# WHY GROW LARGE TREES ANYWAY? A TIMBER GROWER'S PERSPECTIVE

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This conference honors new technologies that are making small logs profitable. Many regions are dedicating lots of plantation area to small logs for fiber and biomass. In the interior West, high speed small log sawmills are newly arrived. In our state of enamored arousal, it is easy to over extrapolate. I'm here to remind you and the people who grow trees for fun and profit that technical small log feasibility does not always equate to financial small tree optimality. Larger trees, containing both larger and smaller logs, are usually still more profitable to grow. Even if one narrow set of mill investors has profitably targeted smaller log inputs, several financial realities still favor growing larger logs.

The definition of small logs is relative and over categorizes. What passed for small at the start of the twentieth century is enormous by twenty-first century standards. This paper considers a range of smaller logs (4 in. small end diameter to larger logs, 26 in.). In the West, larger logs have typically come from long rotation overstocked federal forests. Their adoption of ecosystem-based management has two log supply effects. First, total harvest volumes have fallen. In Idaho, Forest Service harvests dropped from 668 MMBF in 1988 to 147 MMBF in 2000 (USDA-Forest Service 2001). Second, restoration silviculture retains larger trees for ecological reasons and prescribes removing small diameter trees, particularly whitewoods.

The unilateral reorientation of a log supplier with monopoly powers raised log prices that closed many random length mills. In Idaho, average delivered log prices doubled for most species in excess of inflation between 1981 and 2000 (NW Management data 12/01). Most of the new installed milling capacity is designed for smaller logs from nonindustrial forests and could handle projected public ecosystem management small wood.

Others here are discussing small log reorientation for existing mills and new mills. Basically, newer technology, such as hew saws and kerf saws, will automatically process 20 to 30 uniform small logs/minute. New technology capital substitutes for higher cost labor and higher cost logs at the same time. Higher through-put reduces cost per MBF of log input. The archaic measure of log volume, Scribner decimal C, means that the lumber MBF tally recovered exceeds the MBF log tally processed. Old random length mill overruns were in the vicinity of 180%. Actual current overrun is a tightly guarded industrial secret, however, newer installations are whispered to exceed 250%.

Small log mills produce high volumes of small framing lumber. While this is a large volume market, unit product values are low. Reduced lumber size and grade recovery opportunity can be a significant cost in some species. At an extreme, the spread between ponderosa pine utility 1x4 and grade C or better 1x12 may be an order of magnitude (Random Lengths Yardstick 1/02). In Douglas-fir construction grades the spread may only be 200%.

More valuable lumber grades still come from remaining dimension mills that saw larger logs. The value of lumber recovery is reflected in these mills' willingness to pay for larger logs. Size premiums can be significant depending on species and the value range of recovered lumber. Figure 1 shows that framing species, Douglas-fir (*Pseudotsuga* sp) and grand fir (*Abies grandis*) have small size premiums that disappear at 16 in.. The dimension species example, 20 in. ponderosa pine logs (*Pinus ponderosa*) are worth 2.5 times more per MBF than 6 in. logs. However, prices flatten at 20 feet.

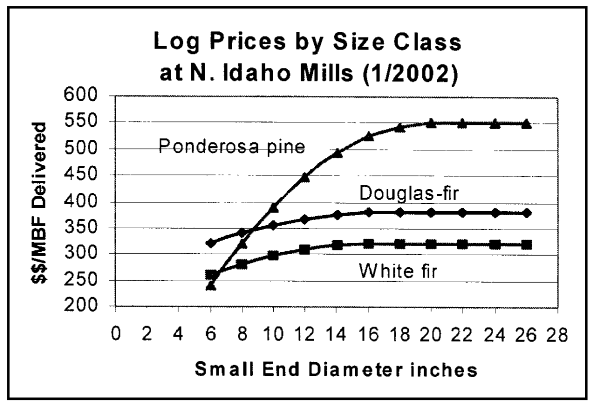


Figure 1.— Log prices by size class at Northern Idaho Mills (1/02).

Such local log size premiums are smaller than a decade ago. The larger log mills have been declining, so purchase competition for larger and higher grade logs has too. As of 2001, there were only 6 large log sawmills remaining in a 100-mile haul radius of North Idaho. Newer small log mills require uniform sized logs and may have trouble even reselling very large logs. They have instituted large log penalties that are becoming more common. Most penalties are reported at $200/MBF if any logs with large end diameters of 26 in. to 28 in. are found in a delivered load of small logs.

As we translate log price behaviors into production signals to timber growers, we encounter two conflicting silvicultural paradigms and some economic complications. A new silviculture of ecosystem management is widespread in public forestry and is being sold to private forests too. As practiced in the interior West, it implies restoring forest stands to pre-European fire-defined stand structures. This implies fewer larger seral species trees per acre. Initial restoration of heavily overstocked existing stands implies large-scale projects to remove large volumes of small diameter whitewoods. Eventually, these stands would be thinned across diameter classes with occasional light harvests of larger trees. A priori financial investment criteria, such as log prices and positive discount rates, are often irrelevant and many eco-silviculturists blithely assume that whatever they harvest will be marketable whenever.

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The alternative view is that consumer markets for wood products define what should be profitably grown. If long-run markets continue to offer size premiums, we can presume that at least some private timber growers would respond to them. A timber economist would incorporate such assumptions into predictions for defining optimal investment, production cycles and management.

A classic view of timber investment optimization presumes that wealth (V) from production is a function of silvicultural costs (w), log prices (p) and log extraction costs (x). Stumpage values are net residual value (p-x). Optimization requires finding the partial derivatives of wealth. From there, optimal grower responses to changes in economic parameters are predictable.

Hyde (1980) formulated the system as wealth (V) responding directly to investment effort (E):

$$\frac{\partial V}{\partial E} = \left[(p-x)Q_E e^{-rT} - w\right]\left(1-e^{-rT}\right)^{-1} = 0 \qquad eq\#1$$

He also showed that wealth should respond to reentry cycle or rotation length (T):

$$\frac{\partial V}{\partial T} = \left\{(p-x)Q_T\left(1-e^{-rT}\right) - r\left[(p-x)Q - wE\right]\right\}e^{-rT}\left(1-e^{-rT}\right)^{-2} = 0 \qquad eq\#2$$

Figure 2 shows a simplified single cycle solution. A constant average log price is multiplied by a smoothly differentiable growth function to generate a smooth sigmoidal value growth function. The rotation (T) optimum occurs where the rate of value growth equals the positive discount rate (i).

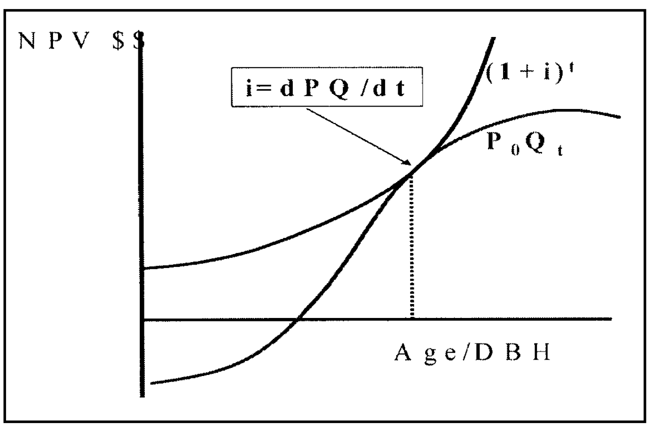


Figure 2.—Graphical mechanics of optimal timber rotations.

When this constant average net stumpage price (p-x) logic is applied to typical northern Idaho stands, a positive discount rate does favor short smaller tree rotations that produce small logs. Figure 3 is a NPV curve for site 80 Douglas-fir/grand fir plantations. Optimal E* is custodial management with T* at 43 years. The NPV is $164/acre for growing a stand of 10 in. DBH trees that yield 1 small log each.

Hyde also deduced that optimal solutions would be particularly sensitive to different levels of either gross log price (p) or the ratio of effort cost to net stumpage price (w/(p-x)). If either rose, then optimal effort (E) would rise. If log price rose or if the ratio dropped, rotation age (T) should drop. However, Hyde also noted that a continual rise in p or decline in w(p-x) should unequivocally raise both E and T. He intended to describe a situation where increasing market scarcity was continually increasing log price levels. We can also presume that E and T are sensitive to stand value changes with time, i.e., where (p-x) increases with increasing log size. If so, we should see higher optimal E and T than Figures 2 and 3 suggest.

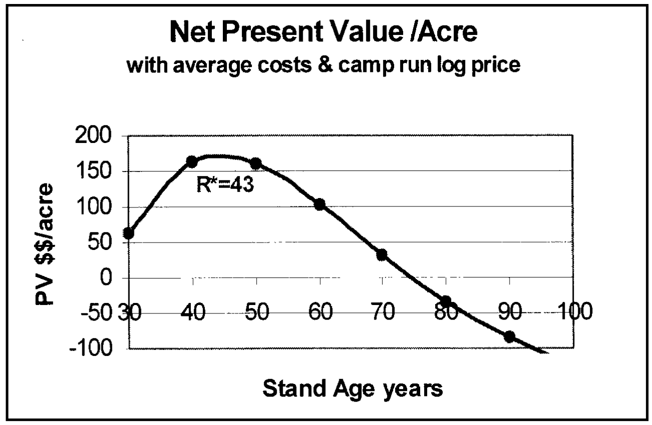


Figure 3.—NPV by stand age (all log diameter prices equal).

We already saw that p = f(size), and increasing analytical reality should recognize that x = f(size). Indeed, figure 4 shows that components of x are all steep negative functions. All tasks in logging have tree or log size sensitive average costs that can be estimated (Lee and Johnson 1996). Felling and skidding are more size sensitive than loading and hauling. When logging task costs are summed vertically by size class, the total logging cost curve can be extremely steep. Larger trees are significantly cheaper to log per MBF.

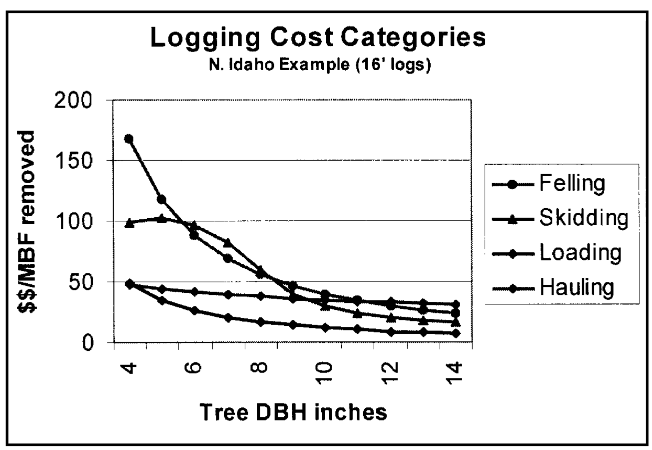


Figure 4.—North Idaho average logging costs by tree diameter.

The hypothetical gross stem volume yield function is sigmoidal over time and smoothly differentiable. Real merchantable net stand volume recovery comes from discrete salable logs and is typically a step function. Figure 5 sums only merchantable logs (>4 in. top) as they grow into measurable size classes. It is an extreme example as only 16-foot log lengths are counted.

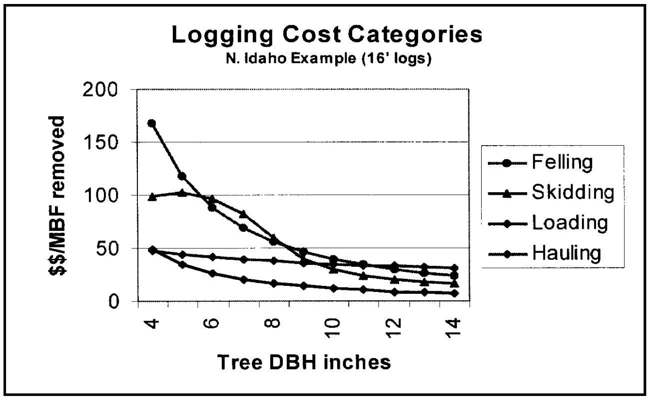


Figure 5.—Step function of increasing salable volume by tree diameter.

Merchantable log size recovery affects the average stumpage prices (p-x) of trees. When we combine average log p = +f(size) and average x = -f(size), average (p-x) has a really significant initial increase as shown in the Figure 6 example up to age 50 where butt logs are getting larger. However, Working in averages causes a later stumpage price anomaly. When top logs become merchantable at larger tree diameters, the $/MBF gain in second log p is very small so the volume weighted average of stand value may actually drop over an interval.

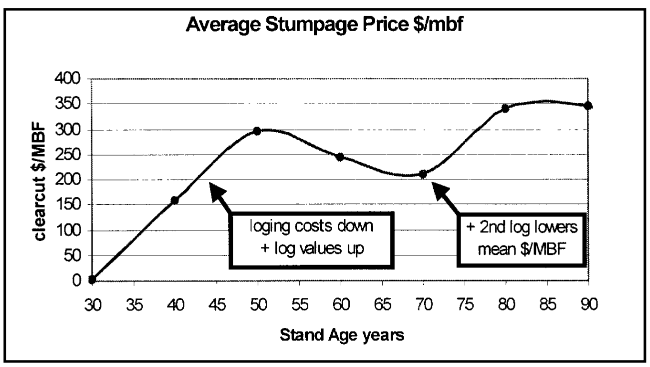


Figure 6.—Stand volume weighted average stumpage price.

This leads to a very irregular average value function that is multiplied by a step function of merchantable volume. The stumpage value function becomes an irregular wave form as shown in Figure 7. Now the discounting process

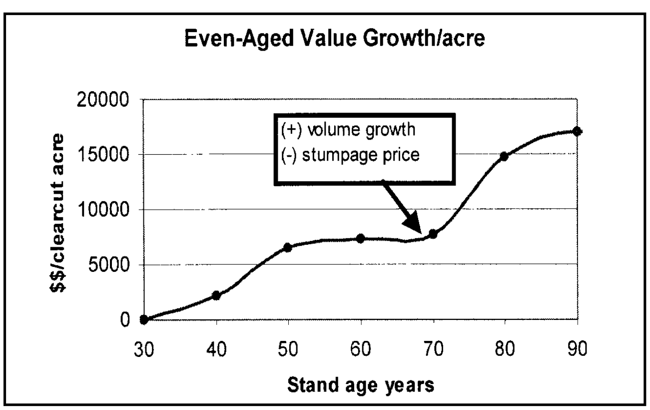


Figure 7.—Stand value growth with average stumpage prices.

that finds optimal T will amplify high points of the wave and bias against the lower, particularly when you have to wait to get it.

The example's T solution pattern is shown in Figure 8. This curve of present value shows the shape implied from the combinations explained above. The final harvest should occur at age 50 compared to age 43 in the constant price solution. Waiting more than age 50 and 2nd-logs become merchantable. That lowers stand average stumpage value and reduces returns.

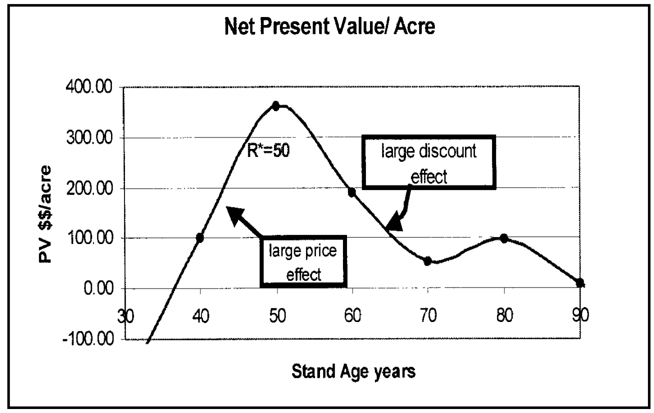


Figure 8.—Optimal regime is higher investment in effort and time.

What can't be seen here is that the optimal volume curve is actually different from the previous example. Small log values can actually mitigate the costs of growing larger logs more intensively. Even at breakeven prices or slightly below, the concept of precommercial thinning drops the "pre" prefix and thinning becomes viable in optimal management. In Figure 8, there was an added breakeven thinning so the volume yield function is actually based on higher management intensities. The combination of recognizing large log size premiums, size based logging costs and free thinning doubles the NPV of this North Idaho Douglas-fir example from $164/acre to $362/acre.

There is another important subtlety. All the example optimization mechanics were based on average stumpage pricing that was irregular over time. The target tree has a larger butt log and we throw away the tops because the stumpage curve wave form came from averaging in small log values with the large log values. When small log markets exist, the relevant stumpage value is marginal not average. In most cases, once a logger pays a fixed move-in cost, the extra cost of collecting small top logs while he's there is lower than average logging cost/unit as long as sorting and merchandizing costs are also low. In the Idaho Douglas-fir example, capturing 2nd-log marginal value would lengthen rotations another 5 years. Growers should still focus on large butt logs and their size premiums, but that doesn't imply leaving net value little logs. In addition their collection mitigates slash treatment costs and bonds

So growers should be pleased that a small log market is developing. More merchandizing opportunity increases management options. However, where larger butt logs are still worth more, ignoring the returns from growing them bigger would, in most cases, significantly undercut stand investment profitability.

Forest economists were always confident that Hyde's E and T inferences worked in the large for big market trends. Now we see that they also work in the small for cost and price changes that occur on site within rotations. For most growers, as long as log size premiums are substantial, optimal rotations should be longer with more intensive regimes for bigger butt logs rather than bulk growing small trees on short cycles.

Further considerations are that small log markets cycles are as proportionally unstable as large log markets. In addition, small log manufacturing capacity is limited. At this moment in the inland West, milling capacity is roughly in equilibrium with private small log supplies. However, log demand is very inelastic (about -.3). In other words, a rapid small log supply increase could swamp mills causing rapid and significant price reductions for the oversupplied size and species classes. The biggest wild card is the national forests' enormous small log volume potential from proposed ecosystem management restoration. Will it ever happen? Sure it would make the public forests healthy again, but from my perspective as a nonindustrial forest owner, I sure hope not.

So, bottom line—rejoice that new markets turned small logs into revenue and cost mitigation items, but hesitate, and don't rewrite your silviculture toward growing small trees—yet.

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