An Assessment of Forest Policy Changes in Western Washington

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ABSTRACT. Changing forest policies in both riparian and upland areas to help protect threatened and endangered species have contributed to the reduction of timber harvests in western Washington. The economic, biodiversity, and environmental impacts of these policy actions have been substantial. Policy simulations across 9.4 million acres of timberland show that relative to proactive management strategies, current habitat conservation and environmental programs (largely based on a reservation strategy) result in net present value reductions to forestland owners of $9.9 billion. Accompanying these asset value reductions are employment losses (sustained) of 30% and tax receipt losses of 26%. The policy simulations further demonstrate that proactive management will not decrease the long-term percentage of the upland landscape occupied by functionally old forests relative to the reservation strategy. In the riparian area, adoption of a reservation strategy actually decreases (by 29%) the

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percent of the landscape occupied by functionally old forests relative to a proactive management approach. These results illustrate the importance of proactively managing western Washington forests to provide maximum functionally old forest habitat for endangered upland animals (such as the northern spotted owl and the marbled murrelet) as well as riparian species.

KEYWORDS. Proactive forest management, reservation strategy, habitat conservation, biodiversity, endangered species, sustainable forestry, forest practices regulations, riparian zone management, forest economics, linear programming

INTRODUCTION

Major policy changes coupled with weak timber markets have resulted in timber harvest levels in Washington State declining by more than 30% from the trend level of the 1970s and 80s. Private timberlands[1] now account for about 82% of the harvest occurring on 60% of the timberland acres. Timber supply analyses have generally concluded that potential harvest levels are sustainable near prior trend levels (Adams et al. 1992, Bare et al. 1995). Changing regulations since 1990, largely driven by the Endangered Species Act and the Washington State Forest Practices Act are the primary contributors to the declining timber harvest. These changes have resulted in large additions to old forest upland reserves, the enlargement of no-harvest zones around streams and wetlands, and a reduction in economic activity and employment within the forest products sector. These conservation efforts have impacted federal, state[2] and private forestlands in western Washington to varying degrees. In addition to these regulatory impacts, weak offshore markets have seriously impacted many private forestland owners in western Washington.

In an effort to protect threatened and endangered species and to ensure that forestry practices are sustainable, policy makers have endorsed a management strategy that largely depends on the reservation of certain land areas and habitat types from proactive management. In addition, for those timberland acres remaining unreserved, increasingly restrictive forest practices have further reduced timber production. As a consequence, when summed across federal, state and private timberland owners in western Washington, a substantial economic cost is generated. The benefits of this new land management strategy often accrue to segments of society other than forestland owners. Thus, issues concerning the equity and the balance between who pays for, and who benefits from, the recent changes in management strategy arise. In addition, the effectiveness of the new management strategy to generate an increased proportion of functionally old forest habitat across the landscape is questionable.

During the past decade, attention has focused on both upland as well as riparian[3] forest areas. The most contentious current issues concern riparian management practices resulting from the listing of Chinook salmon as a threatened species in western Washington. In addition, in Spring 2000, the Washington State Legislature passed new legislation known as the Forest and Fish Agreement. This Agreement was incorporated into the Washington State Forest Practices Rules and became effective in March 2000. In the first half of the 1990s, the emphasis was mostly on upland habitats used by the northern spotted owl and marbled murrelet. Both issues are driven by the need to maintain adequate acres of critical habitat with old forest functionality. Initial efforts to protect the owl and murrelet on federal lands resulted in adoption of the Northwest Forest Plan, a management strategy developed by the Forest Ecosystem Management and Assessment Team (FEMAT 1993). As adopted, the program led to reduced harvest levels on federal timberlands by more than 80%.[4] It provides for upland late-succession reservations and riparian buffers with little or no management. Development of the Washington State Department of Natural Resources Habitat Conservation Plan (WDNR 1996) has a similar, although perhaps not as severe, impact on state-managed lands (Bare et al. 1997, Bare et al. 2000). Habitat conservation plans on private forestlands have had less of an economic impact than the protection efforts affecting federal and state forestlands. However, the recently passed Forest and Fish Agreement is likely to have a substantial impact on private forest owners.

The economic impacts of past policy changes have been substantial and the expectation is that future changes may be even more ominous. Yet, to date no comprehensive assessment of the cumulative effectiveness of existing and proposed policies to meet environmental, biodiversity, and habitat conservation goals has been completed. Nor has there been an assessment of whether there are different management strategies that can reach conservation objectives at significantly reduced costs to the forestland owner.

This study provides a demonstration of the potential economic, biodiversity, and environmental impacts of forest policy changes in western Washington–policy changes aimed at restoring important types of forest habitats that have been declining. We focus on a comparison of the impacts of alternative riparian and upland management strategies that encompass the continued use of set-asides of existing habitat under low levels of management as well as management strategies that rely on proactive management without the need for large set-asides. The potential for proactive management alternatives to improve biodiversity and habitat conditions at lower cost than reservation strategies is examined. This opportunity exists because currently adopted approaches have generally sought to reserve existing habitat rather than to motivate landowners to produce improved habitat over time. Forests are dynamic and ultimately change through growth and natural disturbances suggesting that successful species preservation is ultimately dependent upon the creation of new habitat. Thus, a more thorough assessment of the effectiveness of past and proposed policies is needed.

Simulations of several management options are provided to demonstrate economic, biodiversity, and environmental impacts. All options focus on improving the proportion of the landscape covered by functionally old forests as these were the upland area habitats in shortest supply and were largely responsible for the listing of the spotted owl and marbled murrelet in the early 1990s. Similarly, the listing of the Chinook salmon focused attention on the riparian areas where no-harvest streamside buffers are required to allow functionally old forest conditions to develop. Economic comparisons are benchmarked to the maximum economic potential of the forestland base (i.e., commodity management with limited environmental and habitat constraints). We recognize that this form of management is no longer practiced in western Washington because it may lead to declining environmental and habitat conditions and their associated societal costs. Nevertheless, it is an appropriate benchmark for the purpose of documenting the costs of alternative forms of management to the landowner. Biodiversity across forest stand structures and other environmental and habitat comparisons are benchmarked to current and historic measures to determine changes over time. Since riparian protection for salmon stimulated the most recent policy change, several riparian management strategies for private and state forestlands are examined first. This is followed by an analysis of the effects of changing regulations affecting both upland and riparian areas across all ownership groups.

PREVIOUS WORK

The policy simulations examined herein are based on several previous studies and analyses. The idea of utilizing a proactive management approach to provide for the conservation of biodiversity in a sustainable manner was described by Oliver (1992, 1998). In their study of a single watershed on the Olympic Peninsula of Washington State, Carey et al. (1999) developed and tested many of the biological and ecological concepts suggested by Oliver as well as Carey and Curtis (1996). In analyzing whether certain forest management practices are ecologically sustainable, we employ eight stages of forest ecosystem development to track the status of the forest over time (Carey and Curtis 1996, Carey et al. 1996). In addition, we utilize three composite indices to measure ecosystem diversity and health (Carey et al. 1999, Xu 1997) and three habitat classes to define suitable nesting, roosting, foraging, and dispersal habitat for spotted owls (Washington State Forest Practices Board 2000).

As with Carey et al. (1999), our analysis is based on the assumption that for a forest ecosystem to be ecologically sustainable several key elements must be present. First, the forest manager must provide for a representative mixture of the eight stages of structural development as described by Carey and Curtis (1996). If the ecosystem processes and functions provided by each structure are sustained over time, then the mixture is deemed adequate. Second, the distribution of the eight stand structures must be distributed across the landscape in a spatially directed manner. Green-up requirements of adjacent harvest units, habitat connectivity, and road placement restrictions help facilitate this spatial requirement. Third, both upland and riparian areas require different forms of silvicultural treatments in order to protect ecosystem health and diversity. This requires that no-harvest buffers be retained along certain stream types and around wetlands within the riparian zone. Fourth, a variety of partial harvest, woody debris, and snag requirements are required to provide for diversity in both the upland and riparian areas. By satisfactorily achieving these four elements, we assume that the ecological components are sustainable.

Our policy analysis is facilitated by use of a linear programming model that maximizes net present value within a set of resource, ecological, and environmental constraints. Bare et al. (2000) described a similar model for an analysis of Washington State trust lands. Our current model differs from this previous model in that we calculate separate sets of harvest levels over time for each of three landowners instead of just one. As defined by Davis et al. (2001), our linear programming model is characterized as a Model I, meaning that the basic management unit is always retained over time as an identifiable piece of real estate. Thus, the interpretation of model results can be traced to specific units of land over time. However, model capacity limitations preclude us from incorporating the level of spatial detail needed to develop an operational-level forest plan. Thus, we define our policy analysis as a strategic plan that can be further refined at the tactical and operational levels to reflect additional spatial concerns.

The development of forest management plans within an ecosystem management framework is changing the way forest planning is accomplished. Cortner and Moote (1999) discuss the shift from utilitarian-based sustained yield resource management to ecosystem management where more emphasis is placed on biodiversity; ecosystem restoration, protection, and health; managing for future desired states rather than resource outputs; and the importance of adequately recognizing and incorporating the social and political forces. Sustainable forestry is a form of forestry which is ecologically, socially, and economically sustainable over many generations (Sedjo et al. 1998, Sustainable Forestry Working Group 1998, Maser 1994, Aplet et al. 1993). It is a new form of forest management that is becoming the norm rather than the exception on public as well as private forestlands throughout western Washington. We believe that the proactive management alternatives described below are illustrative of sustainable forestry practices.

SIMULATION OF ALTERNATIVES

Simulations for all acres of commercial unreserved forestland in western Washington (9.4 million acres) were developed for private, federal, and state owners for each of three geographic regions. Initial forest inventory data by age class, forest type, geographic region, and ownership were taken from the most recent Forest Inventory Analysis (McLean et al. 1992). Harvest rates since 1990 (Larsen 1995) were allocated to mature acres and historic growth rates were applied to the unharvested acres to re-benchmark the inventory data to 1996–the starting point for the analysis. Acres were also categorized as upland or riparian. Riparian management zones (RMZs) based on distance from fish bearing and non-fish bearing streams were defined. The largest RMZ examined was calibrated against GIS samples (Marshal and Associates 1997)[5] to correspond approximately to the acreage within 150 ft of

Washington State Forest Practices Rules type 1-3 streams,[6] 100 ft of class 4 streams, and 50 ft of class 5 streams. This is only one of several possible RMZ strategies that could be developed but is close to those incorporated into the Washington State Forest Practices Act under the Forest and Fish Agreement.

Forest productivity classes (site index classes) were selected for each owner-forest type combination and land category (i.e., upland or riparian) to reflect the average site index noted in the western Washington timber supply analysis (Adams et al. 1992). With these starting inventories by land category, age class, and owner for three geographic regions of western Washington, each of several possible management strategies were examined with growth and yield simulators. Stands over 40 years of age were assumed to be essentially unmanaged with growth projections taken from empirical yield tables (Chambers 1974, 1978, 1980). Stands under 31 years of age were assumed to have been restocked artificially and were simulated by DFSIM (Curtis et al. 1981) as adjusted for empirically observed stocking levels. Stands between 31-40 years of age were assumed to be half managed and half unmanaged, reflecting the transition to intensive management that took place in the 1960s.

Silvicultural options examined in the simulations included practices which are currently considered to be commercial as well as those stressing the development of stand structures to promote old forest conditions for biodiversity and habitat management purposes. Also included were no-management strategies whereby the forest is placed in reserves and allowed to age undisturbed by man or natural disturbances. The specific options simulated for upland areas were:

1. no-management reserved set-asides
2. natural stand development without intervention except for final clear cut harvests at age 50 or later followed by natural regeneration
3. planted stands with a pre-commercial thin (PCT) and one commercial thin (CT) at age 30 or later with final clear cut harvest at age 50 or later
4. biodiversity management pathways with planted stands followed by three periodic thins leaving ample quantities of woody debris, downed logs, and snags culminating in forests with most of the ecologically functional equivalent features of old forests in about 100 years with rotations of 100 or more years (Carey et al. 1996)
5. a partial cut in existing 60-70 year old stands followed after 20 or more years by conversion to either the commercial (#3) or biodiversity (#4) pathways.

For riparian areas we included a periodic thin sequence similar to the biodiversity pathway used for upland areas with additional emphasis on retention of large trees for in-stream habitat (stream recruitment) and no clear cut of the overstory.

For each of these silvicultural treatment options a set of stand structure classifications and habitat indices as developed in the Washington Forest Landscape Management Project (Carey et al. 1996, 1999) were determined for each stand for every decade in a 200 year planning horizon. Three habitat classifications as defined by the Washington State Forest Practices Board (2000) for spotted owls were also determined. In addition, estimates of timber volumes removed during thinning and final harvest as well as standing timber inventory volume were made. For purposes of an economic analysis, all timber removals were characterized as a function of species and average diameter. The revenue, employment, and state and local tax receipts were determined for each treatment option based on harvest volumes, trend prices, costs, and subsequent processing activities and indirect activities (Lippke et al. 1996). Lastly, estimates of woody debris, downed logs, and snags left behind after thinning and final harvest to promote biodiversity were made.

From these stand-specific treatment options, the best combination (i.e., the optimal harvest/treatment schedule) was determined over a 200-year time horizon using a linear programming model. The objective was to maximize landowner net present value (NPV) using a 5% real discount rate subject to constraints involving forest reserve set-asides required by regulations, habitat goals designed to meet minimum standards, and operational harvest flow constraints restricting the decade to decade change in harvest volumes over time. Thus, for each possible treatment option, a time profile of economic, environmental, and habitat attributes for the 200-year planning horizon was determined for each decade.

To examine a series of policy alternatives, a series of management scenarios was developed. Measuring the change from one management scenario to another with each designed to reflect different minimum habitat levels provides an opportunity to examine the trade-offs between costs vs. benefits for each scenario. Each management scenario is composed of an economic best mix of treatment options to satisfy the constraints. The output for each scenario includes a rich array of economic impacts and environmental attributes over time that facilitates an examination of the cumulative effects. Different stakeholder groups value output measures differently. Measures of critical importance to key groups are:

- Net present value –landowners
- Rural employment –local communities
- Tax receipts –governments
- Habitat and environmental indices –general public and environmental groups
- Economic activity –business, rural communities and governments

Management treatments are identified with a geographic region, land category, and ownership.[7] Spatially sensitive characteristics within one of the eighteen defined groupings are not available. But for studies of this scale (over 9.4 million acres), it is the description across the total region that is of importance. Implementation of operational plans maintaining desirable spatial features should not deviate significantly from these simulated results at this larger scale.

COMPARISON OF ALTERNATIVE RIPARIAN MANAGEMENT STRATEGIES

To better understand the cumulative impact of alternative management strategies for upland and riparian acres, separate scenarios are developed for each land category. Riparian issues are taken up first because of their current importance in policy debates. Subsequently, the upland acres are considered in conjunction with riparian acres. Prior to the 2000 Forest and Fish Agreement, Washington State Forest Practices Act regulations required limited management buffers along fish bearing (type 1-3) streams.[8] The practical response of these regulations on state and private lands led to no-management buffers within about 85 ft of fish bearing streams (Case 1 in this study). These buffer strips remove about 2.5% of all acres from productive management but affect a slightly higher share of the forest value as the acres are of above average productivity. Outside of the 85-ft streamside buffer on fish-bearing streams, forestlands were subject to normal management actions.

Proposals to better protect declining salmon runs include RMZs of various widths[9] with varying degrees of management permitted beyond a strict no-management interpretation. For example, the WDNR HCP on state lands uses a 150-160 ft distance from streams (extended for wind buffers in some areas) largely as a no-management zone. The FEMAT strategy on federal lands involves a 300-ft (largely) no-management RMZ. For all riparian cases examined in this study, to consistently measure biological contributions, an RMZ is designed to cover the acreage within 150 ft of fish bearing type 1-3 streams, 100 ft of type 4 streams and 50 ft of other streams. No management (Case 2) and proactive biodiversity management (Case 3) within the defined RMZ are examined. Extensions of no-management to include unstable slopes outside of the defined RMZ are included as Case 4. Case 3 also includes a 20-ft no-management streamside stability zone.

A significant problem associated with no-management RMZs is that they do not quickly restore old forest biological conditions around streams and thus, to some degree, lock in the existing conditions for a long time (possibly protecting streams from further damage but also preventing significant restoration). Proactive management alternatives based on biodiversity pathways include successively thinning much of the RMZ to retain an overstory while accelerating the production of larger trees for stream recruitment and more rapidly restoring understory conditions in order to achieve old forest functionality (Carey et al. 1996). These alternatives (Case 3) include a no-management streamside buffer for bank stability (20-ft in this study) immediately surrounding a stream and varying degrees of thinning in the remaining portion of the RMZ. Although not directly incorporated in the simulations demonstrated in this study, increased logging and road maintenance costs to reduce stream sedimentation are also likely. Although these increased costs may significantly impact the cash flow for small private forestland owners, the impacts on NPV will likely be small in relation to the impact of harvest losses induced by riparian set-asides.

The riparian and upland strategies described above are examined in Cases 1-4 for the non-federal timberland acres (7.4 million) in western Washington. We assume that all federal acres (2.0 million) are managed according to FEMAT prescriptions and are, therefore, excluded from the first four comparisons. This allows an assessment of changes in riparian regulations for those owners affected by the Washington State Forest Practices Act.

ASSUMPTIONS COMMON TO ALL CASES

For consistency, each case includes forest practice requirements for green tree retention and green-up of adjacent harvest units (we incorporate a 5% harvest loss for all non-thinning harvests), defect/breakage (a 4% loss for thins and 6% for final harvests), and mensurational adjustments (a 5% loss to measure differences between research and operational settings). Timber volumes left as snags, downed logs, and woody debris range from 0% for commercial treatments to as much as 10% for most biodiversity treatments. Harvest flow constraints allow a ± 25% change from decade to decade over the 200 year planning horizon. This level of change reflects historic conditions in western Washington over the past several decades.

Case 1: Current riparian regulatory minimums with an 85-ft no-management streamside buffer. Case 1 simulates the impacts of minimum regulations on all non-federal riparian acres prior to adoption of new rules to protect endangered species. No spotted owl or murrelet reserves, special management zones, biodiversity pathways, or partial harvests are included. Acres beyond the 85-ft no-management streamside buffer on class 1-3 streams are managed using any available riparian silvicultural option.

The results from this simulation are summarized in Table 1 and show that timber harvest revenues produce a before tax NPV of $41.3 billion from non-federal lands–$28.8 billion for private landowners and $12.5 billion for state (including other non-federal public).

Direct and indirect employment resulting from harvesting, processing, and other indirect activities (Lippke et al. 1996) related to state lands is much higher during the first 20 years at 77,000 employment opportunities than the 44,000 opportunities that are sustainable (defined as the 100-200 year average). This reflects the age class distribution of the timber inventory on state land where an excess of mature timber would be harvested early in the 200 year planning horizon to produce the highest NPV. The simulation results show that on private lands, the sustainable long-term employment level exceeds the average during the first 20 years. This occurs because more intensive management practices produce more volume growth relative to today and because no excess timber inventory currently exists.

Employment losses from one scenario to another are not projections of unemployment but are estimates of full time equivalent jobs. Reduced immigration, early retirements, under-employment, new self-employment, etc., may reduce or delay the impact of job elimination on unemployment levels. About half of the estimated total forest sector employment (direct and indirect) occurs in rural communities (Lippke and Conway 1994). Tax receipts are estimated from the economic activity (over $10 billion in final product wholesale activity) and timber revenue at $1,260 million per year.

TABLE 1. Riparian Protection for Western Washington: Economic and Biological Results of Case 1-4 Simulations.

	Acre % in RMZ or buffer	NPV ($ billions)	% Change Case 1	Employment Yr 1-20 Avg (000s)	% Change Case 1	Employment Sustained (000s)	% Change Case 1	Tax Receipts ($ millions)	% Change Case 1	Late Seral Riparian Current Level	Late Seral Riparian 5th Decade (% of Acres)	Late Seral Riparian 10th Decade
Case 1: Regulatory Minimums (Base case with 85 ft. no-management buffers on class 1-3 streams)												
Non-federal total	2.5	41.3		221		197		1260		1	1	12
Private	2.5	28.8		144		153				1	1	11
State	2.5	12.5		77		44				2	2	13
Case 2: No-Management RMZs (RMZs of 150/100/50 ft. on stream classes 1-3/4/5, respectively)												
Non-federal total	14.4	33.9	−18%	176	−20%	178	−10%	1014	−20%	1	7	59
Private	14.2	23.2	−19%	111	−23%	138	−10%			1	6	57
State	15.8	10.7	−14%	66	−14%	40	−9%			2	11	68
Case 3: Proactive Management in RMZs (Except for 20 ft. stream bank buffer)												
Non-federal total	14.4	37.5	−9%	195	−12%	252	28%	1120	−11%	1	55	66
Private	14.2	25.7	−11%	123	−15%	195	27%			1	53	67
State	15.8	11.8	−6%	73	−5%	57	30%			2	64	65
Case 4: No-Management RMZs as in Case 2 plus Unstable Slopes												
Non-federal total	20	31.5	−24%	163	−26%	166	−16%	938	−26%	1	7	59
Private	19	21.7	−25%	103	−28%	130	−15%			1	6	57
State	24	9.8	−22%	60	−22%	36	−18%			2	11	68

Note: State ownership refers to both state and other non-federal public lands.

The no-management streamside buffer constitutes 2.5% of the state and private timberland acres. Acres within the defined buffer that are occupied by late seral[10] stand structure conditions increase from 1-2% (for private and state owners) in the 5th decade to 11-13% by the 10th decade of the 200 year planning horizon. This is a modest but slow restoration of late seral forest riparian conditions resulting from the no-management streamside buffers.

Case 2: No-management within the defined RMZ. The increase in acres taken out of production by assuming no-management within the entire RMZ, relative to Case 1 where only an 85 ft no-management streamside buffer was assumed, are 11.8% for private and 13.3% for state forestlands. The results of the simulation show that the reduction in NPV for the private owners (−19%) is substantially larger than the acreage reduction and about the same as the acreage reduction for the state (−14%). This larger impact on private land is due to the removal of a high percentage of mature acres from the timberland base with no surplus of other mature acres to substitute for the loss. While the age class inventory of state timberlands includes surplus mature inventory, the same conditions do not exist for the private timberlands. The private inventory has been managed more consistently with economic objectives to effectively harvest all mature timber.

Nearly the same percentage declines observed for NPV are also observed for the near term (1-20 year average) employment impacts. However, the sustained long-term employment impact shows only a 10% reduction for both ownership groups–roughly comparable to the increase in unmanaged RMZ acres. This loss in near term economic activity reduces state and local tax receipts (1-20 year average) an estimated $245 million. While there could be some offsetting job gains in fisheries and other wildlife related activities, they appear to be very small in comparison to the timber losses and have therefore been omitted (Brown and Steel 1994). Although important, society's valuation of habitat is generally not adequately reflected in markets; hence we demonstrate the cost to produce a given level of benefits as provided by regulatory policy.

The environmental benefits from no-management in the RMZ include improved habitat measures. The most notable occur around the 10th decade as the larger number of unmanaged acres ultimately take on the ecological functional characteristic of late seral forests. About 60% of the riparian acres and 10% of all acres reach late seral conditions compared to 12% and 2% for current riparian regulations per Case 1–a five fold increase in these critical stand structures. Full restoration of the riparian zone to pre-European forest conditions would require aging of young stands for 15-20 decades although this presumes a resumption of historic natural disturbances. Given the reductions in fire frequency associated with adjacent managed stands, increased stand density and reduced structural diversity are more likely in today's unmanaged forest stands in comparison to natural forest aging in pre-European times.

The $7.4 billion reduction in total forest asset value, the reduction of 45,000 employment opportunities over the first two decades, and a reduction of $245 million per year in tax receipts is a high price to pay for very slow improvements in the old forest habitat measures simulated. This is especially of concern given that historic conditions are not likely to be replicated. It provides high motivation to look for better management alternatives. An additional measure of effectiveness used to compare results across the various cases is the NPV loss per acre of late seral habitat produced in the RMZ by the 5th decade. Measuring Case 2 results against Case 1 shows this to be $116,000 per acre–a very high cost and ineffective program for improving late seral forest habitat conditions.

Case 3: Biodiversity management within the defined RMZ. While the ultimate goal of managing timberlands within the RMZ is to restore populations for fish and other species, lacking a credible link between riparian conditions and fish populations, we substitute a goal of restoring forest conditions to old forest functionality that existed when fish were assumed to be plentiful. This is measured as restoring late seral forest conditions as quickly and as cheaply as possible. Periodically reopening the RMZ canopy by thinning accelerates the development of late seral forest conditions and reduces the economic and near term job and tax receipt losses resulting from no-management. In Case 3, a no-management streamside buffer of 20 ft is retained for stream bank stability.

The simulated results from this scenario show an NPV loss of $3.8 billion (−9%) relative to Case 1 but a $3.6 billion gain relative to the more restrictive no-management RMZ of Case 2. Of special interest, the thinning treatments also raise the long-term sustained employment level by +28%–well above that produced under current regulations. This follows from the effects of successive thins which are labor intensive but produce larger trees of higher quality. This, in turn, supports more value added processing. In the short term, tax receipts are down half as much as Case 2, a $100 million per year improvement.

Late seral forest habitat improvements are also notable. The number of acres that take on late seral ecological functionality in the RMZ under biodiversity management increases to over 50% by the 5th decade. This is five decades quicker than in Case 2. Further, this probably is comparable to pre-European conditions thereby approximating full restoration within the RMZ. The NPV loss per acre of late seral in the RMZ by the 5th decade is $6,400 per acre. While still high, this is a 94% improvement over the no-management (Case 2) alternative.

One undesirable side effect of the periodic thins without a clear cut final harvest is that Douglas fir will, over a very long time (centuries), be replaced by more shade tolerant species. This could be avoided by allowing small clear cut patches for regeneration after successive thins on long rotations (100+ years) while retaining several large trees and adequate woody debris for stream restoration (Lippke et al. 1996). In addition to sustaining biological conditions more consistent with earlier periods in history, this would also further reduce the economic losses from no management to about 35% instead of the 50% noted with the periodic thinning treatments.

Other strategies that hold promise for greater biological restoration with less negative economic consequences require a more site-specific adaptation of these treatments. By concentrating most protection on the streams feeding low gradient rearing ponds, tributaries capable of recruiting large debris, and the sunny side of these streams for temperature control, more protection could be developed while still allowing management activities to occur (Reeves et al. 1995).

Case 4: No-management within the defined RMZ including unstable slopes. The 150/100/50 ft wide no-management RMZ described by Case 2 is on the low side of protection proposed by some interests. One reason is that additional protection for unstable slopes outside of the RMZ may be required. For purposes of Case 4, unstable slopes are those timberlands with slopes in excess of 60 percent gradient. This is used as a proxy for identifying the acres and age class conditions that might be impacted by policies targeting unstable slopes. This increases the acres requiring special treatment another 4.8% for private owners and 7.8% for the state, and results in 20% of all state and private timberland acres being contained within the RMZ.

By including unstable slopes, the NPV loss relative to Case 1 increases to $9.8 billion (−24%) with an estimated state and local tax loss of $322 million per year. The RMZ habitat improvements from unstable slope set-asides are inconsequential in terms of late seral forest structures within the defined RMZ. Further, the benefit of any reduction in upstream slumping and sedimentation is debatable. These slopes are geologically unstable and, perhaps, more subject to disturbances and slumping from natural disturbances than under management regimes that maintain larger healthy trees with lower fire risk. Management alternatives could reduce the cost impact of unstable slopes but require a more site-specific adaptation similar to those discussed earlier for the RMZ. Short-term employment impacts from Case 4 are about 16% lower on private lands and 18% lower on state lands relative to Case 3.

RMZ CASE STUDY COMPARISONS

Differences between economic, employment, and late seral forest habitat impacts of no-management within the entire RMZ (Case 2) compared to both current regulations (Case 1) and a proactive management restoration of the RMZ (Case 3) is shown to be substantial. Adoption of a 300 ft no-management RMZ for private and state owner groups, such as was adopted in FEMAT for federal acres, would likely more than double the impacts demonstrated in Case 2.

The above NPV impacts may be on the low side because they do not take into account additional logging or road costs, impacts of the RMZ on managing adjacent land, or even larger no-management buffers as suggested by some biologists. For example, analysis of implementation of the WDNR's HCP in the Washougal Watershed in S. Central Washington produced preliminary estimates that harvest levels would be reduced 33% and that riparian acres would account for 27% of the total acres (Scheiss 1998). Relative to Case 2, this is roughly twice the acreage that was assumed to be in the protected riparian zone.

COMPARISON OF ALTERNATIVE UPLAND MANAGEMENT STRATEGIES

Beginning in 1990 with the listing of the northern spotted owl as a threatened species, attention focused on alternative management strategies for managing upland forest areas in western Washington. Current minimum regulations include the impact of spotted owl and murrelet protection strategies for all three owner groups defined in this study. To determine the impact of these regulations and the impact of adopting other management strategies, a base case with no owl or murrelet protection on uplands is simulated. Federal timberlands presently contain a large inventory of mature acres. A management strategy based on pure economics would liquidate these mature stands quickly as they lead to

NPV maximization. However, policies adopted by the U. S. Forest Service require nondeclining harvest flow constraints that defer current harvests to avoid any declines in future harvest levels. Since Case 1 demonstrated that state timberlands also hold an excess of mature inventory, the base case for these upland comparisons (Case 5) includes nondeclining flow constraints for federal timberlands while allowing only a ± 5% decade to decade change on state and private timberlands. Other cases examine the impact of minimum regulations and alternative management strategies applied to both uplands and the defined RMZ for the three owner groups.

Case 5: Base case–for comparison across all timberland acres. This case simulates commodity management on all timberland acres. Like Case 1, it includes current minimum regulations on all riparian acres represented as an 85-ft no-management streamside buffer on type 1-3 streams (2.5% of all acres). In addition, for upland acres it includes green tree retention on harvest units, green-up of adjacent harvest units, defect/breakage, and mensurational adjustments as previously defined. No spotted owl or murrelet reserves are included. The biodiversity pathway and partial harvest options on upland acres are not included.

To avoid rapid liquidation of the excess mature inventory, nondeclining harvest constraints are imposed on the federal ownership. Use of the ± 5% change from one decade to the next was imposed on state and private owners. These harvest flow constraints result in economic losses of −52% for federal, −11.5% for state and −4% for private owners when compared to less restrictive ± 25% harvest flow constraints for each ownership. These losses reflect the potential of each ownership group to convert excess mature inventory into marketable forest products in the first several decades of the 200-year planning horizon. The excess mature private timber inventory is largely located on the timberland of non-industrial owners. In recent years, they have been reducing their excess mature inventory. The excess mature timber inventory on state timberlands has been a consequence of conservative timber harvest policies (Bare et al. 1997).

The results of the Case 5 simulation shown in Table 2 reveal a $48.4 billion NPV for all western Washington timberlands–$27.7 billion for private, $11.1 billion for state, and $9.6 billion for federal timberlands. This supports a forest sector with 254,000 sustained direct and indirect job opportunities. Tax receipts during the first 20 years average $1.5 billion per year. However late seral forest structures across western Washington uplands are reduced from the current level of 11% of the

TABLE 2. Management Alternatives for Western Washington: Economic and Biological Results of Case 5-9 Simulations.

		NPV ($ billions)	% Change Case 5	Employment Yr 1-20 Avg (000s)	% Change Case 5	Employment Sustained (000s)	% Change Case 5	Tax Receipts ($ millions)	% Change Case 5	Late Seral Acres Current Level	Late Seral Acres All Acres Avg % of Acres	Late Seral Acres Riparian Avg
Case 5:	**Base Case (with 85 ft. no-management buffers on class 1-3 streams; no owl or murrelet protection)**											
	Total	48.4		268		254		1485		11	3	11
	Private	27.7										
	State	11.1										
	Federal	9.6										
Case 6:	**Minimum Regulations**											
	Total	37.9	−22%	207	−23%	216	−15%	1166	−21%	11	17	25
	Private	25.7	−7%									
	State	10.5	−5%									
	Federal	1.7	−82%									
Case 7:	**Proactive Management on Other Public and Private**											
	Total	37.5	−23%	191	−29%	261	3%	1099	−26%	11	22	60
	Private	24.7	−11%									
	State	11.1	0%									
	Federal	1.7	−82%									
Case 8:	**HCP on Other Public**											
	Total	33.4	−31%	176	−34%	196	−23%	993	−33%	11	21	32
	Private	25.7	−7%									
	State	6.0	−46%									
	Federal	1.7	−82%									
Case 9:	**Proactive Management on All Ownerships**											
	Total	43.3	−11%	233	−13%	282	11%	1333	−10%	11	21	61
	Private	24.2	−13%									
	State	11.2	1%									
	Federal	7.9	−18%									

Note: State ownership refers to both state and other non-federal public lands area to only 3% (on average) over the 200 year planning horizon–nearly eliminating the critical habitat for owls and murrelets. This latter consequence provides justification for regulatory constraints under the Endangered Species Act and changes to Washington State's Forest Practice Rules. While this base case reflects the economic benefits of market opportunities, biological consequences have proven to be socially unacceptable. The remaining cases investigate potentially more acceptable alternatives.

Case 6: Minimum regulations. Current minimum regulations and practices for western Washington uplands include the use of no-management forest reserves under FEMAT prescriptions on federal timberlands as well as owl/murrelet protected areas on private and state timberlands. The 2000 Washington State Forest Practices Rules require protective spotted owl and marbled murrelet special emphasis areas in addition to green tree retention on harvest units. In addition, an 85-ft no-management buffer along stream types 1-3 (as per Case 1) is assumed to be the current practice under the regulations. In Case 6, harvest flow constraints for private and state timberlands were made less severe by allowing up to ± 25% change per decade in order not to overly constrain meeting the regulatory minimums. Nondeclining harvest flow constraints remain in effect on federal lands. Thus, this case may understate the economic impact of more restrictive regulations as the severity of the flow constraints was reduced. No biodiversity pathway or partial harvest options are included in this case.

As mentioned above, different minimum protection requirements for owls and murrelets are in effect for each landowner. For federal timberlands managed under FEMAT prescriptions, only 21% of the acres appear to be available for harvest activities. In addition, under FEMAT requirements, the volume left to satisfy woody debris requirements was estimated to reduce removable harvest volumes an additional 10%. A simulation using these assumptions supports an annual harvest of 233 million board feet, which is well above both recent U. S. Forest Service harvest levels as well as future projections. Thus, even these assumptions may overstate the volume of future federal harvests. For state and private lands, prior studies were used to estimate the impact of owl protection under different regulations (Lippke and Conway 1994, Bare et al. 1997). For state lands, 105,000 acres of mostly mature timberland were estimated to be in protected circles around owl nests. The comparable private acreage was 82,000 acres. These estimates may understate the full impact of minimum owl and murrelet regulations as they assume a high degree of overlap between owl and murrelet zones and may not consider the long-term affects of other acres being impacted as forests mature. Nevertheless, this estimate demonstrates the impact of different management alternatives in providing comparable levels of habitat protection.

Simulated results from Case 6 reveal that the NPV for all owners is reduced by $10.5 billion–a reduction of 22% from Case 5. Seventy-five percent of the loss is attributed to the FEMAT prescriptions on federal land. The first 20-year average employment level is reduced by 61,000 job opportunities and sustainable employment is reduced by 38,000 opportunities. Tax receipts during the first 20 years are down by $319 million per year relative to Case 5.

The environmental benefits under the minimum regulations of Case 6 relative to base Case 5 are quite notable. As shown in Table 2, the 200-year average percentage of late seral forest structures increases to 17%–a 55% increase from the base case levels. As an effectiveness measure, the 14% increase in late seral acreage (1.3 million acres) costs $7,955 of NPV for each additional late seral acre.

Case 7: Biodiversity management on uplands and the defined RMZ on non-federal lands. In this simulation, biodiversity management and partial harvest regimes are allowed on upland as well as riparian acres (Case 4) for all non-federal owners. In addition, habitat constraints are imposed that require at least as much habitat as resulted from the use of minimum regulations (Case 6). These options are not available for federal lands that continue to be managed under FEMAT guidelines. In Case 7, harvest flow constraints for private and state timberlands allow a ± 25% change from decade to decade while nondeclining harvest flow constraints remain in effect on federal lands.

Simulation results shown in Table 2 for all owners show a NPV of $37.5 billion that is $0.4 billion less than minimum regulations (Case 6) and 23% less than the base case (Case 5). Recall that a loss of $3.8 billion was generated from managing the defined RMZ (Case 3 vs. 1). Most of this loss is offset by the lower cost required to reach similar levels of upland habitat. Sustained employment increases by 45,000 over minimum regulations (Case 6) as a consequence of the additional management activities and higher quality wood produced from the larger trees. However, during the first 20 years, average employment opportunities are down 16,000. This is a substantial improvement over the 26,000 job opportunities lost from managing the defined RMZ versus minimum regulations (Case 3 vs. 1)

By setting goals for the number of habitat acres with late seral forest functionality to be the same or better as under minimum regulations (for private and state acres), comparable levels of upland habitat are produced. The percentage of late seral acres for all owners is increased from 17 to 22%. This is 100% above current levels and is better than the 55% gain under minimum regulations.

Results in Table 2 also show that there is a $3 billion loss for private owners versus the Case 5 base case and a $1 billion loss relative to minimum regulations (Case 6). This latter loss is less severe than the $3.8 billion loss for the RMZ restoration (i.e., Case 1 vs. 3). State lands show no loss from the base case and a $0.6 billion gain over minimum regulations. This latter gain is better than the $0.7 billion loss for RMZ restoration. By combining proactive management options with less restrictive harvest flow policies, it is possible to more than offset the RMZ losses for state lands. This is possible because reserves for spotted owls and murrelets are a significant share of the harvestable acres and thus permit more substitution of managed habitat for reserves than was possible on private lands. The first 20 year average tax receipts loss is $386 million per year relative to the base case and $67 million per year relative to minimum regulations (Case 6).

Case 7 demonstrates that substantial improvement in both riparian and upland habitat can be achieved with little or no cost increase over current minimum regulations (Case 6). The combined cost of owl, murrelet, and a no-management RMZ is $10 billion for private and state owners, but is reduced to $3 billion under the biodiversity and partial harvest alternatives of Case 7. The 19% increase in late seral (1.8 million acres) over Case 5, costs $6,080 per acre and produces late seral habitat much faster compared to minimum regulations.

Case 8: Habitat conservation plans (on state trust lands). In order to obtain an incidental take permit under the Endangered Species Act, some landowners in western Washington have developed Habitat Conservation Plans (HCP). The biggest developed to date is that of the WDNR–manager of the state trust lands. The WDNR HCP is being implemented on 1.6 million acres of forestland–mostly in western Washington (WDNR 1996). Some private timberland owners developed HCPs as well. However, adequate data for each of these were not available in a comparable format.

Generally, HCPs are expected to provide habitat protection comparable to (or in excess of) that produced by meeting minimum regulatory requirements in exchange for economic relief and regulatory certainty. There is insufficient data available on private HCPs to adequately characterize their cumulative impacts. However, because the WDNR HCP has been extensively analyzed, adequate data describing its impacts are available (WDNR 1996, Bare et al. 1997). Case 8 simulates the consequences of the WDNR HCP, while private and federal timberlands are managed under the same assumptions that were in effect for Case 6.

Results for Case 8 in Table 2 show that the NPV for the WDNR HCP on state lands is $5.1 billion less than that expected under the more proactive forms of management assumed in Case 7 and $4.5 billion less than that observed under minimum regulations. This demonstrates that the WDNR HCP greatly exceeds minimum regulations. While the area of upland habitat that attains a late seral stand structure reaches the same level as under alternative management, the no-management emphasis in the RMZ provides most of the restoration. The 18% increase in late seral (1.7 million acres), costs $8,838 per acre. However, the 0.4 million acres of additional late seral acres on state land costs $15,040 per acre. This is essentially the full cost to put mature acres in reserves.

Case 9: All-owner proactive management. The last case examined allows for the use of biodiversity pathways and partial harvests on upland acres for all owners, not just for private and state owners as in Case 7. The heavy reliance on unmanaged reserves by federal timberland managers does not allow for the timely improvement of biodiversity even when it is advantageous to both habitat and rural communities. By allowing for biodiversity pathways on private land and state land (Case 7) and, in addition, on one-half of the unmanaged federal uplands (1/3 of the federal timberlands), additional economic benefits are possible.

Table 2 shows that NPV losses for Case 9 are reduced by $5.1 billion for all owners relative to base Case 5 and $5.4 billion above the all-owner minimum regulations (Case 6). However, because the late seral forest habitat constraints are met across the collective area of the three owner groups, private NPV losses are greater than under minimum regulations. The single biggest gain in NPV occurs on the federal lands where the NPV increases by $6.2 billion relative to minimum regulations. Employment over the first 20 years averages 35,000 job opportunities below Case 5, but 26,000 above minimum regulations. Sustained employment opportunities are 28,000 above Case 5 and 66,000 above minimum regulations. Tax receipts during the first 20 years are $152 million per year below Case 5 but $167 million above minimum regulations.

The proportion of the area reaching late seral habitat structures is essentially the same as for Case 7. Therefore, the overall effectiveness at reaching habitat goals is 15% higher–equal to the NPV improvement.

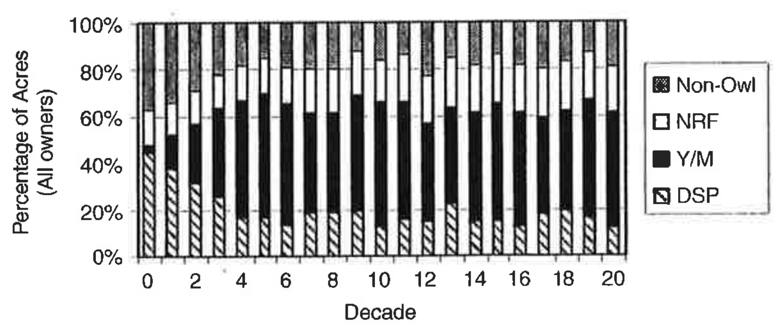
The 18% increase in late seral (1.7 million acres) costs $3,000 per late seral acre–considerably less than the other alternatives.

ADDITIONAL HABITAT AND BIODIVERSITY MEASURES

The analyses discussed above emphasized the development of late seral forest structures. However, for each policy simulation, we produced a time profile that included additional measures of ecosystem health. As a demonstration, we include Figures 1-4 to illustrate the types of information included in the time profile for each policy simulation. These figures represent all forest owners in western Washington for the conditions established for Case 7. They do not show the differential impacts that accrue to different owner groups.

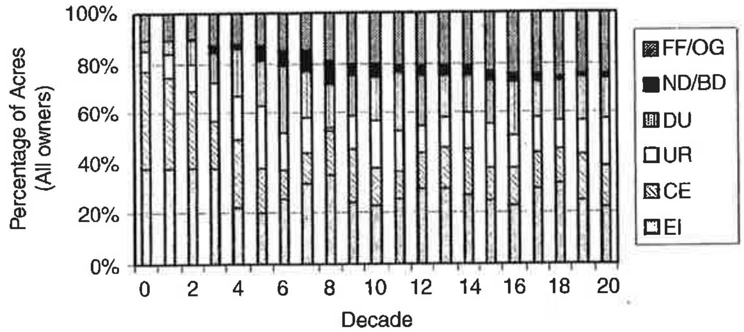
Figure 1 illustrates the changing nature of the landscape across western Washington in terms of percentages of the area occupied by three categories of spotted owl habitat as defined by the Washington State Forest Practices Rules (2000). Results show that the total number of acres suitable for owls is expected to increase over initial conditions. However, dispersal acres decline in order to produce more acres of nesting, roosting, and foraging (NRF) and sub-mature and young forest (Y/M) habitat conditions. The Y/M habitat class acreage increases the

FIGURE 1. Washington State Forest Practice Board Owl Habitat (Case 7)



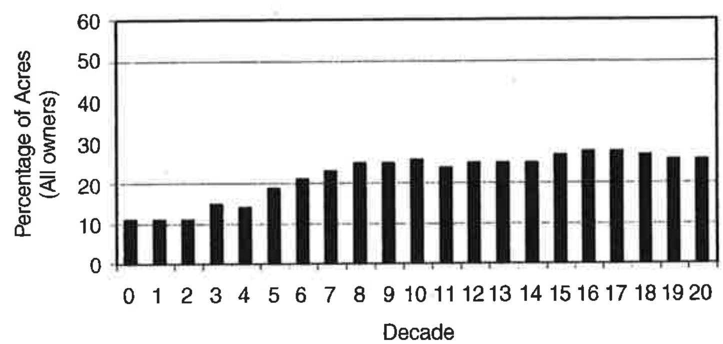
NRF FPB definition of nesting, roosting, and foraging habitat.
Y/M FPB definition of young forest to mature habitat.
DSP FPB definition of dispersal habitat.
Non-owl Is not owl habitat under the FPB Rules.
Source: Washington State Forest Practices Rules (2000)

FIGURE 2. Stand Structure Distribution (Case 7)



EI Stand initiation stage.
CE Competitive exclusion stage.
UR Understory re-inititiation stage.
DU Developed understory stage.
ND/BD Niche and botanically diverse stage.
FF/OG Fully functional and old growth stage.
Source: Carey et al. (1999)

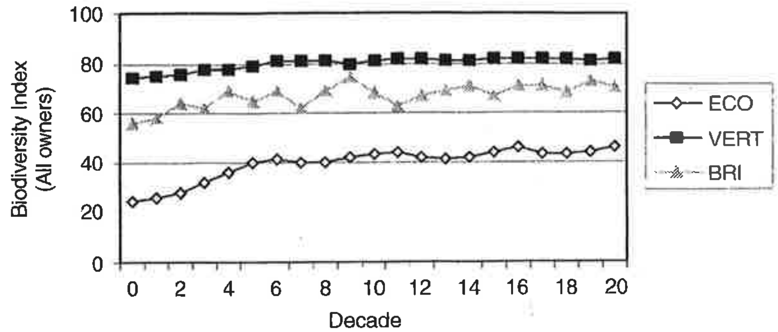
FIGURE 3. Late Seral Stand Stucture (Case 7)



Late seral Includes the niche diverse, botanically diverse, fully functional, and old growth stand structure stages.
Source: Carey et al. (1999)

most over the planning horizon. Figure 2 illustrates how the landscape changes when characterized by the eight stand structure classes of Carey and Curtis (1996). Acreage in the fully-functional/old-growth (FF/OG), developed understory (DU), and understory reinitiation (UR) classes increase at the expense of acres in the ecosystem initiation (EI)

FIGURE 4. Biodiversity Indices (Case 7)



ECO Ecosystem Productivity Index.
VERT Vertebrate Index.
BRI Biodiversity Restoration Index.
Source: Carey et al. (1999); Xu (1997)

and competitive exclusion (CE) classes. This is a reflection of the late seral forest habitat constraints imposed on the Case 7 simulation. It illustrates that while acreage with late seral forest functionality has increased over time, young forest acreage has decreased. Thus, while some at-risk species such as spotted owls and murrelets may benefit, other species may be put at greater risk because of such management. Figure 3 further illustrates the changing nature of the landscape by showing the development of late seral acres over time. Figure 4 illustrates the time profile of two biodiversity indices used by Carey et al. (1999) and a broader restoration index used by Xu (1997). Carey et al. utilized a vertebrate index and an ecosystem index, with the latter measuring the fruits of the forest serving the owl food chain. Xu's index is based on the deviation of stand structures from estimated pre-European conditions. Each index helps to characterize the health of different components of the ecosystem. They all show a slightly increasing trend over time under the proactive management regimes of Case 7.

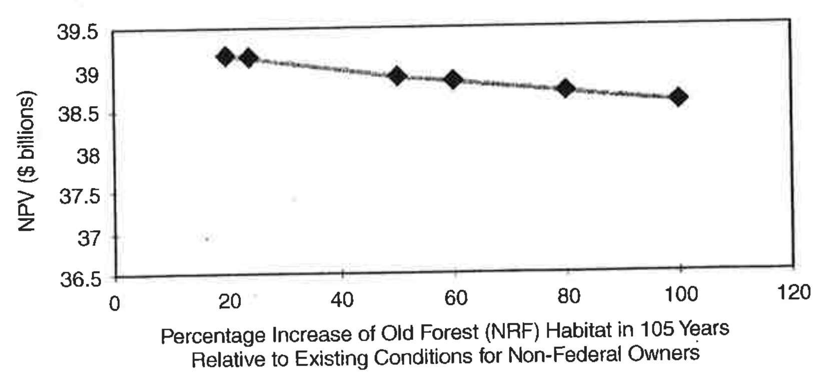
SENSITIVITY IMPACTS OF DIFFERING OLD FOREST HABITAT GOALS

One of the most important issues facing decision makers is how to manage western Washington timberlands if the goal is to increase the percentage of the area covered with old forest structures relative to present day conditions. To examine the impact of reaching various percentages of restoration at different points in the future, a series of additional simulations were performed.

NPV loss from increasing the old forest habitat goals. The first sensitivity analysis simulation examined the impact on NPV associated with producing higher percentages of old forest habitat stand structures (i.e., nesting, roosting, foraging (NRF) habitat) as defined in the Washington State Forest Practice Rules (2000). Goals of increasing old forest structures 105 years in the future were varied from 20-100% over existing levels on non-federal acres. Because FEMAT management prescriptions were assumed to apply on federal timberlands, no increase was imposed on these acres. The lowest habitat goal of a 20% increase is satisfied almost entirely from federal lands. As shown in Figure 5, the NPV loss is nearly linear over the range examined and is $7.25 million per 1% increase in old forest structures, or $77 per additional acre of old forest produced 105 years in the future. The upper limit of the old forest habitat goal was not tested but at some level above a 100% increase over initial old forest acres, the NPV would fall off rapidly.

NPV loss from achieving old forest habitat goals sooner in time. Another sensitivity simulation examined the NPV loss associated with reaching a 50% increase in old forest structures (relative to current conditions) sooner in time. As shown in Figure 6, the target year for reaching a 50% increase was varied from as little as 45 years in the future to as much as 185 years. Results show almost no NPV increase for shifting the target age beyond 105 years. The NPV loss for decreasing the target

FIGURE 5. NPV with Increasing Old Forest (NRF) Habitat



to 85 years in the future was only 0.2%, but the loss for moving the target age to 45 years increased by 6%. While it is not possible to reduce the target below 45 years unless additional silvicultural options are defined for non-federal land, it is possible to produce old forest structures more quickly if the federal timberland acres are managed in like manner. Under FEMAT prescriptions which rely heavily on set-asides and natural aging, old forest structures develop very slowly.

Increasing the minimum old forest habitat during transition to goal attainment. Figure 7 shows the impact on NPV of more tightly constraining the allowable decline in the old forest habitat percentage relative to its current level. Constraining interim reductions in old forest

FIGURE 6. NPV as a Function of Years to Increase Old Forest (NRF) Habitat by 50%

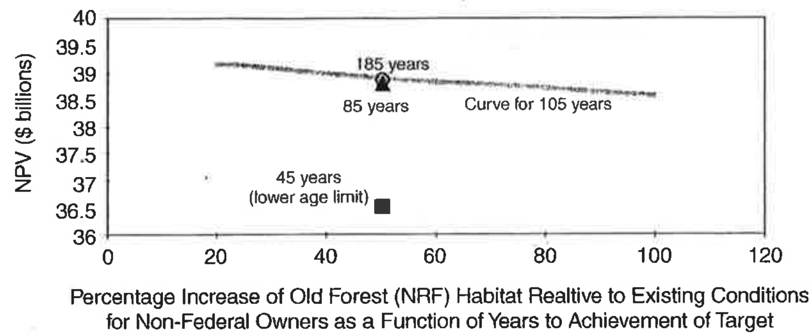
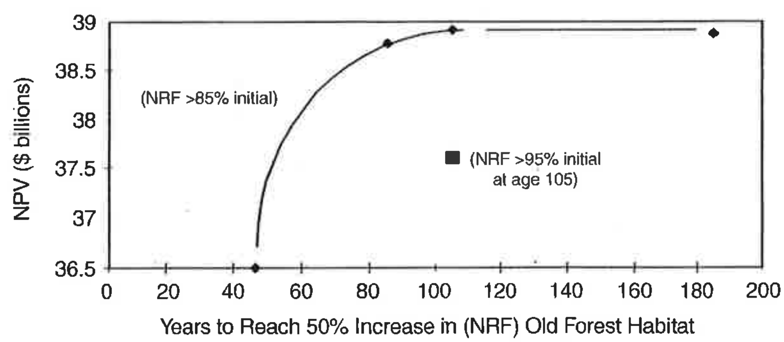


FIGURE 7. NPV as a Function of Years to Increase Old Forest (NRF) Habitat by 50% for 85 and 95 Percent Allowable Declines



habitat to not less than 95% of the initial level in contrast to the 85% assumed in the previous simulations results in a 3% reduction in NPV. The average loss for retaining an additional 10% of the initial old forest is $8,730 per acre of old forest structures.

These sensitivity comparisons suggest that the cost required to motivate landowners to produce substantially more old forest structures over time, so long as the period of time to reach the target is 50 years or more, is low. Current regulations do not provide any motivation for this approach to restoration. Constraining the amount of old forests that can be harvested in the early years comes at a much higher average cost (e.g., $9,000 per acre) because it approaches the cost of a set-aside strategy. This essentially eliminates the possibility for management options to accelerate the creation of old forest structures.

CONCLUSIONS

Riparian strategies that require no-management within an RMZ (similar to those being applied on federal timberlands [300 ft widths]) would likely reduce state and private timber asset values by as much as $18 billion, with a loss of as many as 65,000 employment opportunities (larger in the first few decades) with about one-half occurring in rural areas. A no-management strategy in a smaller RMZ (150 ft on type 1-3 streams, 100 ft on type 4 streams and 50 ft on type 5 streams) is expected to reduce state and private timber asset values by $7.4 billion, 20,000 job opportunities (in the long term), and considerably more in the first few decades (with about one-half occurring in rural areas).

Proactive management within the defined RMZ in order to promote the development of late seral forest functionality more quickly may only cut the cost in half to $3.8 billion. However, it also cuts in half the time that it takes the riparian forests to achieve 50% late seral conditions. Effectiveness measured in terms of cost per acre of late seral functionality in the RMZ by the 5th decade is reduced from $116,000 per acre of late seral increase to $6,400 per acre, an improvement of 18 times in habitat per dollar of cost to the landowner.

Upland strategies to provide minimum (current) regulatory protection for the owl and murrelet cost more than $10.5 billion in timber asset values with about 75% traced to the imposition of the FEMAT strategy of set-asides on federal timberlands. Meeting minimum regulations produces a rising trend in the percentage of late seral stand structures with a loss of 30,000 rural job opportunities and $320 million per year of state and local tax receipts over the first several decades.

The planned implementation of the WDNR HCP on state timberlands raises the loss to $15 billion with about 46,000 fewer rural job opportunities in the first few decades. Late seral functionality is not restored in the RMZ until after the 5th decade.

Through use of proactive management strategies on private and state timberlands, the cost in riparian and upland areas can be reduced to $10.9 billion while more quickly restoring the RMZ to late seral forest functionality. No sustained job losses are anticipated as a consequence of the increased forest management activity. However, these benefits take several decades to materialize and there could be 8,000 less rural job opportunities than under minimum regulations during the first few decades. This is a much smaller loss than the 24,000 rural job opportunities lost if no-management is required in the RMZ.

Adopting proactive management strategies on federal lands can cut the economic impacts in half, thus greatly improving the cost effectiveness to rural communities. However, there is no direct benefit to private and state timber owners.

NPV reductions to attain higher percentages of old forest (NRF) stand structures are not large for increasing levels of habitat beyond 100 years, and even quite moderate for reaching habitat targets as early as 50 years. The cost for incremental acres of old forest functionality after 100 years is as low as $80 per acre. The cost of reaching a 50% increase in old forest functionality in half that time is $3,600 per acre.

NPV reductions associated with setting aside mature acres that could otherwise be harvested are much larger. The cost of not allowing a 10% interim decline in old forest (NRF) habitat percentages is $8,730 per acre–rapidly approaching the full cost of a reserve acre. There must be some flexibility in the near term old forest percentage target in order to benefit from substituting managed stands for unmanaged stands. It takes some time after thinning for the improved habitat to be realized. Given the potential economic savings and environmental benefits demonstrated for management alternatives designed to restore old forest structures, more research to better characterize the relationship between old forest structure and habitat functionality will have a high return.

NOTES

1. Timberlands refer to commercial unreserved forestlands used primarily for timber production and multiple use.

2. The term "state" ownership refers to both state and other non-federal public lands.

3. Riparian acres refer to those acres within defined distances of streams and wetlands.

4. Presently, the federal harvest in western Washington accounts for about 1.5% of the total.

5. Recent evaluation of the initial calibration suggests that the RMZ used in the study may understate the acreage found within 150 ft of class 1-3 streams, 100 ft of class 4 streams and 50 ft of class 5 streams by 18%. In addition, the State is in the process of redefining and remeasuring fish bearing streams and preliminary indications suggest the mileage of fish bearing streams may increase substantially.

6. Type 1-3 streams are greater than 2 feet wide containing significant fish populations and habitat for many fish species such as coho, steelhead and resident game fish; type 4 streams are greater than 2 feet wide without fish populations; type 5 streams are less than 2 feet wide with intermittent flows and no fish populations.

7. Land classifications include 2 land categories, 3 geographic regions, and 3 owners, each with its own age class distribution, for a total of 18 separate profiles.

8. Under the recently adopted Forest and Fish Agreement, the riparian management zone ranges from 140-170 ft in width for average to good site land along Type 1-3 streams. This includes a core 50-ft no harvest buffer; an inner zone ranging from 43-78 ft; and an outer zone ranging from 47-42 ft. Harvesting is permitted within the inner and outer zones if specific stand density conditions are satisfied.

9. RMZ widths refer to only one side of a stream.

10. Late seral acres refer to those acres containing diverse forest structures capable of supporting the ecological functions of old forests. Using the Carey and Curtis (1996) stand structure classification system, late seral includes the niche diverse, botanically diverse, fully functional, and old growth classes.

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