribal Harvests

year	Standing MMBF	Cut MMBF	Target MMBF	% of target
1991	9160	3002	2973	101.0%
2001	9524	2528	2427	104.2%
2011	10017	2464	2427	101.5%
2021	11175	2403	2427	99.0%
2031	12232	2587	2427	106.6%
2041	13710	2442	2427	100.6%
2051	15350	2495	2427	102.8%
2061	17102	2490	2427	102.6%
2071	18994	2526	2427	104.1%
2081	21047	2438	2427	100.5%
2091	22765	2679	2427	110.4%
2101	24551	2484	2427	102.3%

Table B-2: Southeast Region Base Case – Private and Tribal Harvests

year	Standing MMBF	Cut MMBF	Target MMBF	% of target
1991	739	312	311	100.4%
2001	632	203	205	99.1%
2011	515	189	205	92.3%
2021	465	124	205	60.5%
2031	522	42	205	20.5%
2041	571	44	205	21.5%
2051	660	22	205	10.7%
2061	582	177	205	86.4%
2071	644	86	205	42.0%
2081	720	51	205	24.9%
2091	719	135	205	65.9%
2101	732	92	205	44.9%

Table B-3: Tonasket Region Base Case – Private and Tribal Harvests

year	Standing MMBF	Cut MMBF	Target MMBF	% of target
1991	5334	643	642	100.2%
2001	5945	738	720	102.5%
2011	6447	758	720	105.3%
2021	7181	720	720	100.0%
2031	7865	738	720	102.5%
2041	8296	728	720	101.1%
2051	8789	757	720	105.1%
2061	9217	737	720	102.3%
2071	9470	777	720	107.9%
2081	9747	729	720	101.2%
2091	10078	771	720	107.1%
2101	10257	775	720	107.6%

Table B-4: Okanogan Region Base Case – Private and Tribal Harvests

year	Standing MMBF	Cut MMBF	Target MMBF	% of target
1991	3269	570	564	101.1%
2001	3527	584	535	109.1%
2011	3636	572	535	106.9%
2021	3772	546	535	102.0%
2031	3957	551	535	102.9%
2041	4297	561	535	104.8%
2051	4579	546	535	102.0%
2061	4852	509	535	95.1%
2071	5023	600	535	112.1%
2081	5265	534	535	99.8%
2091	5373	638	535	119.2%
2101	5435	552	535	103.1%

Table B-5: Wenatchee Region Base Case – Private and Tribal Harvests

year	Standing MMBF	Cut MMBF	Target MMBF	% of target
1991	3507	1071	1073	99.8%
2001	2863	1246	1227	101.5%
2011	2361	1220	1227	99.4%
2021	2061	1182	1227	96.3%
2031	1747	1237	1227	100.8%
2041	2111	792	1227	64.5%
2051	2049	1058	1227	86.2%
2061	1883	1187	1227	96.7%
2071	2336	518	1227	42.2%
2081	2558	866	1227	70.6%
2091	2477	1141	1227	93.0%
2101	2357	1138	1227	92.7%

Table B-6: Yakima Region Base Case – Private and Tribal Harvests

year	Standing MMBF	Cut MMBF	Target MMBF	% of target
1991	6917	2476	2395	103.4%
2001	7352	2247	2230	100.8%
2011	7609	2228	2230	99.9%
2021	7484	2387	2230	107.1%
2031	7771	2368	2230	106.2%
2041	8159	2383	2230	106.9%
2051	8578	2261	2230	101.4%
2061	9000	2395	2230	107.4%
2071	9338	2379	2230	106.7%
2081	9841	2417	2230	108.4%
2091	10032	2397	2230	107.5%
2101	10608	2283	2230	102.4%

Table B-7: Timbershed 6 Base Case – Private and Tribal Harvests

year	Standing MMBF	Cut MMBF	Target MMBF	% of target
1991	13693	4117	4032	102.1%
2001	13742	4077	3992	102.1%
2011	13606	4020	3992	100.7%
2021	13317	4115	3992	103.1%
2031	13475	4156	3992	104.1%
2041	14567	3736	3992	93.6%
2051	15206	3865	3992	96.8%
2061	15735	4091	3992	102.5%
2071	16697	3497	3992	87.6%
2081	17664	3817	3992	95.6%
2091	17882	4176	3992	104.6%
2101	18400	3973	3992	99.5%

Table B-8: Timbershed 7 Base Case – Private and Tribal Harvests

year	Standing MMBF	Cut MMBF	Target MMBF	% of target
1991	15233	3957	3926	100.8%
2001	16101	3469	3352	103.5%
2011	16979	3411	3352	101.8%
2021	18821	3247	3352	96.9%
2031	20619	3367	3352	100.4%
2041	22577	3214	3352	95.9%
2051	24799	3274	3352	97.7%
2061	26901	3404	3352	101.6%
2071	29108	3389	3352	101.1%
2081	31514	3218	3352	96.0%
2091	33562	3585	3352	107.0%
2101	35540	3351	3352	100.0%

Table B-9: Percent of Timberland in RMZ by buffer type

Timbershed	County	Percent of timber land in RMZ by buffer type				Economically Inoperable*	Riparian Reserve*
		Core	Inner	Outer	Total		
East Cascades	Chelan	15.93%	2.26%	0.11%	18.30%	0.70%	18.89%
	Kittitas	6.50%	2.40%	0.17%	9.08%	0.70%	9.60%
	Klickitat	5.22%	2.44%	0.15%	7.81%	0.70%	8.36%
	Okanogan	5.82%	1.98%	0.02%	7.82%	0.70%	8.50%
	Yakima	7.04%	2.29%	0.00%	9.33%	0.70%	10.02%
East Cascades Total		6.09%	2.23%	0.09%	8.41%	0.70%	9.02%
Inland Empire	Asotin	8.97%	2.23%	0.02%	11.22%	0.70%	11.90%
	Columbia	7.18%	1.94%	0.09%	9.21%	0.70%	9.82%
	Ferry	6.37%	2.13%	0.05%	8.55%	0.70%	9.20%
	Garfield	6.91%	2.39%	0.05%	9.35%	0.70%	10.00%
	Pend Oreille	4.96%	2.21%	0.18%	7.34%	0.70%	7.87%
	Spokane	5.35%	2.13%	0.10%	7.58%	0.70%	8.19%
	Stevens	4.85%	2.12%	0.13%	7.10%	0.70%	7.67%
	Walla Walla	7.19%	1.97%	0.08%	9.24%	0.70%	9.86%
Inland Empire Total		5.39%	2.14%	0.12%	7.65%	0.70%	8.23%
Grand Total		5.66%	2.17%	0.11%	7.94%	0.70%	8.53%

Table B-10: Average Standing and Cut Volume/acre - Private

Average Standing and cut volume per acre (all years)				
Region	**Standing MBF/acre**	**Cut MBF/acre**	**Standing MBF/ harvested acre**	**Cut MBF/ harvested acre**
Okanogan	12,038	1,531	7,971	11,452
Wenatchee	8,471	3,794	5,145	13,724
Yakima	15,072	4,144	8,164	15,471
Timbershed 6	12,727	3,290	7,467	13,941
Northeast	13,927	2,315	4,095	19,920
Tonasket	17,095	1,566	7,163	19,943
Southeast	4,741	947	3,119	5,679
Timbershed 7	11,693	1,889	4,080	16,073

Table B-11: Average Metrics for Timber Volume Removed - Private

Region	Stand Metric	YEAR 1991	2001	2011	2021	2031	2041	2051	2061	2071	2081	2091	2101	Grand Total
Northeast	Average DBHq	9.1	12.2	12.5	12.4	11.1	14.8	12.2	14.7	15.5	17.3	16.2	15.4	13.1
	Average BA/acre	114	95	93	105	112	124	122	132	130	133	161	118	116
	Average BF/Acre	19,928	14,585	14,588	16,851	17,376	22,535	19,839	23,893	22,266	25,844	30,656	22,702	19,920
	Average CF/Acre	3,889	2,972	2,947	3,421	3,588	4,302	4,020	4,636	4,356	4,874	5,816	4,404	3,929
Okanogan	Average DBHq	14.8	17.0	14.5	14.6	16.0	13.8	15.7	14.0	17.1	16.2	17.3	15.6	15.4
	Average BA/acre	53	56	75	66	51	64	62	49	86	161	74	65	65
	Average BF/Acre	9,630	11,662	12,003	11,847	8,737	9,723	9,779	7,513	15,336	33,354	13,178	12,930	11,319
	Average CF/Acre	1,845	2,136	2,355	2,233	1,636	1,886	1,866	1,477	2,967	6,374	2,502	2,394	2,156
Southeast	Average DBHq	11.3	12.9	15.0	14.4	16.4	12.8	15.5	11.8	15.5	14.8	14.0	9.2	13.3
	Average BA/acre	63	66	65	48	29	32	11	39	32	37	45	30	45
	Average BF/Acre	8,847	9,012	7,934	5,149	3,252	3,829	1,190	4,262	4,912	2,892	5,824	4,720	5,553
	Average CF/Acre	1,937	1,917	1,789	1,191	717	869	287	991	1,049	738	1,318	1,025	1,242
Tonasket	Average DBHq	11.6	13.0	14.0	13.7	16.2	12.7	14.8	17.4	13.6	18.1	19.6	18.6	15.2
	Average BA/acre	66	68	100	108	103	133	132	102	90	124	96	96	98
	Average BF/Acre	14,043	14,279	19,963	22,559	24,339	27,322	22,887	18,287	16,118	20,730	18,413	18,900	19,063
	Average CF/Acre	2,523	2,552	3,606	4,061	4,190	4,940	4,426	3,379	2,971	3,932	3,350	3,471	3,481
Wenatchee	Average DBHq	20.7	18.7	17.7	14.8	16.1	11.3	10.3	12.4	10.2	10.1	11.3	11.2	13.3
	Average BA/acre	136	127	105	111	62	89	94	73	76	75	74	72	85
	Average BF/Acre	24,867	26,091	19,686	19,386	10,259	13,310	14,021	11,040	10,755	11,554	10,574	10,317	13,724
	Average CF/Acre	4,615	4,687	3,635	3,748	1,991	2,728	2,912	2,266	2,224	2,403	2,222	2,175	2,722
Yakima	Average DBHq	18.0	16.1	17.5	17.1	14.6	15.6	17.4	14.4	14.3	15.2	15.2	16.5	15.9
	Average BA/acre	98	89	99	72	74	89	70	83	90	76	96	94	85
	Average BF/Acre	19,327	15,481	19,606	13,705	13,085	14,975	13,626	14,690	15,518	13,706	15,976	18,480	15,414
	Average CF/Acre	3,856	3,279	3,930	2,815	2,701	3,114	2,718	3,068	3,219	2,810	3,389	3,685	3,164
Total Average DBHq		13.5	14.5	14.9	14.7	14.1	14.3	14.5	14.0	14.4	15.1	15.0	14.8	14.4
Total Average BA/acre		96	88	93	88	81	96	89	84	97	95	98	89	91
Total Average BF/Acre		17,541	15,307	16,279	15,309	13,586	16,540	15,089	14,221	16,464	16,991	16,841	16,443	15,793

Table B-12: Average Metrics for Standing Timber (all stands) - Private

Region	Stand Metric	YEAR 1991	2001	2011	2021	2031	2041	2051	2061	2071	2081	2091	2101	Grand Total
Northeast	Average DBHq	5.5	6.0	6.4	6.9	7.3	7.6	8.2	8.7	9.1	9.5	10.3	10.8	8.0
	Average BA/acre	75	78	82	87	90	96	101	108	113	120	126	131	101
	Average BF/Acre	8,397	8,688	9,116	10,194	10,978	12,296	13,720	15,323	16,990	18,808	20,482	22,133	13,927
	Average CF/Acre	1,978	2,054	2,189	2,375	2,510	2,757	2,988	3,286	3,554	3,869	4,154	4,419	3,011
Okanogan	Average DBHq	5.5	5.9	6.6	7.2	7.1	7.0	7.3	7.4	7.8	8.7	9.4	9.5	7.4
	Average BA/acre	73	80	86	89	92	95	98	101	104	108	107	105	95
	Average BF/Acre	9,051	9,796	10,099	10,166	10,605	11,501	12,248	13,010	13,712	14,579	14,851	14,836	12,038
	Average CF/Acre	1,960	2,086	2,162	2,217	2,317	2,444	2,572	2,677	2,785	2,921	2,936	2,892	2,498
Southeast	Average DBHq	7.2	6.7	7.0	6.3	6.7	6.3	6.8	6.8	6.7	6.8	6.9	7.3	6.8
	Average BA/acre	61	57	54	57	63	68	74	66	69	70	68	69	65
	Average BF/Acre	5,694	4,775	3,881	3,506	3,967	4,316	5,015	4,422	4,872	5,453	5,413	5,575	4,741
	Average CF/Acre	1,416	1,236	1,071	1,044	1,166	1,282	1,429	1,277	1,342	1,434	1,402	1,448	1,296
Tonasket	Average DBHq	6.1	6.6	7.2	8.0	8.5	9.4	10.3	11.0	11.6	12.5	12.9	13.3	9.8
	Average BA/acre	79	91	103	114	125	131	133	133	132	132	133	133	120
	Average BF/Acre	11,104	12,295	13,476	14,893	16,446	17,326	18,329	19,142	19,614	20,197	20,948	21,369	17,095
	Average CF/Acre	2,289	2,518	2,798	3,066	3,366	3,563	3,684	3,755	3,803	3,878	3,955	4,010	3,390
Wenatchee	Average DBHq	6.2	6.4	6.0	6.0	5.5	5.1	5.3	5.0	5.2	5.6	5.4	5.1	5.6
	Average BA/acre	89	84	82	82	76	82	80	74	86	90	84	79	82
	Average BF/Acre	12,440	10,166	8,458	7,450	6,321	7,652	7,526	6,704	8,348	9,164	8,880	8,540	8,471
	Average CF/Acre	2,568	2,222	2,019	1,922	1,749	1,918	1,881	1,710	2,053	2,185	2,093	1,995	2,026
Yakima	Average DBHq	5.6	6.2	6.6	7.1	6.9	6.7	6.8	6.8	6.6	6.7	7.0	6.7	6.7
	Average BA/acre	88	100	107	110	109	110	113	116	117	123	125	131	112
	Average BF/Acre	12,259	13,127	13,234	13,268	13,810	14,603	15,088	15,678	16,168	17,262	17,674	18,690	15,072
	Average CF/Acre	2,683	2,917	2,997	3,151	3,182	3,327	3,428	3,513	3,645	3,840	3,927	4,129	3,395
Total Average DBHq		5.7	6.2	6.6	7.0	7.2	7.3	7.8	8.1	8.4	8.9	9.4	9.6	7.7
Total Average BA/acre		79	84	89	94	97	102	105	107	111	116	118	120	102
Total Average BF/Acre		9,866	10,163	10,370	10,918	11,542	12,595	13,516	14,372	15,453	16,674	17,533	18,416	13,451

Table B-13: Average Metrics for Standing Timber (for stands where harvest was simulated in that decade only) – Private

		YEAR											
REGION	**Data**	**1991**	**2001**	**2011**	**2021**	**2031**	**2041**	**2051**	**2061**	**2071**	**2081**	**2091**	**2101**	**Grand Total**
Northeast	Average Standing DBHq	5	5	6	6	6	7	7	8	8	11	8	9	7
	Avg Standing TPA	294	315	262	237	208	147	233	137	156	103	98	109	208
	Average Residual BA	40	38	37	43	36	39	61	40	44	37	26	31	40
	Avg Standing Vol	3,578	3,419	3,646	3,653	3,687	4,341	6,135	5,142	4,810	5,672	2,593	3,255	4,095
	Average Stand SDI	95	91	84	97	80	81	127	81	91	68	54	65	86
Okanogan	Average Standing DBHq	6	5	6	10	9	7	9	8	8	12	10	10	8
	Avg Standing TPA	362	538	429	288	166	282	142	316	329	155	162	208	286
	Average Residual BA	55	56	62	43	53	59	48	94	66	112	45	76	61
	Avg Standing Vol	8,395	8,318	6,691	4,985	7,165	7,874	5,194	10,112	5,887	16,833	7,433	12,460	7,961
	Average Stand SDI	126	133	146	95	104	128	96	192	142	193	82	146	129
Southeast	Average Standing DBHq	6	6	7	6	16	7	7	7	7	8	7	8	7
	Avg Standing TPA	199	305	331	290	21	267	257	203	253	199	137	192	225
	Average Residual BA	32	45	20	43	27	63	68	46	60	40	41	50	43
	Avg Standing Vol	3,767	3,591	759	2,438	2,904	2,966	5,729	2,813	3,117	2,570	3,275	3,965	3,120
	Average Stand SDI	73	103	55	99	42	137	142	99	129	87	84	102	94
Tonasket	Average Standing DBHq	6	6	5	9	4	5	8	9	7	11	13	13	8
	Avg Standing TPA	407	358	512	194	432	335	213	174	299	70	164	122	273
	Average Residual BA	81	72	58	51	37	58	34	64	61	47	60	67	59
	Avg Standing Vol	9,028	7,736	4,395	8,171	4,148	7,203	4,648	7,648	6,880	7,056	8,685	10,685	7,384
	Average Stand SDI	179	158	145	104	97	128	76	120	132	81	112	114	124
Wenatchee	Average Standing DBHq	4	9	5	6	6	6	6	5	5	5	5	5	6
	Avg Standing TPA	670	275	592	326	466	343	323	450	405	424	363	456	423
	Average Residual BA	42	48	70	39	59	57	44	65	53	51	59	55	55
	Avg Standing Vol	5,014	5,669	7,397	3,077	5,285	4,939	4,869	4,540	4,458	5,003	5,884	5,316	5,145
	Average Stand SDI	112	105	170	93	139	131	104	153	125	124	136	133	130
Yakima	Average Standing DBHq	4	5	5	7	6	5	6	6	6	5	7	7	6
	Avg Standing TPA	677	494	478	515	430	520	512	391	501	479	485	386	487

Table B-14: Acres burned per year by jurisdiction for eastern Washington

Owner group	Wildfire Acres 1995-2006	Average Acres Burned Per Year	Acres in Jurisdiction	% Acres burned per year
USFS	936,951	78,079	3,277,533	2.4%
State/Private	220,140	18,345	3,804,662	0.5%

Source: DNR Fire Reports and USFS Fire Summaries compared to FIA acreage estimates

Table B-15: Acres burned and estimated carbon emissions from lands under DNR fire protection 1970-June 2007

		All WA	E WA	W WA
Acres burned	**Grand Total 1970-June 2007**	593,225	490,075	103,150
	1970-1994 average	12,443	10,778	1,665
	1995-2006 average	23,467	18,345	5,122
	Carbon emissions/year since 1995 (tonnes)	140,802	110,069	30,733
	legacy emissions since 1995 (tonnes/year)	46,934	36,690	10,244
Estimated upper bound of emissions on DNR protected lands	Carbon emissions/year assuming all acres are merchantable	187,736	146,759	40,977
Estimated lower bound of emissions on DNR protected lands	C emissions using % of merchantable acres within identified acres	155,863	121,843	34,020

Source: DNR Fire Reports

The average number of acres that burn each year is increasing for all jurisdictions and owner groups. The percentage of acres that burn each year is higher for federal lands than for DNR protected lands Table B-14, but lands under DNR jurisdiction have experienced a 70% increase in average acres burned in the past 12 years over the prior 25 in Eastern Washington. For Western Washington, the acreage burned/year since 1995 has increased by 207%. Trend data to 1970 were not available for national forests of Eastern Washington, but correlation of research to data from 1995 forward suggests that there has been a doubling of the burn rate on Eastside National Forest lands as well (See Discussion Paper 8).