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NEW TOOLS FOR ANALYZING PACIFIC NORTHWEST DOUGLAS-FIR MANAGEMENT: A Case Study

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Introduction

For decades, Douglas-fir (*Psuedotsuga menziesii*) has been the dominant commercial timber species of the U.S. Pacific Northwest. During that time, field and office-level management technology have advanced tremendously. Understanding these advances has given foresters outside the Douglas-fir region new ideas and new tools for managing their forests. This article highlights some advances in Douglas-fir management analysis techniques. Its specific purpose is to outline basic Douglas-fir silviculture and economic principles and to then illustrate how these are combined in an analysis. It begins with a overview of Douglas-fir silviculture and economics followed by a general discussion of the decision analysis process. The silviculture and economic analysis procedure is then illustrated using a case study example and a sophisticated new personal computer spreadsheet template.

Douglas-fir is used to produce many products, ranging from logs to specialty timber products. They are marketed worldwide at prices ranging from inexpensive to substantial amounts depending on the product. Valuation of these products follows conventional retail merchandising pricing procedures. Valuation and analysis of silviculture treatments, however, is done quite differently.

Historically when prices and interest rates were low, foresters often overlooked the effect of compound interest when evaluating forest production. Those economic conditions have definitely changed, however. Discounted cash flow analysis is now the standard approach to evaluating forestry economic performance. Depending on the project, silvicultural and economic analyses can be extremely detailed or relatively superficial. They can cover full-rotation time periods or just portions of full rotations, called "time-slice" evaluations. Finally, depending on the specific tools used to perform the analyses, they can be prepared by hand or they can be fully computerized.

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Silviculture and Economics

Large stands of even-aged Douglas-fir are considered characteristic of Pacific Northwest forests west of the Cascade Mountain crest. Despite covering vast areas with even-aged stands, Douglas-fir occurs with many other species including red alder (*Alnus rubra*), Western white pine (*Pinus monticola*), Pacific madrone (*Arbutus menziesii*), Oregon oak (*Quercus garryana*), ponderosa pine (*Pinus ponderosa*), big leaf maple (*Acer macrophyllum*), western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), grand fir (*Abies grandis*), Pacific silver fir (*Abies amabilis*), and Sitka spruce (*Picea sitchensis*).

Douglas-fir is a species of medium tolerance, long life, large size, and moderately rapid height growth during its younger years. Douglas-fir exhibits great variation in individual-tree development. Heights may vary from 80 to 220 feet at 100 years, depending on site and stocking. Diameter growth can vary from 2 or 3 rings per inch to 20 or more. Trees in dominant crown classes respond well to additional growing space up to maturity, permitting Douglas-fir to be managed under several different silvicultural systems. Clearcutting and shelterwood methods of regeneration are common in even-aged management. Uneven-aged systems characterized by selective cutting, are much less common, but still advocated by some.

Depending on site characteristics and production objectives, in managed situations, Douglas-fir is sometimes grown for time periods up to 200 years. However, on good sites, sawtimber rotations commonly range from 40 to 100 years. Rotations of about 80 years produce a good combination of sawtimber and smaller-log products.

Competition by brush and other herbaceous plants is a problem, especially on good sites and in the moist Coast Range. Cleaning and weeding is essential and in the past was done primarily by chemical treatment methods. Using techniques such as burning scarification, and herbicides, much effort goes into controlling competing vegetation before, and for 3 to 10 years after planting or seeding.

Planting and seeding are the two most common reforestation methods. Planting can be with either bare-root or containerized seedlings. Recent reforestation trends can be characterized by planting fewer trees per acre at wider spacing, good site preparation to reduce vegetative competition, and the use of larger seedlings. Special practices on some sites include such practices as shade protection, animal damage protection, and trapping of small mammals.

The Decision Analysis Process

Silviculture in a systems context requires planning for different activities, tracking their progress, and then making adjustments as needed. The increasingly complex forest planning and budgeting process creates special problems in silvicultural planning and analysis because of the need to plan multiple uses for many acres. A systems approach has therefore become essential.

Analysis and decision making can be approached from several viewpoints. We identify four basic categories: 1) scientific, 2) common sense and experience, 3) historical, and 4) wishful thinking. Some discussion is helpful in understanding the differences between these practices and then adopting an appropriate approach.

The scientific approach involves planning silvicultural treatments based on the latest research. Science is useful and helpful, but practicing foresters must be careful when attempting to transfer scientific methods or techniques into operational practice. Foresters must be wary of using new techniques until those techniques have been validated by more than one researcher in actual field applications.

Common sense and experience is basically an intensive examination of what has worked on similar sites in the past. It is probably the most useful approach listed here since it builds on past successes. It does, however, require a person who has time and the inclination to study past efforts and then relate them to current site conditions.

There is only a subtle difference between the historical approach and the common sense and experience approach. Many foresters claim to use common sense and experience, but are instead following the historical approach – doing things "the way we always have" or as the previous silviculturist did.

Wishful thinking has no place in silvicultural planning. In this approach the forester plans a given treatment and then wishes that it were true. A good example of this is the misguided assumption that "Grass does not compete with seedlings during the establishment period." We all wish that this were true, but science and common sense and experience have shown otherwise.

Past successes and failures indicate that foresters should use common sense and experience combined with some science to most effectively plan, evaluate, and implement new silvicultural projects. Care must be taken to eliminate using the historical and wishful thinking approaches when evaluating alternative treatment options. Increasingly intensive management of Pacific Northwest forests has caused the number of alternative treatment options considered in any silvicultural and economic analysis to increase dramatically. This makes evaluation more complex, in turn requiring increasingly sophisticated, yet still practical, analysis tools.

Practical Tools

Like other fields, forestry has seen tremendous progress in the practical tools available for analyzing silviculture projects. While paper and pencil, compound interest tables, and adding machines "did the job" for years, electronic calculators were great improvements. Innovation in electronic calculators was both dramatic and rapid. The first decade of commercial availability saw programmable calculators become much smaller and yet more powerful, culminating in hand-held models capable of interfacing with many types of peripheral devices. Simultaneously, personal computers (PC's) appeared, introducing another level of sophistication to silvicultural and economic analysis. During all of this, foresters adapted current technology to their specific needs, whether for simplified growth projections or complex forest planning analysis.

Since PC's represent the latest major technological advance commonly available to most foresters, we will focus here on PC applications to silvicultural and economic analysis. Coupled with PC's, of course, is a wide range of extremely powerful software. Foresters continue to make extensive use of one particular type of software — the spreadsheet.

From the beginning, spreadsheets were adaptable to many different jobs. And, they allowed substantial labor savings during repetitive tasks. While some of the early spreadsheets are still in use, most serious spreadsheet users have adopted state of the art programs like Lotus 1-2-3; Symphony; or Excel. Because of its extreme power, flexibility, and popularity (millions of copies in use worldwide) we will use a Symphony template to illustrate the case study evaluation of a Pacific Northwest Douglas-fir stand.

Case Study Example

To examine some of the principles outlined above and to demonstrate the utility of a spreadsheet template called ANALYST[1] we have chosen a recently harvested site in Oregon's central

[1]ANALYST is a copyrighted spreadsheet template available from SEAD, Inc. (2750 NW Royal Oaks Dr.; Corvallis, OR 97330; USA). It is compatible with the LOTUS 1-2-3 and Sympony programs.

Coast Range. Before we begin the analysis process, it is important that you know more about the site. Review the site description and stand history contained in figure 1. These documents show that the site is productive (Site Index = 121, which is classed as a mid-site 2, where site 1 is best and site 5 poorest) and that the site has had numerous treatments during the past 24 years.

SITE DESCRIPTION AND STAND HISTORY

Acreage — 41 acres
Predominant Aspect — Northwest to Northeast
Predominant Slope — 25% (highly variable)
Site Index — 121 (50 year table – med. site II)

The property was acquired in two pieces in 1932 and 1935. No harvest performed by previous owners.

1966 — Salvage logged/thinned after the Columbus Day storm. 182 MBF (4.4 MBF/AC) removed.

1974 — A shelterwood was attempted on the stand. The overstory was thinned to approximately a two crown width spacing to provide light to the understory. 465 MBF (11.3 MBF/AC) were removed.

1974 — 1000 2-0 Grand Fir seedlings were planted beneath the overstory on the west side of the 580 road. No follow up treatment.

1977 — 1-1/2 quarts/acre Roundup (glyphosate) in 10 gallons water was aerial sprayed via helicopter through the overstory. This was a research trial to determine the feasibility of pre-harvest vegetation control. The study showed only a very small amount of understory vegetation control.

Figure 1: Site Description and Stand History

The first step in deriving the best treatment schedule is to examine a series of silvicultural alternatives and then to examine more closely some of the implications of economics on the chosen alternative. Figure 2 is a printout of the ANALYST spreadsheet that describes four alternative prescriptions. The costs and returns of the different prescriptions have been entered into the spreadsheet to reflect possible treatments that will insure a new and successfully established stand. In identifying these alternatives the forester must use a combination of common sense, experience and science to insure that each identified alternative is feasible. From these basic alternatives, because of its high performance as measured by present net worth, we have chosen Alternative 3 (Brown + Burn) for further economic analysis.

ANALYST SUMMARY TABLE

TREATMENT & COSTS ALT 1			TREATMENT & COSTS ALT 2			TREATMENT & COSTS ALT 3			TREATMENT & COSTS ALT 4		
ACTIVITY	YR	COST/ ACRE	ACTIVITY	YR	COST/ ACRE	ACTIVITY	YR	COST/ ACRE	ACTIVITY	YR	COST/ ACRE
Mechanical Site Pre	0	$95	Burn	0	$200	Brown + Burn	0	$225	Seedling + Plant	0	$200
Seedling + Plant	0	$180	Seedling + Plant	0	$150	Seedling + Plant	0	$180	Grass/Weed Control	1	$50
Grass/Weed Control	1	$50				Chemical Release	3	$50	Grass/Weed Control	3	$50
Chemical Release	4	$45				Precomm Thin	10	$75	Precomm Thin	10	$75
Total APPARENT Cost		$370 (current $)	Total Cost		$350 (current $)	Total APPARENT Cost		$560 (current $)	Total APPARENT Cost		$375 (current $)
Constant Annual Cost		$0	Constant Annual Cost		$0	Constant Annual Cost		$0	Constant Annual Cost		$0

REVENIUE

ALT 1			ALT 2			ALT 3			ALT 4		
ACTIVITY	YR	$/ACRE	ACTIVITY	YR	$/ACRE	ACTIVITY	YR	$/ACRE	ACTIVITY	YR	$/ACRE
Thin	40	$139	Harvest	60	$1,299	Thin	40	$234	Thin	40	$195
Harvest	60	$1,181			$0	Harvest	60	$1,575	Harvest	60	$1,313
		RETURN/ ACRE			RETURN/ ACRE			RETURN/ ACRE			RETURN/ ACRE
CONSTANT ANN. RETURN		$0	CONSTANT ANN. RETURN		$0	CONSTANT ANN. RETURN		$0	CONSTANT ANN. RETURN		$0
OTHER PERIODIC RETURNS			OTHER PERIODIC RETURNS			OTHER PERIODIC RETURNS			OTHER PERIODIC RETURNS		
ACTIVITY	YR	AMOUNT	ACTIVITY	YR	AMOUNT	ACTIVITY	YR	AMOUNT	ACTIVITY	YR	AMOUNT

ECONOMIC RESULT

		ALT 1	ALT 2	ALT 3	ALT 4
PNW(1)	—	$958.49	$949.39	$1,277.52	$1,162.92
SEV(INF)	—	$965.72	$956.55	$1,287.16	$1,171.69
B/C	—	3.65	3.71	3.41	4.38
ROR	—	10.87%	10.90%	10.74%	11.20%

ECONOMIC CRITERIA DEFINITIONS

PNW(1) Present Net Worth. The sum, over one investment period, of all discounted costs and discounted returns.

SEV(INF) Soil Expectation Value. Can be though of as the PNW of a cycle of identical rotations successively repeated to infinity.

B/C Benefit-Cost Ratio. The ratio obtained by dividing the sum of the discounted benefits by the sum of the discounted returns.

ROR Rate of Return. There are many kinds of "ROR" values that can be calculated for any project. Here, we use what the forestry literature has called the Realizable Rate of Return or Composite Internal Rate of Return. Numerically it is very close to the Internal Rate of Return (IRR).

Figure 2: ANALYST Summary Table – Basic Alternatives

ECONOMIC ASSUMPTIONS

	ALT 1	ALT 2	ALT 3	ALT 4
Mkt Disc Rate (4-12%)	8.5	8.5	8.5	8.5
Mkt Reinv Rate (4-12%)	8.5	8.5	8.5	8.5
Infl Rate (1-4%)	4.5	4.5	4.5	4.5
Rl. Tbr Price Incr. (.5-2%)	0.0	0.0	0.0	0.0
Real Cost Incr. (0-1%)	0.0	0.0	0.0	0.0
Invest Period	60	60	60	60

INPUT ECONOMIC DEFINITIONS

MARKET DISCOUNT FACTOR (Mkt Disc Fact.)

The discount rate that will be used to analyze your project. It includes whatever inflation rate you enter, including 0% if you choose to exclude inflation from the analysis.

MARKET REINVESTMENT FACTOR (Mkt Reinv Fact.)

The annual earnings rate at which intermediate incomes from the current project will be invested. It includes whatever inflation rate you enter, including 0% if you choose to exclude inflation from the analysis. When you have no option other than to reinvest in the current project, enter a reinvestment factor equal to the market discount factor.

INFLATION RATE (Infl Rate)

The annual rate at which costs and product prices are increasing. This rate is applied equally to costs and returns.

REAL TIMBER PRICE INCREASE (Rl. Tbr Price Incr.)

The annual rate at which timber prices are increasing above (or in addition to) inflation. Over the long-term, U.S. timber prices have increased slightly faster than inflation. You can model this trend in several ways: aggressively, try a 2% real increase factor; moderately, try a 0.5% to 1% increase, or conservatively, try a 0% increase.

REAL COST INCREASE (Real Cost Incr.)

The annual rate that costs are increasing above (or in addition to) inflation. Most users enter 0% because they generally because they generally lack adequate data about cost increases beyond what is contained in the inflation rate.

PERIOD FOR INVESTMENT (Invest Period)

The time frame over which the project is analyzed. In forestry, this is generally one rotation. Any unit of time (months, years, etc.) is acceptable provided other data are appropriately scaled.

Figure 2: ANALYST Summary Table – Basic Alternatives (Contenued)

Discussion

Figure 2 contains considerable information about the alternatives. We immediately see wide viriation in the present net worth [PNW(1)] and soil expectation values [SEV(INF)] and somewhat less variation in the benefit/cost ratios (B/C) and rates or return (ROR). We observe considerable difference in the Total APPARENT Cost across the four alternatives. And, we note that preference rankings of the four alternatives differ when using the B/C and ROR criteria compared to the dollar return criteria, PNW(1) and SEV(INF) (called PNW and SEV, respectively).

If we were to choose an alternative based strictly on the amount of discounted revenue generated, it would be "Brown + Burn" since it slightly exceeds Alt. 4. Obviously, the more intensive site preparation and extra care taken during reforestation pays off in higher dollar yield at the end of the rotation, despite the considerably higher "up-front" cost.

In contrast, however, if we make our choice based on relative earning power, as shown by B/C and ROR, we would choose Alt. 4 since its performance exceeds the second best prescription, Alt. 2. The effect of the intensive reforestation expense is apparent when using B/C and ROR to compare the alternatives' relative earning performances. Due to the high reforestation cost, "Brown + Burn" ranks last despite having the highest final harvest revenue.

In this case study, the correct choice is "Brown + Burn" because here, we are evaluating only *one* site. We can implement only *one* alternative. Thus, the investment objective is to implement the alternative that generates the largest dollar return. This means that we should use either PNW or SEV as decision criteria. When doing so, "Brown + Burn" is clearly the best choice. After making this initial selection, the next step is to further analyze "Brown + Burn" by testing its response to different economic assumptions.

Figure 3 (Alternatives 1, 2 and 3) shows the results of making some changes in the economic assumptions surrounding our chosen "Brown + Burn" prescription. First, we examine the effect of lowering the discount and reinvestment rates to 6% (Alt. 1). As expected, the result is a large increase in PNW and SEV when compared to the original "Brown + Burn" evaluation shown in Fig. 2. Next we increase the discount and reinvestment rates to 11% (Alt. 2) and again, as expected, we see a large change (this time, a decrease) in PNW and SEV. Next, using the original 8.5% discount and reinvestment rates, we examine the effect of increasing real timber prices 1%

annually. As expected, we see an increase in the dollar return, but it is somewhat smaller than with the 6% discount and reinvestment rates.

ANALYST SUMMARY TABLE

TREATMENT & COSTS ALT 1			TREATMENT & COSTS ALT 2			TREATMENT & COSTS ALT 3			TREATMENT & COSTS ALT 4		
ACTIVITY	YR	COST/ ACRE	ACTIVITY	YR	COST/ ACRE	ACTIVITY	YR	COST/ ACRE	ACTIVITY	YR	COST/ ACRE
Brown + Burn	0	$255	Brown + Burn	0	$225	Brown + Burn	0	$255	Brown + Burn	0	$255
Seedlings + Plant	0	$180	Seedlings + Plant	0	$180	Seedlings + Plant	0	$180	Seedlings + Plant	0	$180
Chemical Release	3	$50	Chemical Release	3	$50	Chemical Release	3	$50	Chemical Release	3	$50
Precommercial Thin	10	$75	Precommercial Thin	10	$75	Precommercial Thin	10	$75	Precommercial Thin	10	$75
Total APPARENT Cost		$570 (current $)	Total Cost		$560 (current $)	Total APPARENT Cost		$560 (current $)	Total APPARENT Cost		$560 (current $)
Constant Annual Cost		$0	Constant Annual Cost		$0	Constant Annual Cost		$0	Constant Annual Cost		$0

REVENUE

ALT 1			ALT 2			ALT 3			ALT 4		
ACTIVITY	YR	$/ACRE	ACTIVITY	YR	$/ACRE	ACTIVITY	YR	$/ACRE	ACTIVITY	YR	$/ACRE
Thin	40	$594	Thin	40	$94	Thin	40	$348	Thin	40	$167
Harvest	60	$6,378	Harvest	60	$402	Harvest	60	$2,861	Thin	60	$263
		$0			$0			$0	Harvest	80	$885
		RETURN/ ACRE			RETURN/ ACRE			RETURN/ ACRE			RETURN/ ACRE
CONSTANT ANN. RETURN		$0	CONSTANT ANN. RETURN		$0	CONSTANT ANN. RETURN		$0	CONSTANT ANN. RETURN		$0
OTHER PERIODIC RETURNS			OTHER PERIODIC RETURNS			OTHER PERIODIC RETURNS			OTHER PERIODIC RETURNS		
ACTIVITY	YR	AMOUNT	ACTIVITY	YR	AMOUNT	ACTIVITY	YR	AMOUNT	ACTIVITY	YR	AMOUNT

ECONOMIC RESULT

		ALT 1	ALT 2	ALT 3	ALT 4
PNW(1)	—	$6,424.28	($22.28)	$2,678.08	$783.71
SEV(INF)	—	$6,625.12	($22.32)	$2,698.28	$784.85
B/C	—	12.72	0.96	6.04	2.48
ROR	—	10.59%	10.92%	11.80%	9.74%

Figure 3: ANALYST Summary Table – Sensitivity Testing of Brown + Burn Alternative

From this, we can conclude that the "Brown + Burn" alternative is quite sensitive to changes in discount and reinvestment rates. Both increases and decreases create large changes in PNW and SEV, with a 1.5% decrease causing the most change. And, we see moderate sensitivity to the 1% annual increase in real timber prices. Further, anything that we can possibly do to lower the cost of capital (decrease the discount rate), raise the reinvestment rate, or generate higher timber prices will considerably enhance our investment's performance.

Finally, we return to the original economic assumptions to examine the effect of lengthening the rotation (Fig. 3, Alt. 4). Doing so requires adding another commercial thinning. In possible contrast to expectations, financial performance declines across all criteria. Clearly, revenue from an additional thinning and the price premium for larger logs at final harvest does not offset the discounting effect of an additional twenty years in rotation length. We can conclude that if the rotation is extended, considerably more volume must be generated, both current and/or future prices must increase, the basic economic climate must improve, or a combination of all three must occur for the longer rotation to be as attractive or more attractive than our basic "Brown + Burn" alternative with a 60-year rotation.

Sensitivity testing might continue indefinitely as we explore various economic and silvicultural combinations. Using the ANALYST program, we have illustrated the procedure by examining several possible combinations. There is seldom one *absolutely* correct or incorrect decision, since both economic and silvicultural conditions usually vary with each situation. One must first establish the most extreme (ie., best and poorest) conditions expected and then analyze all expected situations in between. Only then will sufficient information exist to confidently suggest a decision. In this case study, the best that we can say is that although our first analysis showed the "Brown + Burn" alternative to be the most expensive initially, it also generates the largest dollar return. Further analysis shows that the alternative is sufficiently sensitive to changes in discount and reinvestment rates, to real timber price increases, and to changes in silvicultural assumptions that certain combinations could cause our decision to "cross over" to another alternative. Further testing could be done to establish decision rules for when to "cross over," but this exceeds the scope of this article.

Our conclusion, then, is to implement the "Brown + Burn" alternative and to do everything possible to minimize captial costs, to maximize the reinvestment rate, and to seek the highest possible timber prices. We should not expect longer rotations to improve the financial performance without significant increases in either timber volume or prices.

As a final note, we should highlight that our analysis has considered the implementation of only one alternative, and hence uses the decision criterion of maximum dollar return (measured by PNW). Often, however, several alternatives on different sites will be implemented. This requires using a different analytic approach and different decision criteria.

When several alternatives are to be selected, the usual objective is to implement those with the highest relative earning power (as ranked by B/C or ROR) while simultaneously implementing the combination that maximizes cumulative PNW (or SEV) *and* still stays within set budget, labor, or other constraints. Although sounding complicated, it is really pretty simple. First, one lists the alternatives in descending B/C or ROR order and then selects those that equal or exceed the minimum performance level. Last, from that subset, the combination that maximizes cumulative PNW (or SEV) *and* adheres to specified constraints is implemented.

Summary

Douglas-fir is an important commercial timber species worldwide. Nearly all of its production comes from the U.S. Pacific Northwest region. We have described the general situation in the U.S. surrounding Douglas-fir silviculture and economic analysis. This is coupled with a general discussion of common approaches to decision analysis in use today. Practical tools that foresters have used to conduct silvicultural and economic analysis are then reviewed. Finally, we illustrate such analysis using a popular computer spreadsheet template — ANALYST, to examine a typical Pacific Northwest Douglas-fir case study.

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