ECONOMIC CONSIDERATIONS IN MANAGING FOR OLDER FOREST STRUCTURE

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ABSTRACT

Forest conomists at Oregon State University have been conducting analyses of cost-effective management for older forest structure on private forest land in western Oregon. We describe three studies in this paper: a stand-level study, a forest-level study, and a simulation of forest certification. We also present a case study in which a stand not part of the original study is used to demonstrate how results from the stand-level study can be applied to a typical production forest stand in such a way that generates more complex structure in a relatively cost-effective manner.

KEYWORDS: Management regimes, opportunity cost, older-forest structure.

INTRODUCTION

For several high-profile wildlife species of concern in the Pacific Northwest, old-growth conifer forest is a critical component of habitat. But its area is dwindling. While these forests may once have covered 30 percent to 70 percent of the western Oregon coastal-forested landscape (Teensma et al. 1991, Wimberly et al. 2000), it is estimated that they now account for only about 5 percent (Spies et al. 2002). Concern about this loss has fueled a number of responses that seek to preserve and enhance the area of older forest on production forests of the Pacific Northwest. We believe that, regardless of the goal of a conservation program or the means by which it may be implemented, the more cost-effective it is, the more likely it will be accepted and implemented.

In three recent studies by forest economists at Oregon State University, different aspects of cost-effective active management for stands that are structurally similar to old-growth on private forest land in western Oregon have been explored: (1) stand-level silvicultural regimes, (2) forest-level targets for the area of structurally old forest, and (3) the effectiveness of certification in achieving forest-level targets.

In the first study, Latta and Montgomery (2004) used a random search heuristic and an individual tree simulation model, ORGANON (Hann et al. 1997), to search for cost-effective old forest management regimes for a wide range of stand types that occur on private land in western Oregon. The regimes were required to meet older forest structural criteria, defined by the Oregon Department of Forestry (Oregon Department of Forestry 2001), for 30 years prior to clear-cut harvest. The opportunity cost of managing for older forest structure was estimated for each stand type as the value of forgone timber production under maximum net present value management. Opportunity cost was found to be positively correlated with site quality, stand age, and stocking.

In the second study, Montgomery et al. (2006) examined the use of active management to achieve targets for the area of private forest land in western Oregon that meet these old forest structural criteria within a range of time frames. The idea of area targets is consistent with standards for sustainable forestry that include measures of the extent of area in the full range of forest successional stages (Montreal Process Working Group, http://www.mpci.org, accessed in August 2004). A model of regional timber

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supply was used to search for cost-effective strategies to reach these targets. The model provides a method for quantifying tradeoffs between the area and timing of alternative targets. It was estimated that a target of 20 percent of private forest area that met older forest structural criteria within 95 years could be achieved at an aggregate loss to forest landowners and lumber and plywood manufacturers of $341 million[3]; doubling the area target from 20 to 40 percent could increase cost 3.4 times and extending the time horizon by 25 years could reduce the cost four-fold.

In the third study, Busby et al. (in press) used the same regional timber supply model for western Oregon to simulate the response of private forest landowners to incentives to certify their forest land. In the case of a $35 per acre certification bonus payment, 20 percent of the forest area was certified within a 100-year time horizon; with a $69 per acre certification bonus payment, 60 percent of the area was certified. However, the ecological benefit of certification, measured in terms of forest area meeting older forest structural criteria, was minimal.

In this paper, we use a case study to illustrate how foresters can use the information from these studies, particularly Latta and Montgomery (2004), to meet sustainability objectives related to older forest structure while generating income from timber harvest. In the next section, a case study stand is described. Stand development under three different management regimes is simulated and costs compared. A discussion of factors leading to the type of older forest structural management regime found in the studies follows. The paper concludes with a brief discussion of the trade-offs involved in identifying optimal versus pretty good management regimes.

CASE STUDY

In the Latta and Montgomery (2004) study, management regimes were developed for a range of stands using an optimization algorithm. While forest land managers are unlikely to have access to such a program, it may be possible for them to generalize from the results of that study in order to generate pretty good regimes for the stands they manage.

To illustrate, a 15-year-old even-aged Douglas-fir stand from Lincoln County, Oregon was selected. This stand was not part of the original study. It was planted using a ten-by-ten ft spacing and it currently has 474 trees per acre, 15 of which are hardwoods (97 percent of normal stocking). The 50-year Douglas-fir site index is 133 and the current quadratic mean diameter is 4.9 in.

Only a brief description of the growth and yield, silvicultural regimes, logging and other costs are provided here. Additional details may be found in Latta and Montgomery (2004).

Silvicultural Regimes

Growth of the case study stand was simulated for 100 years under three different management regimes: one designed to maximize the net present value of timber harvest with no other objective, one designed to maximize the net present value of timber harvest while generating a stand that meets older forest structural criteria within 125 years, and one that set aside the stand in a reserve with no timber management activities allowed. The first two regimes were based on the optimization results published in Latta and Montgomery (2004).

In tables 1 and 2, we show the average values reported in Latta and Montgomery (2004) for number of years to thinning and percent volume removed in up to three proportional thinnings from the optimized management regimes that meet older forest structural criteria within 125 years. In table 1, the regimes are for newly regenerated stands and, hence, years to thinning are stand ages. The regimes are summarized for all stand types, by forest type, by site class, and by ecological region. In table 2, the regimes are for the 834 existing stands that were included in the original study. Average number of thinnings is shown because less than three thinnings were prescribed for some stands. Again, these are summarized for all stand types, by age class, and by stocking level.

Ideally, a land manager, seeking to achieve older forest structural criteria while maximizing the value of the stand, would find the optimal regime for each existing stand using an optimization algorithm. Or, as a second-best strategy, the manager would identify the regime for the stand in the original study that most closely approximates the stand that is being managed. But this study demonstrates how the published results can provide the basis for a pretty good older forest structural regime.

[3] All dollar values in the paper are in 2005 dollars.

Table 1—Silvicultural regimes for achieving older forest structure in 125 years in newly regenerated stands. Years until thinning is equivalent to total stand age for regenerated stands

	Years until thinning / percent volume removed		
Prescription Categories	**1st thinning**	**2nd thinning**	**3rd thinning**
All stand types	40 yr/63%	59 yr/56%	79 yr/40%
By forest type:			
Douglas-fir	39 yr/63%	57 yr/62%	76 yr/46%
Other conifer	42 yr/63%	63 yr/48%	83 yr/32%
By site index:			
Over 135	33 yr/61%	49 yr/63%	68 yr/52%
115 to 135	39 yr/61%	54yr /60%	76 yr/40%
95 to 115	45 yr/67%	65 yr/51%	85 yr/37%
95 and under	41 yr/60%	66 yr/54%	86 yr/30%
By ecological region:			
West Coast Range	35 yr/61%	56 yr/54%	78 yr/38%
Other Coast Range	40 yr/66%	57 yr/62%	79 yr/34%
West Cascade Range	39 yr/61%	57 yr/55%	75 yr/49%
Klamath	55 yr/65%	73 yr/53%	89 yr/36%

Table 2—Silvicultural regimes for achieving older forest structure in 125 years in existing stands

		Years until thinning / percent volume removed		
Prescription Categories	**Thinning**	**1st thinning**	**2nd thinning**	**3rd thinning**
All stand types	2.6	18 yr/68%	3 9yr/60%	72 yr/42%
By age class:				
20 and under	2.5	31 yr/67%	51 yr/63%	78 yr/42%
20 to 40	2.6	12 yr/68%	34 yr/59%	69 yr/43%
40 to 60	2.6	5 yr/68%	28 yr/58%	68 yr/40%
60 to 80	2.8	4 yr/69%	28 yr/58%	71 yr/36%
over 80	2.9	6 yr/69%	35 yr/56%	67 yr/42%
By percent of normal stocking:				
40 percent and under	2.6	28 yr/67%	50 yr/61%	77 yr/43%
40 to 120 percent	2.6	11 yr/68%	32 yr/60%	68 yr/40%
over 120 percent	2.5	6 yr/68%	28 yr/56%	68 yr/42%

In developing a pretty good older forest structure management regime, a manager could select and average the applicable prescriptions from the categories presented for newly regenerated stands (table 1) and/or older existing stands (table 2). Prescription categories for regenerated stands are: all stand types, forest type, site index, and ecological region (table 1). Similarly, prescription categories for existing stands are: all stand types, age class, and percent of normal stocking (table 2). A manager could then select an applicable prescription, or multiple prescriptions from appropriate categories in tables 1 and, or 2 and then develop a composite thinning regime by averaging the values for 1) years until thinning and 2) percent volume removed.

To illustrate this process, we show in table 3 the applicable thinning prescriptions from tables 1 and 2 that relate to the case study stand. Because the 15 year-old case study stand is close to falling between a newly regenerated and an older existing stand, prescriptions from both tables 1 and 2 apply. Activities in table 3 are presented at total stand age (e.g. from existing stands table 2, years to thinning

Table 3—Silvicultural regimes for the case study stand from tables 1 and 2. Years until thinning is equivalent to total stand age for the case study stand, which is 15 years old at the start of the simulation

	Years until thinning / percent volume removed		
Prescription categories (from tables 1 and 2)	**1st thinning**	**2nd thinning**	**3rd thinning**
Table 1, all stand types	40 yr / 63%	59 yr / 56%	79 yr / 40%
Table 1, forest type, Douglas-fir	39 yr / 63%	57 yr / 62%	76 yr / 46%
Table 1, Site index, 115-135	33 yr / 61%	49 yr / 60%	68 yr / 40%
Table 1, Ecological Region, West Coast Range	35 yr / 61%	56 yr / 54%	78 yr / 34%
Table 2, all stand types	33 yr / 68%	54 yr / 60%	87 yr / 42%
Table 2, age class, < = 20	46 yr / 67%	66 yr / 63%	93 yr / 42%
Table 2, percent of normal stocking 40-120 percent	26 yr / 68%	47 yr / 60%	83 yr / 43%
Averages	36 yr / 64%	55 yr / 59%	81 yr / 41%

plus 15). Simply averaging these prescriptions and rounding to the nearest five yields the following prescription: 65 percent volume removed at age 35, 60 percent volume removed at age 55, and 40 percent volume removed at age 80. We also simulated this stand as if it was set aside as a reserve for 100 years and as if it was managed for maximum net present value of timber harvest. The latter regime involves a clearcut timber harvest every 40 years and no thinnings.

Economic Returns

An important aspect of valuing forest stands is accounting for the time value of money. Because returns on forestry investment alternatives occur in varying years and far in the future, the methodology employed in determining the present value of those alternatives is important. To simplify this analysis, we used a simple discounting formula for each of the thinning and final harvest returns for each of the three regimes. The financial value of the growing stock was evaluated at the end of the 100-year time horizon and discounted to present as well. Because each dollar in 2106 is worth only one third of a penny in 2006, this is a valid approximation of the total stand value.

In table 4, the volume and value of the removals under each of the three regimes are shown, along with the value of the standing inventory at the end of 100 years. These values were discounted using three different interest rates: 4-, 6-, and 8-percent. Log price is an average of #2 and #3 sawlog prices projected for a 50-year base case in a recent western Oregon timber supply study (Adams et al. 2002). Logging costs were computed using equations from Fight et al. (1984) that take volume per acre and average diameter into account. Haul cost was assumed to be $59 per thousand board ft. For the *net present value* regime, we included a $441 per acre planting cost.

The net present value regime represents the highest return possible to the landowner given the growth and yield and costs associated with the stand. Any deviation from this management is an opportunity cost borne by the landowner; the landowner is giving up income by choosing to manage for some non-market objectives.

The reserve regime generates the highest volume. But it does not generate financial value because it is never harvested. Therefore, the opportunity cost of the reserve option is the total value of the stand under the net present value regime.

The older forest structural regime has heavier than traditional thinning intensities that occur early in the life of the stand and final harvest age is far greater than financial maturity. This reduces the value of the stand from the maximum net present value regime. The heavy thinnings generate value early, but even so, the opportunity cost of older forest structural management is substantial. For example, over 50 percent of the value of the stand is foregone with a discount rate of 6 percent.

Stand Structure

To evaluate whether structural criteria were being met, we used the Stand Visualization System (McGaughey 1997). In figure 1, the stand development at 20-year intervals over the 100-year time horizon is shown for each of the three management regimes. The first 20 years (i.e., to age 35 years) are identical for all three regimes.

At 40 years into the simulation, however, the disparate paths of the three regimes become evident. The 55-year-old reserve stand is very dense and the crowns have receded up the boles of the trees, leaving little live crown per tree. The net present value stand was clearcut at 40 years of age, 25

Table 4—Economic returns per acre case study stand for three management strategies

Year	Stand age	Volume Removed (mbf)	Logging Cost ($/mbf)	Revenue	Discounted value at 4	6	8
					- - - - - - -*Percent* - - - - - - -		
Older forest structure							
2026	35	10.1	146	3,384	1,544	1,055	726
2046	55	12.6	95	4,793	998	466	221
2071	80	6.4	81	2,510	196	57	17
2106	115	62.8	68	25,272	500	74	11
Total	92	35,960	3,239	1,653	975		
Reserve							
2106	115	138.7	60	56,793	1,124	167	26
Net present value							
2031	40	35.5	96	12,998	4,876	3,029	1,898
2071	40	35.5	96	12,998	1,016	294	87
2106	35	24.8	117	8,948	177	26	4
Total	96	34,944	6,069	3,349	1,989		

years into the simulation, leaving a fully stocked 15-year-old stand. The 55-year-old older forest structure stand has been thinned just following the stand representation at 20 years old with a volume removal of 65 percent. The opening up of growing space in the stand has allowed the larger trees to retain lower branches resulting in longer crowns than the reserve stand.

At 60 years into the simulation, the 75-year-old reserve stand looks structurally much as it did at age 55 years, with a dense single story and short crowns. The largest trees in the stand are just under 28 in diameter at breast height (d.b.h.). The net present value stand is once again 5 years from a regeneration harvest. The older forest structure stand has been thinned again removing another 60 percent volume removal. The understory has the light required for development of a new cohort. The 75-year-old older trees have retained much of their live crown, providing for greater diameter growth. There are just under 5 trees per acre with greater than 32 in d.b.h..

At 80 years, the 95-year-old reserve stand now has 16 trees per acre larger than 32 in d.b.h., yet with the dense canopy it has limited ability to generate an understory of any kind. The net present value stand is once again at 15 years of age. The older forest structure stand just received its final thinning, a 40 percent volume removal. The stand has a well-established younger cohort (age <20 years) and still has 6 trees per acres of 95-year-old trees larger than 32 in d.b.h. following the final removals.

Finally at 100 years, the 115-year-old reserve stand has over 30 trees per acre that are larger than 32 in d.b.h.. The largest tree is just under 38 in d.b.h.. Despite its size, there is not much diversity in this stand. The canopy closure is 89 percent, compared to the 51 percent for the older forest structure stand, letting little light down to the forest floor to support understory vegetation. In contrast, the older forest structure stand has at least two distinct cohorts, with over 9 trees per acre greater than 32 in d.b.h.. The largest trees (115 years-old) are over 45 in d.b.h..

DISCUSSION

This case study reinforces silviculturists' concerns that the young fully stocked production forests of today may not develop into the natural old-growth forests we are familiar with if they are left unmanaged in reserves (Andrews et al. 2005). They may instead develop into dense overstocked forests with increased risk of fire, insects, and disease. To hasten the development of large trees and multiple cohorts it may be necessary to employ thinning regimes which appear extreme when compared to the traditional commercial or uneven-aged stand removal levels (Tappeiner et al. 1997, Carey and Curtis 1996).

There are several factors leading to the selection of multiple heavy thinnings as a silvicultural pathway to older forest structure. It is notable that the management regimes developed to meet older forest structural criteria while maximizing the financial value of the stand are very similar to management regimes developed by silviculturists who

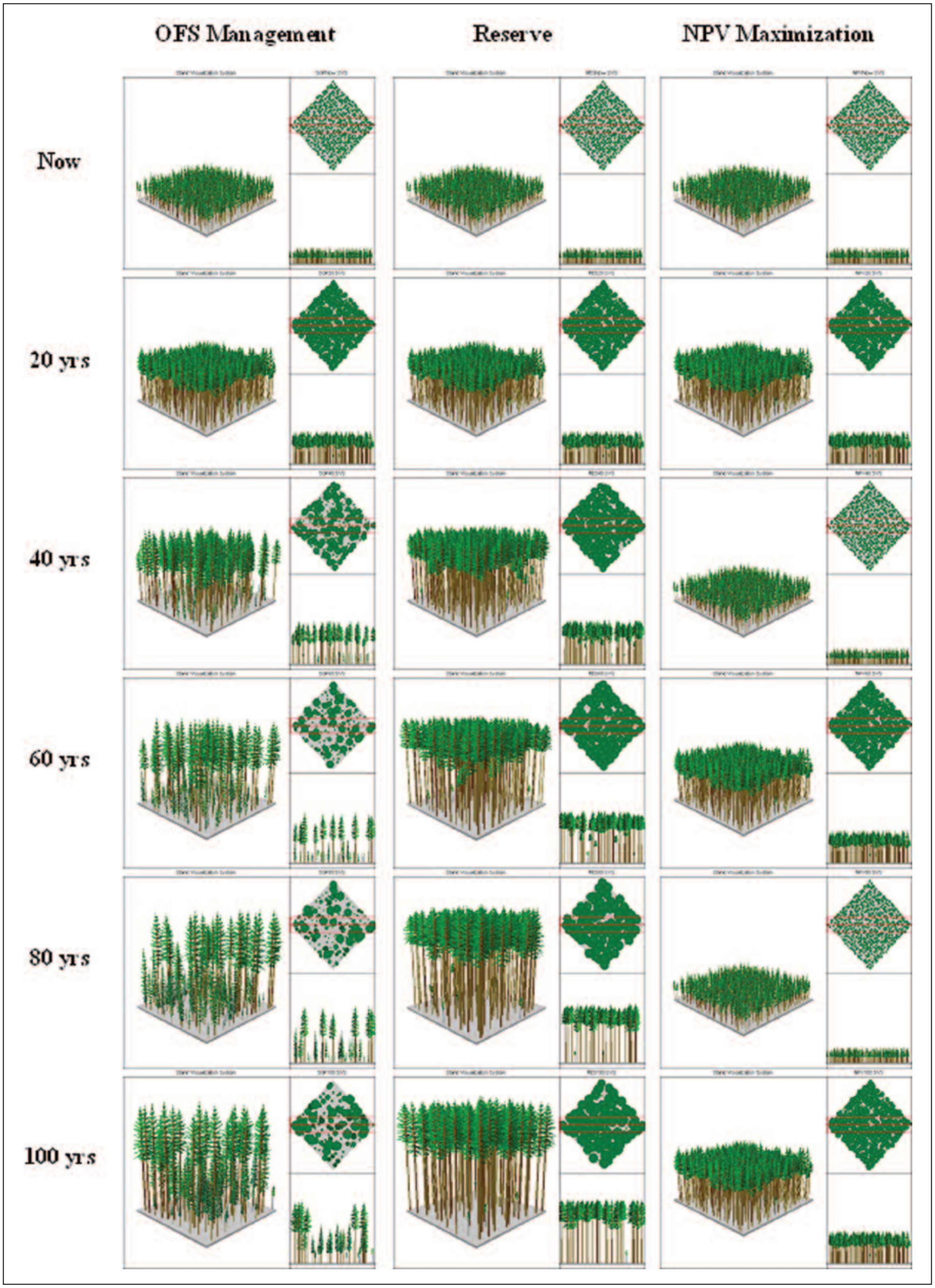

Figure 1—Stand Visualization System representations of the Older Forest Structure (OFS) Management, Reserve, and Net Present Value (NPV) Maximization regimes for the case study stand in 20 year intervals for 100 years.

Table 5—Logging cost variation for differing stand attribute and removal levels

Stand attributes						Logging cost ($ / mbf) based on percentage of stems removed			
Number of trees	Diameter (In)	Stand density Index*	Basal area (Square ft)	Thousand board ft	Cubic ft	100	70	40	10
100	10	100	55	3	1426	249	265	299	493
300	10	300	164	10	4277	208	221	242	322
500	10	500	273	17	7129	196	203	223	284
100	12	134	79	7	2291	149	159	176	271
300	12	402	236	22	6873	127	132	145	188
500	12	670	393	37	11455	122	125	133	169
100	16	213	140	18	4623	79	84	93	132
300	16	638	419	55	13870	71	73	76	98
500	16	1063	698	92	23117	69	70	73	89

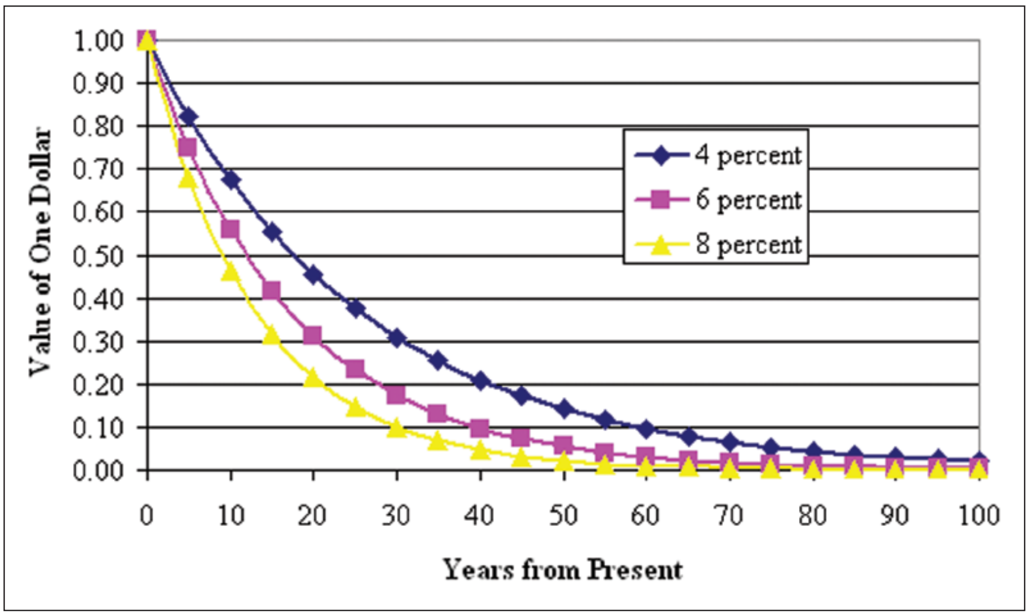

Figure 3—Present value of one dollar received up to 100 years in the future.

general, these costs decrease as the logs get bigger or as the thinning intensity increases.

Economic Considerations

Finally, the time value of money refers to the fact that, all things equal, a dollar today is preferable to a dollar received some time in the future. This is an important concept in valuation of a forest investment because the time horizon of forest investment is typically very long. To illustrate the importance of the time value of money, the present value of one dollar received up to 100 years in the future is shown in figure 3 for discount rates of 4-, 6-, and 8-percent. Economic returns even one rotation out have very limited value today. Even when considering a rather conservative discount rate of four percent, a dollar 50 years in the future would only be worth fourteen cents today, and at 100 years it would be worth just under two pennies. This discounting gives preference to positive events, such as thinning revenue, happening sooner in the future rather than later.

CONCLUSION

We utilized a case study of a typical young even-aged production forest stand to compare stand development under a silvicultural regime designed to increase the development of older forest structure while minimizing the economic impact and to a regime designed to maximize the net present value of the stand. We also compared it to a forest reserve. We based the older forest structure regimes on published results from a study in which least cost old forest structural regimes were identified for a range of stand types on private land in western Oregon. It that study, the opportunity cost of old forest structure (the present value of forgone timber harvest revenue when old forest structural criteria are imposed) was found to average around 30 percent of the maximum net present value of the stands in the study. In our case study, in which we simply applied average values for the timing and intensity of thinnings, the value loss associated with old forest structure was about 50 percent. While it would be nice if, in practice, you could simply go to a table from a published study and find a management regime that would work for a particular stand, we found a potential gain of 20 percent between an optimized regime and a non-optimized regime.

The ideas portrayed in this case study can serve as a rule of thumb in developing a regime to generate old forest structure in an economic way. As any forester knows, though, every stand is a little different, and adjusting for those differences can matter.

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