Discussion Paper 2 (DP2): The Economics of Westside Forest Management Treatment Alternatives

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Preliminary Management Simulations

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

Each pathway was simulated over four rotation lengths: 40, 45, 50, and 55 years in order to illustrate comparative economic returns and forest structures.

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

Figure DP2.1. shows the harvest volume on an annual basis for each management pathway simulation. For each management pathway, volume production per year increased with longer rotation lengths. This is to be expected, as the longer rotations approach closer to the maximum volume production per year (culmination of mean annual increment). The economic optimum rotation based only on the value of timber (exclusive of non-market environmental values) occurs earlier at the point in time when the growth in volume plus value per unit of volume falls below the targeted interest rate. Volume production per year decreased with thinning, with the no-thinning pathway producing the highest volumes and the PCT_CT pathway producing the lowest volumes. This example illustrates a common trade-off for thinning; increased individual tree growth versus total stand production (Oliver and Larson 1990). However, with improved utilization and silvicultural treatments, there may be a larger volume boost from thinning than is reflected in these simulations. Further simulations with growth models better calibrated to post thinning performance may better reflect the economic benefits of intensively managed forests.

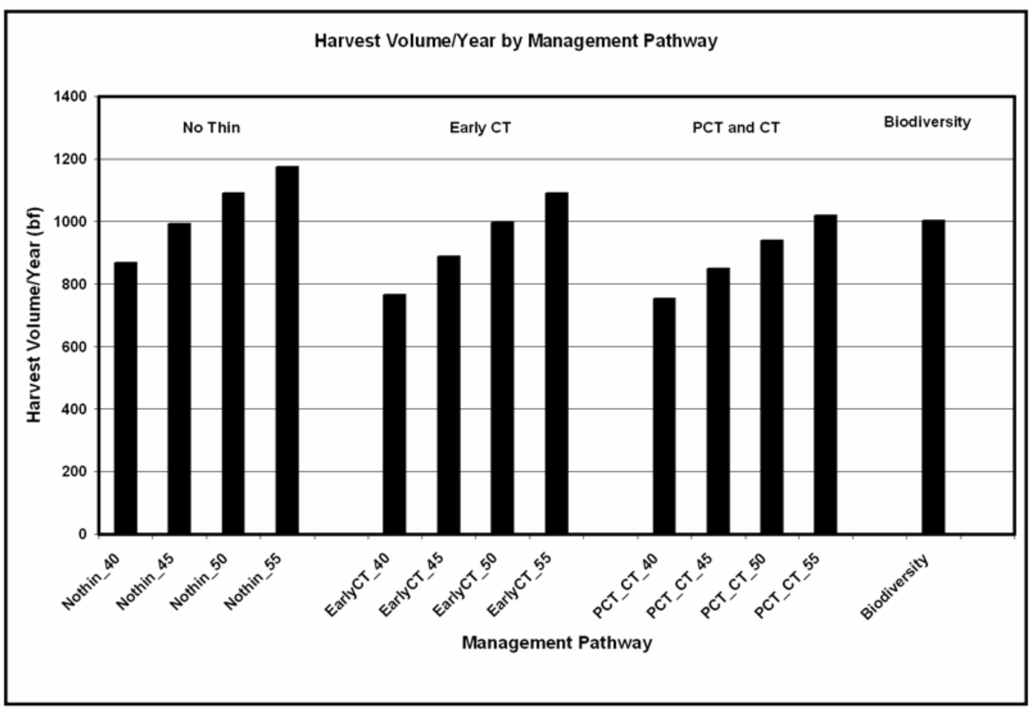

Figure DP2.1: Board foot (bf) harvest volume per year across different management pathways. Longer rotations result in greater harvest volume. Less thinning also results in greater harvest volume.

Economic performance depends not only on how much volume is produced, but when the volume is produced, the quality of the logs, and the magnitude of management costs. These factors are all reflected in a Net Present Value (NPV) analysis. When comparing the performance of different management options, especially when looking at different rotation lengths, a special type of NPV calculation known as soil expectation value (SEV) is useful. Soil Expectation Value (SEV) is a commonly used measure of forestry economic performance that calculates the NPV of expected costs and revenues for a complete forest rotation repeated in perpetuity. The SEV of each management pathway simulation with an assumed 5% real interest rate is presented in Figure DP2.2.. SEV calculations were done assuming a $300 per acre cost for stand establishment (planting and site preparation), a $100 per acre cost for PCT treatments, and $15 per acre annual administrative costs (administrative costs for small owners are generally much larger). Early commercial thinnings were assumed to break even. Log values are based on average year 2000 delivered prices for the Puget Sound Region (from Log Lines Report Service). Combined logging and hauling costs were applied based on the average cut diameter and typically ranged between $115 and $150 per thousand board feet (MBF) for regeneration harvests and from $200 to $250 per MBF for commercial thinnings. SEV figures were computed before taxes except for land taxes included in administrative costs.

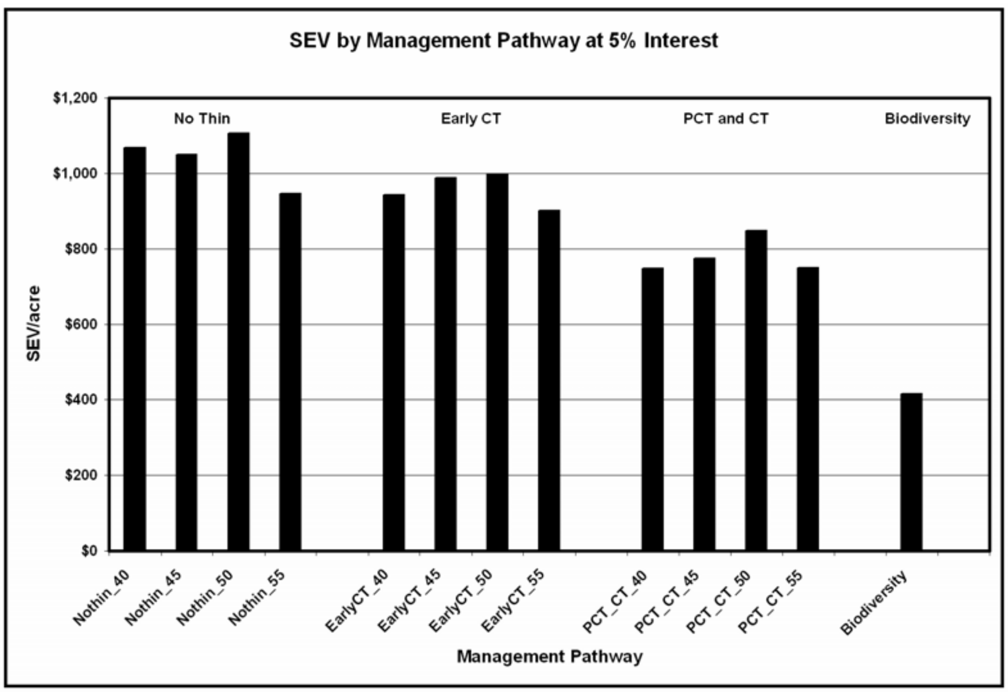

Figure DP2.2: Soil expectation value (SEV) for different management pathways at 5% interest. The optimal rotation length at this interest rate is 50 years.

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

SEV and economically optimal choices are highly dependent on the interest rate. For firms with a higher or lower cost of money, the economically optimal choice will be different. As an example, the SEV/acre at a 6% real interest rate is shown in Figure DP2.3. At 6% interest, no thinning still performs best, but the economically optimal rotation length shortens to 40 years. The SEV/acre of the biodiversity pathway is $1/acre, which is $523 less than the maximum SEV of $524/acre with a 40-year rotation and no thinning. At higher interest rates, the cost of managing for biodiversity decreases in absolute terms. However, it is greater in relative terms, with a 99.8% decrease relative to the maximum SEV compared to a 62.5% decrease at 5% interest.

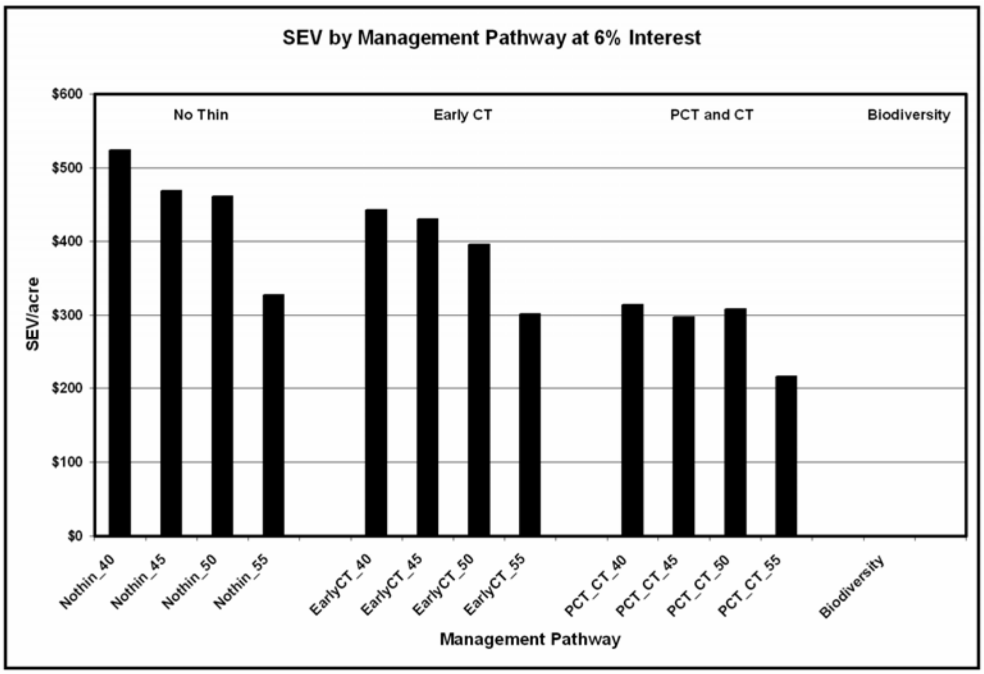

Figure DP2.3: Soil expectation value (SEV) across different management pathways at 6% interest. The optimal rotation length shortens to 40 years.

In terms of stand structure, thinning and longer rotations can be expected to produce larger trees and greater structural complexity as compared to shorter rotations without thinning. This is especially true for the biodiversity pathway. Figure DP2.4. shows that quadratic mean diameter (QMD) and average height at rotation age (just prior to final harvest) increase with thinning and longer rotations. The biodiversity pathway results in significantly larger trees than any of the commercial pathways.

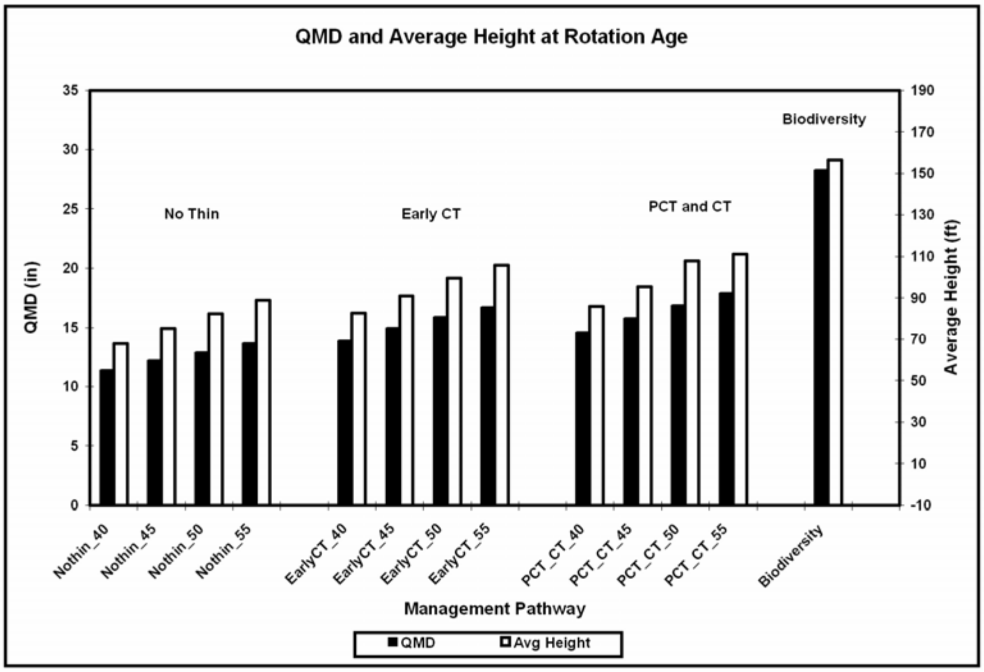

Figure DP2.4: Quadratic mean diameter (QMD) and average height across different management pathways. Thinning and longer rotations result in greater average tree sizes. The biodiversity pathway results in significantly larger trees.

In addition to thinning treatments there are opportunities for greater diversity in managing alternative species such as Cedar and Alder. Both have risen in value while the premiums that once characterized Douglas-fir and hemlock have declined. The relative returns for species management are described in Appendix 1.

Commercial / Environmental Tradeoffs

The biodiversity pathway is not the only treatment that could be considered beneficial to habitat. Habitat Suitability Indices (HSIs) can be linked to the stand structures produced from any number of management alternatives (Ceder 2001, US Fish and Wildlife Service 1981). Indices for many different bird and animal species can create a very complex analysis as any treatment that benefits some habitats will do so at the expense of others. A course filter approach that has been used to illustrate the benefits of different treatments was developed with the introduction of biodiversity pathways (Carey et al. 1996, Carey et al. 1999). The progression of either natural forest growth or managed stand growth tends to move through stand structure classes over time: Ecosystem Initiation (EI) for the early open stage after a stand clearing disturbance or treatment; Competitive Exclusion (CE) for the period when the canopy is closed restricting understory development; Understory Reinitiation (RI) when, through mortality, disturbances or treatments, stands are thinned sufficiently to allow understory growth; Developed Understory (DU) as this process matures; Diverse structure (D) although not necessarily old, with Niche Diverse (ND) denoting managed diversity and Botanically Diverse (BD) denoting unmanaged disturbance related processes; and finally Fully Functional (FF) when stands approach the statistical metrics associated with what have been considered to be unmanaged mature forest stands.

Without any thinning and including regeneration treatments that accelerate early stand growth, only the first 15 years would be in EI, 30% of the 50 year optimal rotation with 70% remaining in CE, the stage with the least support for habitat diversity. Including a CT at age 20 reduces the closed CE structure stage to 10% of the acres with 60% transition from RI to a more developed understory or if the thinning is too light, back to a closed structure. Including a PCT and CT replaces the 70% of closed structures with 30% UI and 40% DU and if the second CT maintained enough woody debris and snags it would be considered Diverse albeit a young diverse structure. The longer rotation Biodiversity pathway reduces the EI structure to 15% and the

CE structure to 5% resulting in 30% in UI and about 50% transitioning to the more diverse Niche Diverse structure and perhaps Fully Functional near the 100 year harvest rotation age. There is a fairly clear transition to greater complexity and biodiversity supporting species that tend to be more sensitive to older forests by incorporating thinning treatments and especially successive treatments, while also maintaining snags and downed dead wood in the understory. While it is fairly straight forward to determine the management cost to produce these benefits as has been shown above (i.e. the simulated loss compared to the optimal economic treatment), and has been illustrated before for the Westside (Lippke et al 2002), cost responsibility and relative worth is a policy determination. Federal and State managers are placing more emphasis on restoring old forest attributes with significant public costs. Private managers are generally absorbing costs to meet regulatory minimums thereby increasing the pressure for land conversions to non-forest uses.

There may be benefits in analyzing the habitat for a specific species instead of a course filter approach. The process of developing more detailed habitat suitability measures for specific species generally involves keeping track of a greater number of forest structure types than the course filter approach described above. Simulating tree list models can easily break plot information into a much finer resolution of stand structures to model a large number of individual species. The problem rises at the analysis or policy level since what is good for one species will often be bad for another making the analysis of impacts much more complicated. Treatments designed to increase habitat for one species can easily leave out the impacts on other species that might be just as important. We provide several fairly simple habitat suitability case studies in Discussion Paper (DP4) to illustrate the additional detail and complexity associated with species-specific habitat suitability.

Westside Management Treatments: Options and Outcomes

With this introduction of the economics of management treatments we will capture the major impacts for a wide range of management options using six specific treatment alternatives. A no action (NA) alternative assumes restocking as required by the forest practices but no subsequent removals. It characterizes the impact of many lands that, 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 owners, 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-retention) is included to hold a significant 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 they effectively span the space of a wide range of different alternatives.

On the Westside, plantation growth response is heavily influenced by shade. Douglas-fir (*Psuedotsuga menziesii*), a 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. Such treatments are commonly 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).

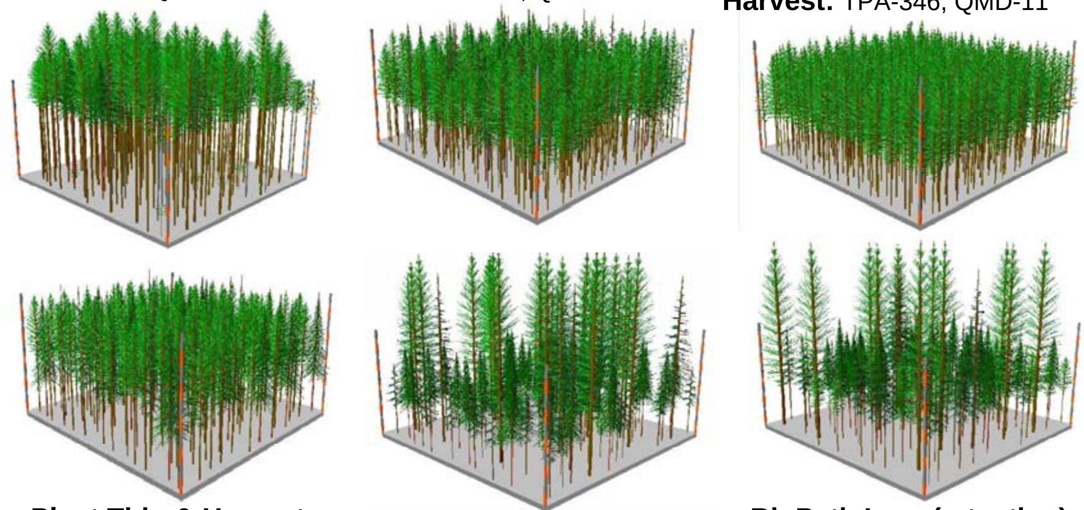

Figure DP2.5: Stand Visualization, Trees per Acre & QMD (at 100 yrs or end of second rotation)

As noted in the stand visualizations (Figure DP2.5.) the unthinned alternatives contain almost 350 trees per acre (TPA) at time of harvest but with a significantly larger quadratic mean diameter (QMD) 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 rotation, although vegetation control produces more early growth even without thinning.

Economic Performance Affects Management Choices

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 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.

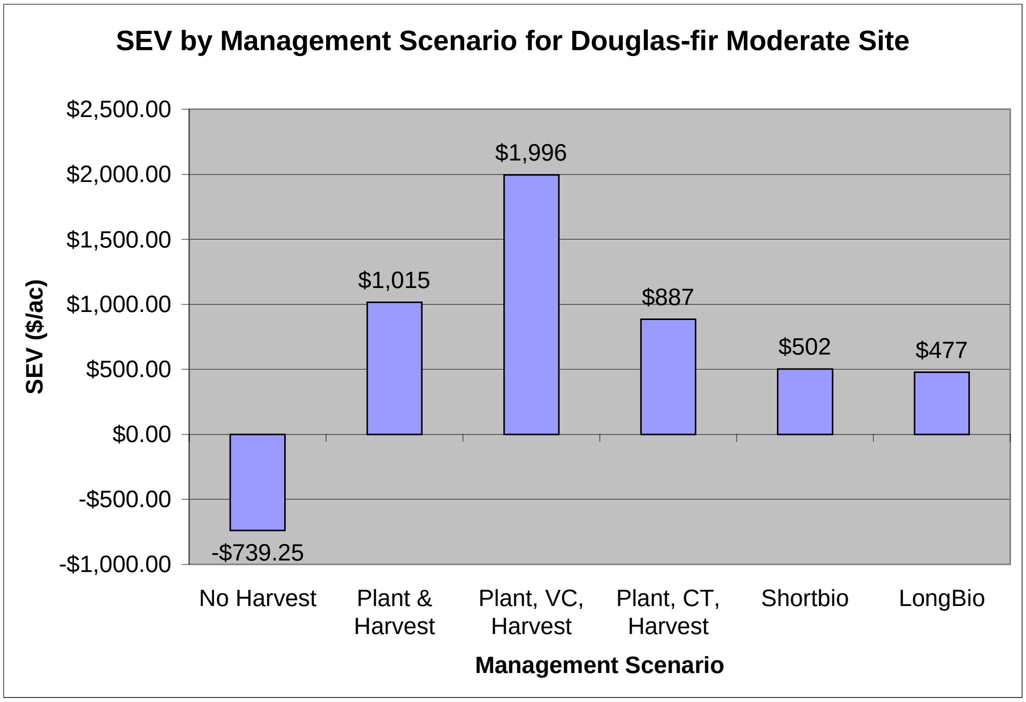

Figure DP2.6: SEV, the sustainable forestry return under different management treatment scenarios

The SEV for the two thinning options are not substantially different and the relationship may change with modest differences in inventory and log prices. The much higher return from vegetation control 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 action 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.

Management Choices Ultimately Impact Regional Economic Activity

The economic impacts induced by these management alternatives are determined by the direct labor and other purchases required for each treatment activity carried through an analysis of indirect impacts based on an economic model for the state. The economic models used to develop these links are described in Discussion Paper DP3 with an explanation on how recent surveys of mills and logging operations were used to link the forest sector data to the most recent State of Washington Input/Output Model.

The regional economic impacts are modestly different than the direct return to landowners as each treatment results in a different share of wood going into primary processing, secondary processing, or paper. For example, the biopathways noted in Figure DP2.7. could support more secondary manufacturing in the long term if facility investments take place to process large logs for higher valued uses, hence we demonstrate the economic impact of different treatments and their removals on labor, the Net Present Value of gross output and the Net Present Value of future state and local taxes, approximately 1/10th of the sector's business output.

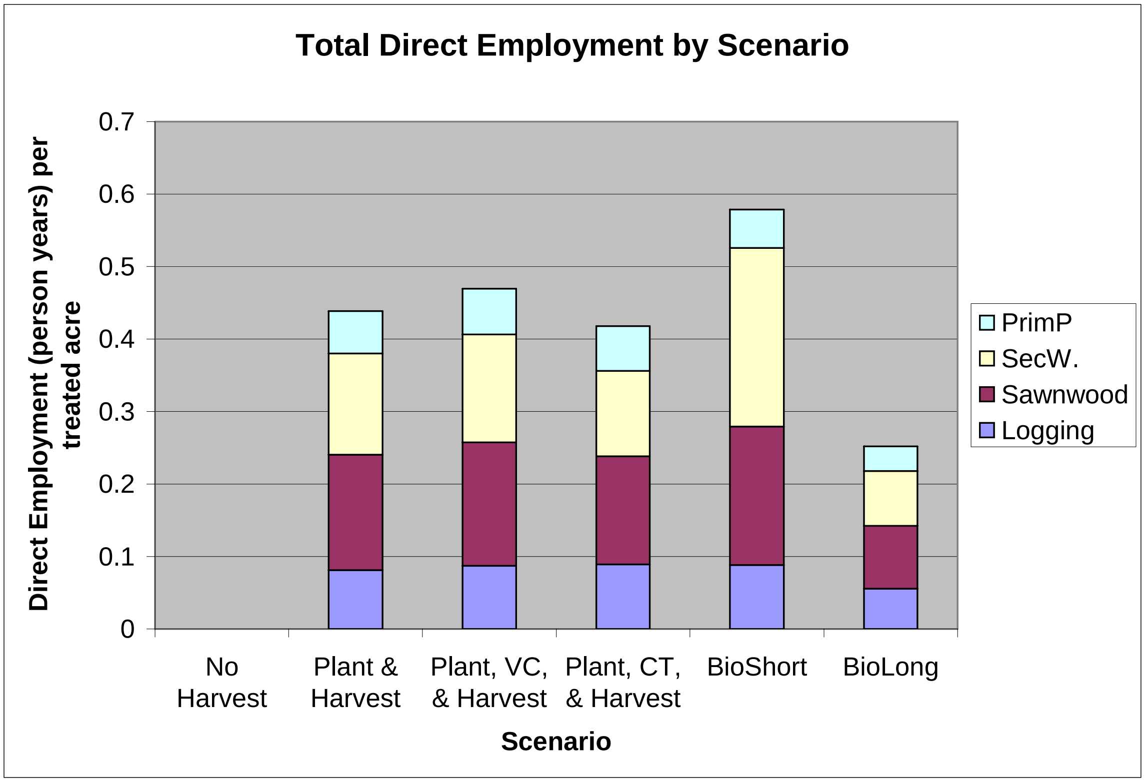

Figure DP2.7: Total direct employment contribution for different management treatment pathways

The No Harvest alternative might have produced some forest regeneration activity, much smaller than shown for logging but prior to employment benefits from logging, sawnwood processing, secondary wood manufacturing, and primary paper and hence was not included. The direct labor is most noticeably different for the short biopath since it produces the largest amount of jobs, especially in secondary manufacturing, however these jobs occur some 50 years later than the other treatments and would not be considered as important with the benefits reduced in dollar value using a discounted valuation of future economic activity.

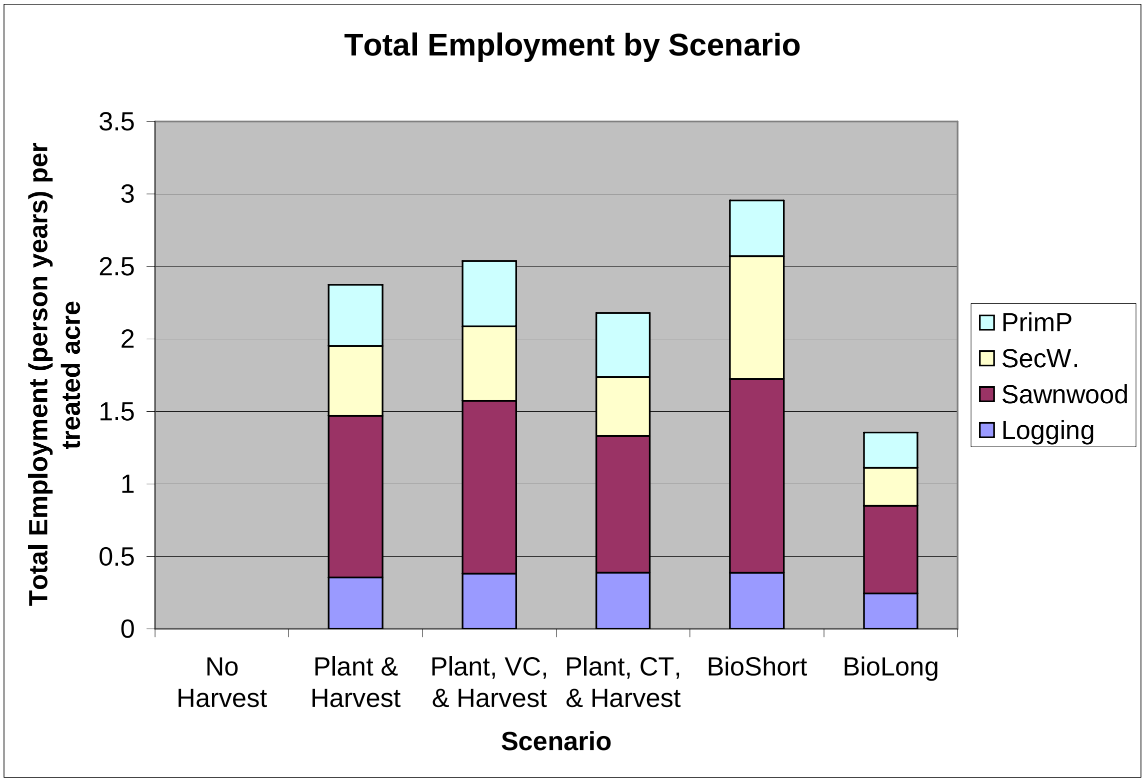

Figure DP2.8: Total direct and indirect employment contribution for different management treatment pathways

Total direct and indirect employment is based upon the interindustry economic multipliers developed as a part of the State of Washington Input/Output Model analysis in DP3. These models are in a state of periodic re-estimation to be consistent with changing data definitions.

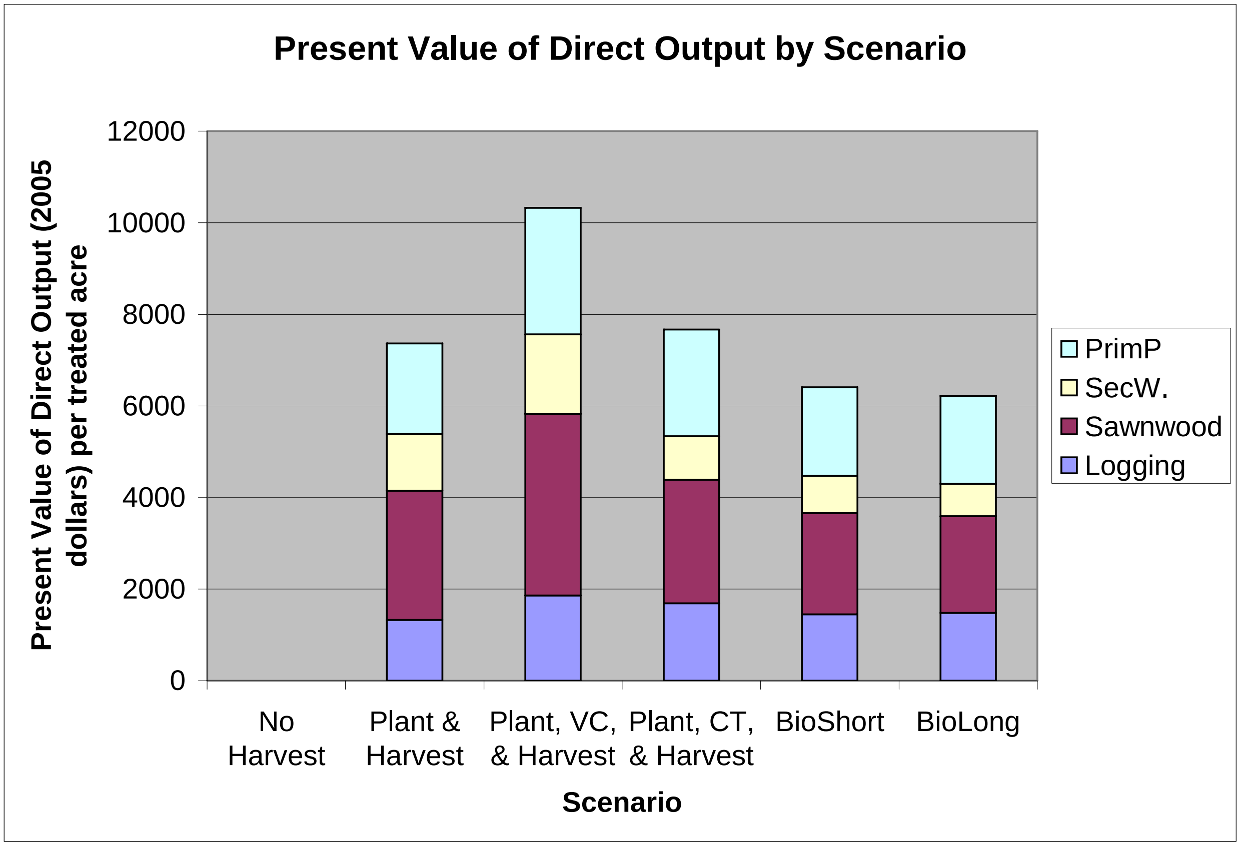

Figure DP2.9: Present Value of direct output for different treatment pathways

The present value of direct sector output provides a more useful economic activity measure as it discounts outputs in the future at the assumed 5% discount rate. It is noteworthy that the short rotation commercial thin produces a higher NPV than the no thinning alternative whereas the return to the landowner 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 the loss was 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.

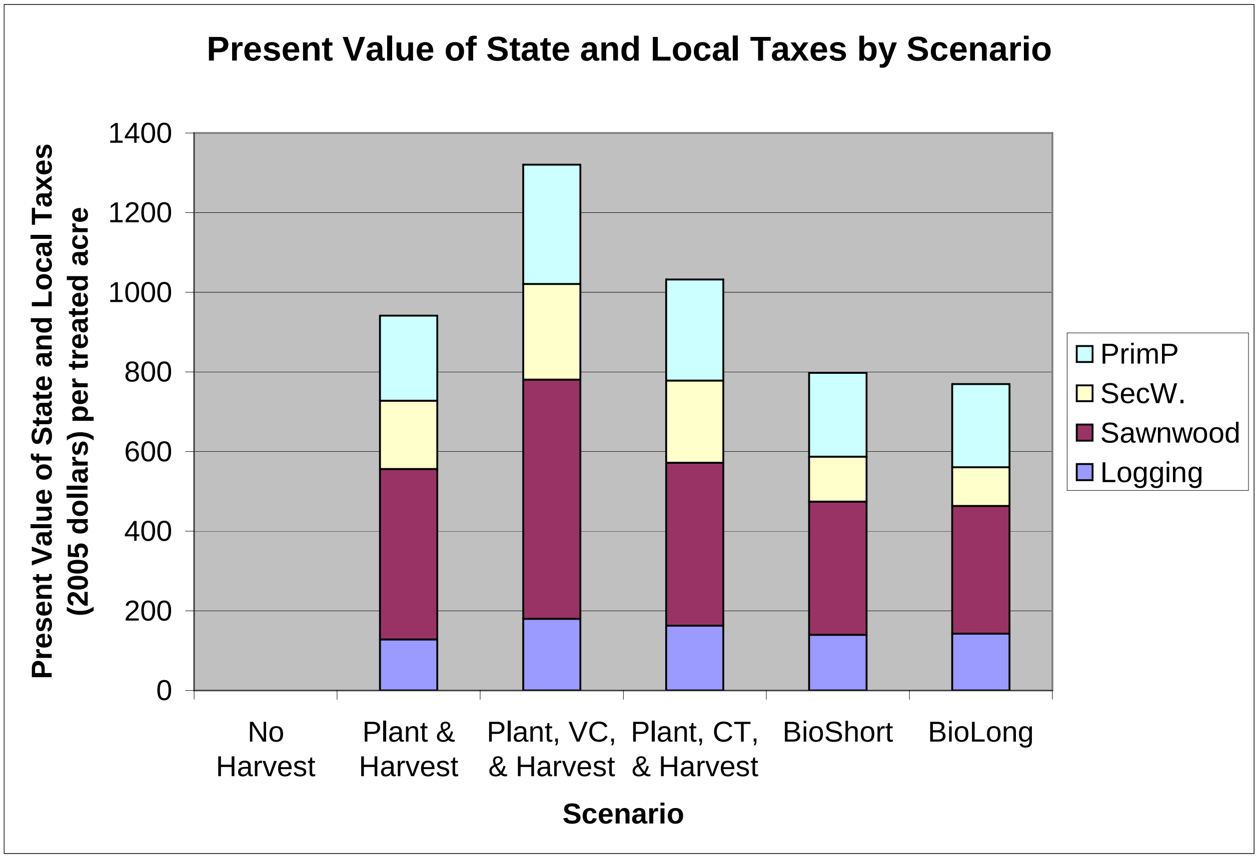

Figure DP2.10: Present Value of State and Local Taxes derived from state economic activity

State and Local taxes are collected as a part of the economic activity and essentially reflect the same relationships as the present value of total economic output. The higher volumes produced by the Vegetation Control (VC) treatment result in the highest level of regional economic activity and State & Local Taxes. The economic activity shown in figures DP2.8-10 can be attributed to harvests in the local growing region or timbershed but the economic activity flows to other regions across the state. The direct employment impacts (Figure DP2.7.) will be largely focused near the harvest to the degree that processing facilities are reasonably close to the harvest.

Conclusion

While landowners generally select the preferred treatment to meet their specific management objectives and that decision will likely be strongly linked to what they consider to be their best economics dependent upon the market outlook at the time of their decision, that selection also determines what kind of forest structure and habitat is produced, and what kind of down-stream economic opportunities are made available, including not just mill processing and job opportunities but also the contributions to State & Local Taxes.

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Appendix 1: Shifting Economics of Alternative Species in Western Washington

Larry Mason

Log Price Comparisons

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

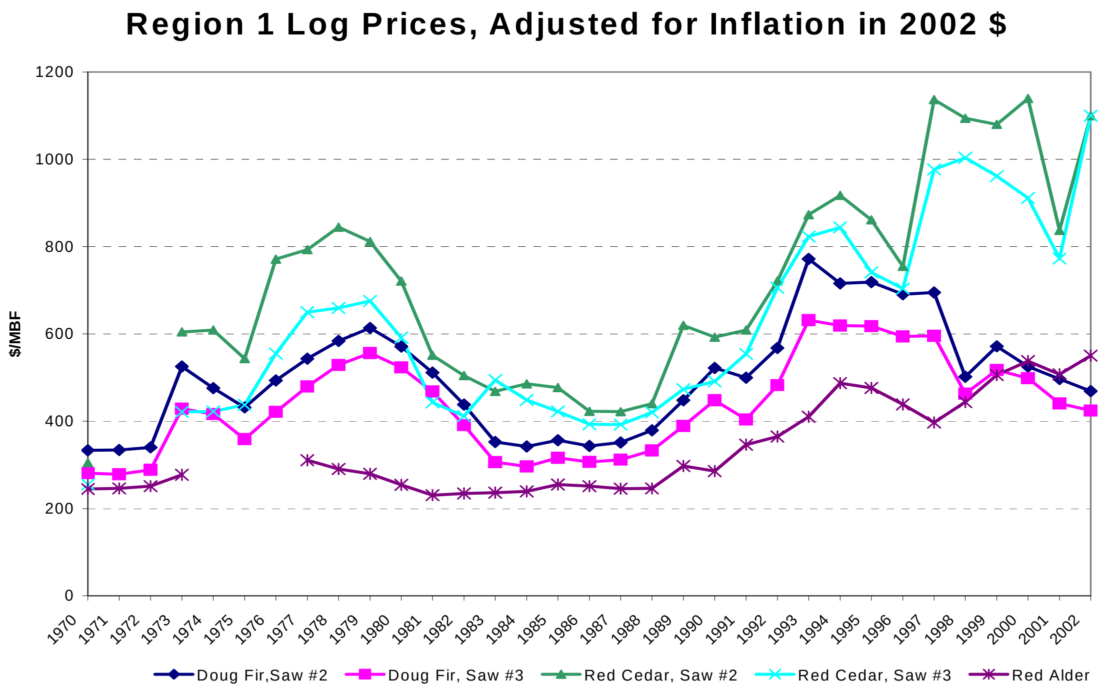

Figure A-1: Region 1 Log Price Comparisons.

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

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

Species/Management Alternatives

Financial performance simulations can help in making species yield comparisons. For demonstration purposes, assumptions will be that plantations are hardy and on good site, a single rotation is to be examined

where prices remain constant, 5% is the expected rate of return, results are reported before taxes, and yield estimates are consistent with growth expectations described in the literature.
Seven simulations are displayed here.

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

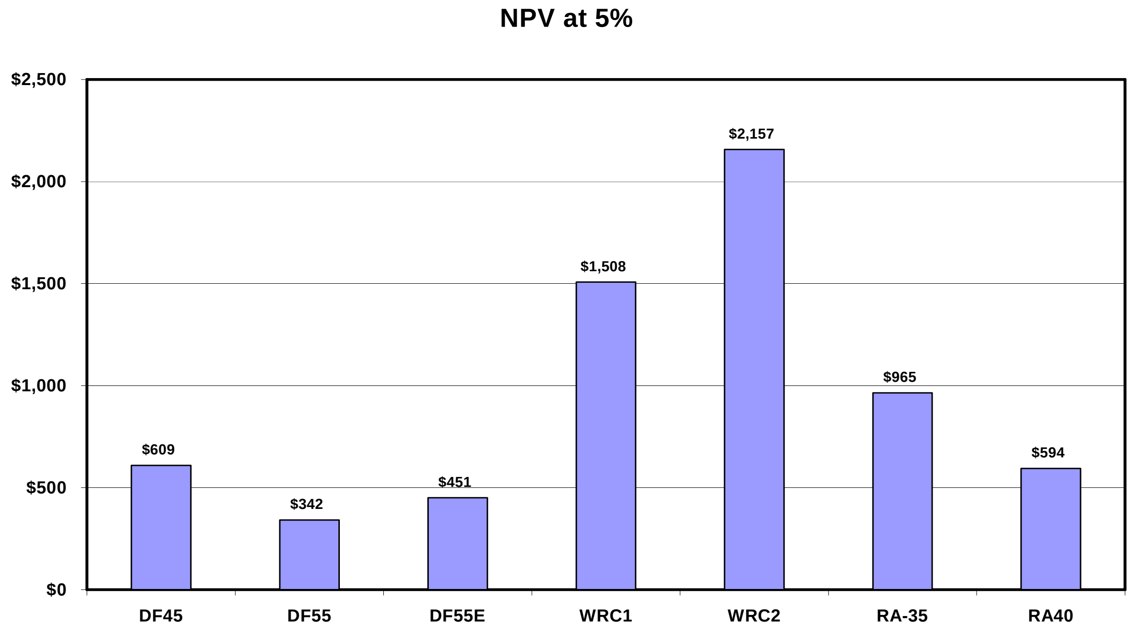

Figure A-2: NPV Comparisons

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

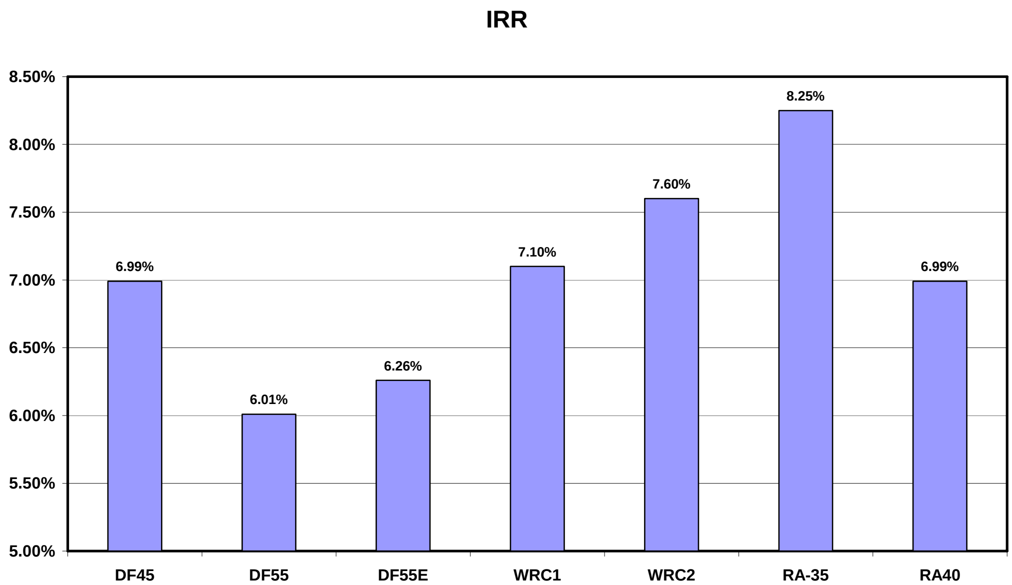

Figure A-3: IRR Comparisons

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

Management Implications

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

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

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

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