THE ECONOMIC IMPACT OF TIMBER HARVESTING PRACTICES ON NIPF PROPERTIES IN WEST VIRGINIA

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Abstract.—Post-harvest inventories were performed on 90 timber harvests conducted on nonindustrial private forest (NIPF) properties in West Virginia. Each harvest was evaluated based on a combination of residual stocking level, proportion of the residual stand in acceptable growing stock, and damage to the residual trees. Four post-harvest stands representative of good or poor harvest practices were projected for 20 years into the future using the Forest Vegetation Simulator.

Twenty years after harvest, stands subjected to good harvesting were projected to contain twice the volume of high quality sawtimber and nearly three times the volume in acceptable growing stock sawtimber compared to stands subjected to poor harvesting. Good stands also contained much higher volumes in trees 20 inches diameter at breast height (d.b.h.) and larger and had lower future harvesting costs.

After adjusting stumpage prices to account for differences in harvesting costs, tree quality, and tree size, good harvest practices resulted in 20-year timber values three to five times higher compared to poor harvesting. Despite this, poor harvest practices resulted in real internal rates of return (IRR) of 5 to 7 percent, whereas good harvest practices resulted in real IRRs of 4 to 5 percent.

INTRODUCTION

Poor timber harvesting practices are commonly used throughout the Appalachian hardwood region. Many landowners cut their largest, most valuable trees and leave the less valuable trees after harvest (Fajvan et al. 1998; Luppold and Bumgardner 2009; Nyland 1992, 2001; Pell 1998) A survey of nonindustrial private forest landowners (NIPFs) who harvested timber in West Virginia found that 62 percent of the harvests were conducted using a diameter-limit cut, even though professional foresters were involved with 60 percent of the harvests (McGill et al. 2006). In addition, Moss (2011) found that many harvests described by landowners or loggers as “selection” harvests were actually high-grades, and concluded that silvicultural harvesting practices are used on only a small fraction of timber harvests on NIPF properties in West Virginia.

An important factor contributing to the prevalence of diameter-limit harvests and high-grading is the considerable short-term economic benefit that accrues to both the landowner and timber buyer who engage in these practices. What is less well understood are the longer term economic impacts of various harvesting practices. This study provides a 20-year economic evaluation of good and poor harvesting practices that were employed on nonindustrial, private forest land in West Virginia during 2005 to 2007.

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STUDY AREA

This study was conducted on 90 forested sites distributed throughout West Virginia. All sites were owned by nonindustrial, private, forest landowners and had been subjected to partial timber harvesting between January 2005 and June 2007.

METHODS

Field Measurements

Ninety recently harvested NIPF properties in West Virginia were inventoried in 2007 to measure various harvest attributes (e.g., percentage of basal area and value harvested) and residual stand characteristics (e.g., percentage of residual basal area in acceptable growing stock). Each harvest was given an overall evaluation based on three residual stand attributes: (1) stocking level, (2) percent of basal area in acceptable growing stock, and (3) percent of basal area damaged during logging. Using these criteria, we rated each harvest as good, fair, or poor (Moss 2011).

Residual stand data collected during the field investigations were used to project future stand attributes using the U.S. Forest Service's Forest Vegetation Simulator (FVS) Northeast Variant (Dixon 2003). Residual stands from four properties were selected for this analysis: two properties representative of good harvest practices and two properties representative of poor harvest practices. Table 1 lists the important residual stand attributes of these four stands, relative to the average values for all residual stands resulting from good and poor harvest practices investigated by Moss (2011).

Growth Projections

Residual stand data entered into FVS included: diameter at breast height (d.b.h.), species, tree quality, and damage severity. The impact of damage to the residual trees was included in the model as adjustments to future merchantable volume or mortality. Trees with moderate bole damage (100 - 500 in^2 of exposed wood) were assumed to suffer a 10 percent loss in merchantable volume by the end of the projection period (20 years), while trees with severe bole (> 500 in$^{2.}$ of exposed wood) were assumed to suffer a 15 percent loss in merchantable volume by the end of the projection period. Trees with slight bole damage (< 100 in^2 of exposed wood) were assumed to suffer no loss in merchantable volume. Trees with severe crown damage (more than 50 percent of crown removed) and trees with a broken main stem pushed entirely over were assumed to have died during the

Table 1.—Percentage of basal area in acceptable growing stock (AGS), percentage of basal area damaged during logging, and percent stocking level for residual stands subjected to good (G1 and G2) and poor (P1 and P2) harvest practices and average values NIPF harvests in West Virginia rated as "good" or "poor" (from Moss 2011)

Stand	Percent AGS	Percent damaged	Stocking percent
G1	73	4	60
G2	71	2	60
Avg. for 8 "good" stands	70	6	58
P1	46	15	40
P2	50	17	40
Avg. for 38 "poor" stands	49	13	37

projection. These assumptions are consistent with research on the impacts of logging damage to hardwood stands (Lamson and Smith 1988, Lamson et al. 1985, Ohman 1970, Smith et al. 1994).

There were significant differences in the proportion of residual basal area in dominant/codominant trees between tracts subjected to good and poor harvest practices (Moss 2011). Research has shown that crown class is often the single best predictor of future diameter growth in hardwoods, particularly for the more shade-intolerant species, but also for certain shade-tolerant species subject to release (Nyland 2006, Trimble 1969). Low-vigor trees in intermediate and suppressed crown classes often grow slower and are more apt to die (Marquis and Ernst 1991). Thus, tracts subjected to good harvest practices might experience faster growth rates after harvest than tracts subjected to poor harvest practices, all other factors being equal. Unfortunately, the models in FVS do not incorporate crown class/canopy position into the calculation of diameter growth. Therefore, no attempt was made to adjust growth rates based on this attribute. However, the financial analyses of harvesting practices presented in this paper include an adjustment for possible higher growth rates on good tracts.

Stand projections were made for 20 years into the future. This time period was selected because it represents a reasonable timeframe during which re-entry into the stand for future harvesting might occur. Merchantable sawtimber board-foot volume (International 1/4-inch scale) was calculated by species, tree quality, and d.b.h. class.

Determination of Stumpage Prices—Adjustments for Tree Quality and Diameter

Stumpage prices for hardwood sawtimber reflect the expected revenue from the sale of hardwood lumber minus mill production costs, profit, and expenses related to the procurement, harvesting, and transportation of saw logs to the mill. To estimate the value per board foot of lumber expected to be sawn from a log, it is necessary to determine the species, quality, and size of the log.

Luppold et al. (1998) concluded that there is a strong correlation between lumber and stumpage prices over the long term, even though there is weak correlation over the short term. Our study assumed that lumber and stumpage prices are in long-term equilibrium and, as a consequence, lumber prices can be used to derive appropriate stumpage prices.

Hardwood lumber yield data, by species, tree grade, and tree d.b.h. were obtained from Hanks (1976), while Appalachian hardwood lumber prices were obtained from the Hardwood Market Report average prices for June 2007 (Johnson et al. 2007). These data were combined to calculate expected lumber value, per thousand board feet, for each important timber species, by tree diameter and grade. For example, the lumber expected to be produced from a sugar maple tree that is 20 inches d.b.h., contains 32 merchantable feet, and meets Forest Service Grade 2 criteria would have been worth $116.63 in July 2007. The volume in a 20–inch-d.b.h. two-log tree is 180 board feet, International 1/4-inch scale. Therefore, the expected lumber value from this tree is $647.95 per thousand board feet (MBF) of tree scale ($116.63 ÷ 180 * 1000).

These calculations were performed for tree diameters from 12 to 40 inches d.b.h. for each of the three Forest Service tree grades and for the following timber species: red maple, black oak/scarlet oak, sugar maple, black cherry, white oak, yellow-poplar/cucumbertree, northern red oak, and chestnut oak. Because there are no standardized criteria for determining veneer grade, no attempt was made to estimate the potential for future veneer quality for the residual trees. Consequently, there was no need to calculate stumpage prices for veneer-quality trees.

The resulting lumber values per MBF tree scale formed the basis for adjusting stumpage prices to reflect the effects of tree grade and diameter. Prices were obtained from the Appalachian Hardwood Center's Timber Market Report (AHC-TMR) for the second and third quarters of 2007 (Appalachian Hardwood Center 2007). It was assumed that the stumpage prices in the AHC-TMR reflect prices of "average" timber. Although any number of definitions of "average" timber might be appropriate, it was assumed that Grade 2 trees from 16 to 24 inches d.b.h. would constitute "average" timber in most circumstances. For sugar maple, the average lumber value per MBF tree scale for Grade 2 trees from 16 to 24 inches d.b.h. was $676.83/MBF. The statewide average price for sugar maple stumpage reported by the AHC-TMR for the second and third quarters of 2007 was $254.00/MBF. The difference between lumber value per MBF and stumpage price per MBF represents sawmill operating costs, harvest and transportation costs, procurement and transaction costs, market forces arising from localized supply and demand for sugar maple stumpage, and profit for various entities, as well as random variation and market inefficiencies. Collectively, these are referred to as "conversion costs," because they represent all costs associated with converting standing timber into lumber. Subtracting the sugar maple conversion cost of $422.83/MBF from the lumber price per MBF for every combination of tree grade and d.b.h. yields the indicated stumpage prices for various diameters and grades of sugar maple sawtimber trees. For example, subtracting the conversion cost of $422.83/MBF from the expected lumber value for 20-inch grade 2 sugar maple trees ($647.95/MBF) yields an indicated stumpage price of $225.12/MBF for trees of this species, d.b.h., and grade. This process was repeated for the other timber species. Figure 1 summarizes the resulting stumpage prices for sugar maple. Graphs for the other species can be found in Moss (2011).

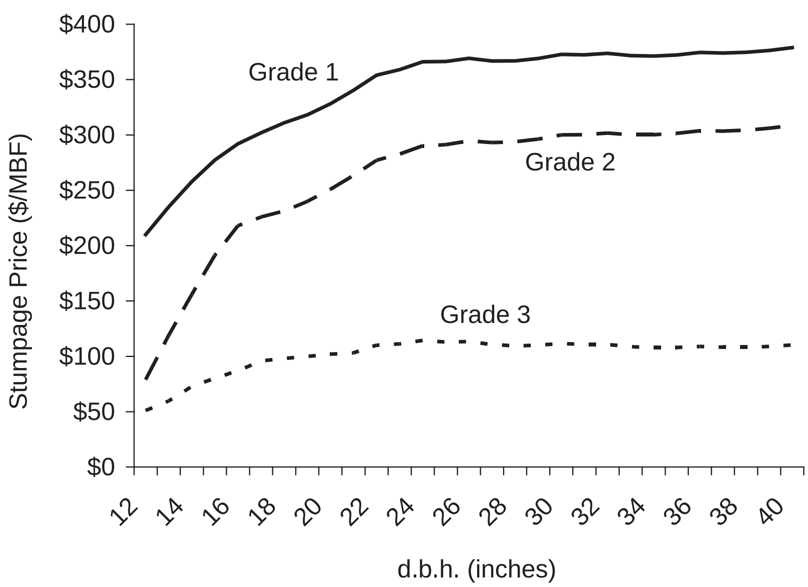

Figure 1.—Estimated stumpage prices for sugar maple trees in West Virginia from 12 to 40 inches d.b.h. and Forest Service tree grades 1, 2, and 3, based on predicted lumber value.

Because the analysis by Hanks (1976) contained only the previously listed eight species, all other species were grouped together as miscellaneous hardwood. To make an adjustment to the miscellaneous hardwood stumpage price from the AHC-TMR, average lumber value by tree grade and d.b.h. for the eight species were used. Although this clearly does not represent the actual lumber values for miscellaneous hardwoods (many of which are low value species), the purpose of calculating lumber value was to adjust the stumpage price reported by the AHC-TMR, and so the method is reasonable.

Determination of Stumpage Prices—Adjustments for Differences in Harvesting Cost

Per unit harvesting costs directly impact stumpage prices and are affected by harvest volume per acre and average tree size (Cubbage et al. 1989, Egan and Baumgras 2003, Li et al. 2006). Twenty years after harvest, projected timber volume per acre and average tree size varied greatly between tracts, as a consequence of the harvest practices initially employed. Stands with significantly different average tree volumes and merchantable trees per acre will incur different harvesting costs because these factors influence felling and skidding efficiency. Therefore, stumpage prices had to be adjusted for possible differences in harvesting costs between tracts.

Harvesting cost was simulated using the Central Appalachian Harvesting Analyzer (CAHA). This model incorporates the important factors that determine harvesting costs for ground-based harvesting systems in the Appalachian Region (Wang and LeDoux 2003, Wang et al. 2004, Wang et al. 2007). The simulated harvesting system used consisted of a single manual feller using a chainsaw, two cable skidders, and a knuckle-boom loader. Site input variables not affected by the harvesting practices being examined (e.g., moving and setup costs, tract acreage, miles of roads constructed, operator efficiency, etc.) were identical for all tracts and were selected by the investigator to represent typical properties in West Virginia. Operating cost variables (depreciation, maintenance and repair expense, labor expense, etc.) were provided by the developers of the computer model and were deemed typical for a harvesting operation in West Virginia. Because the objective was to compare harvesting costs between tracts subjected to various harvest practices, rather than to calculate a highly accurate estimate of harvesting costs, the accuracy of these input variables is unimportant, as long as they are reasonable.

The good and poor harvesting practices examined in this study had significantly different impacts on future per acre timber volumes and average tree diameters. To model these effects, stand tables (trees per acre by d.b.h. class and average board-foot volume per tree by d.b.h. class) were entered into the CAHA model for the initial harvests, as well as 20-year projections for stands G1, G2, P1, and P2. The CAHA model provided default values for felling time per tree. These values reflect the increased time required to harvest larger diameter trees. Skidding efficiency was simulated by assuming three trees are skidded to the landing during each cycle. Therefore, volume per cycle equaled three times the average board-foot volume per tree, with a maximum volume of 600 board feet, to simulate skidder capacity.

Simulated timber harvesting costs using the CAHA are shown in Table 2. The initial (actual) harvests used on the four stands resulted in similar estimated harvesting costs, with an average cost of $101/MBF. This cost was assumed to represent "average" harvesting costs on typical stands. Thus, any

Table 2.—Simulated timber harvesting costs and resulting adjustments to timber stumpage prices ($/MBF) for four NIPF properties in West Virginia subjected to good (G1 and G2) and poor (P1 and P2) harvesting practices over a 20-year projection period; all costs and adjustments are $/MBF

Stand	Scenario	Harvest year	Harvesting cost	Stumpage adjustment
G1	Initial "good" harvest	0	$100	$0
G2	Initial "good" harvest	0	$107	$0
P1	Initial "poor" harvest	0	$98	$0
P2	Initial "poor" harvest	0	$98	$0
G1	Future harvest	20	$99	$0
G2	Future harvest	20	$101	$0
P1	Future harvest	20	$146	- $45
P2	Future harvest	20	$170	- $69

stand with expected harvesting costs of approximately $101/MBF or less would not be subject to any stumpage price adjustment due to excessive harvesting costs. Twenty years after the good harvest, stands G1 and G2 recovered to stand conditions similar to the pre-harvest stands. As a consequence, estimated harvesting costs at Year 20 were similar to the harvesting costs estimated for the initial harvest (i.e., "average" cost) and no adjustment was made to stumpage values at Year 20.

Twenty years after the initial harvest, projected per acre volumes and average tree sizes on stands P1 and P2 were still much less than what was initially harvested, resulting in harvesting costs roughly 50 percent higher than "average" cost. As a result, per acre timber values for these tracts were reduced by $45/MBF and $69/MBF, respectively, at Year 20.

Quality and diameter-specific stumpage prices were applied to the sawtimber volumes harvested from each tract and future sawtimber volumes were projected using FVS. Because the quality of the initial harvested trees was unknown, all harvested trees were assumed to be grade 2. This produced a less precise estimate of the true value of timber that was harvested, but was unavoidable. Unless there were significant differences in the quality of timber harvested on the stands subjected to good and poor harvest practices, the effect on the comparative financial analysis of harvesting practices should be relatively small.

The resulting per acre timber values were then adjusted for above-average harvesting costs, when appropriate, as indicated in Table 1. The resulting net per acre timber values were used in all present value calculations for the financial analyses. Stumpage prices used to calculate future timber values were not adjusted for expected future inflation, and thus represent "real" 2007 prices and assume no real stumpage price appreciation over the 20-year projection period.

Selection of Discount Rates

One of the most troublesome aspects of financial analyses is the selection of an appropriate discount rate to apply to future cash flows. The purpose of a discount rate is to reduce (discount) future revenues/benefits to account for: (1) delayed consumption (all else being equal, we would rather enjoy benefits now rather than later) and (2) risk (future revenues/benefits are not certain). Time preference for consumption (placing a discounted value on future benefits because we must wait to receive them) varies among individuals and is affected by many factors. Likewise, individuals have varying levels of risk tolerance/aversion and, therefore, require differing levels of compensation as reward for assuming risk. To further complicate matters, risk is often difficult to quantify, so individuals may have varying perceptions of the risk involved in a particular investment/activity.

Given that NIPF owners are a numerous and diverse group, it is difficult to derive a single discount rate, or even a relatively narrow range of discount rates, that might be appropriate for analyzing forestry practices on NIPF land. To address this issue, financial analyses for this study were done using a range of real (inflation-adjusted) discount rates from 1.0 to 10.0 percent. The resulting "present value profiles" graphically illustrate present values for various options/scenarios for the range of discount rates analyzed. This allows the reader to ascertain the range of discount rates under which one scenario would be financially superior to another. Readers are free to select the discount rate they feel is most appropriate and draw their own conclusions about the attractiveness of each option/scenario, rather than being presented with an analysis showing which option is superior under a single, predetermined discount rate assumption. In addition, internal rate of return (IRR) can be derived from net present value profiles, because net present value will equal $0 at the discount rate that is equal to the IRR.

RESULTS

After 20 years, projected sawtimber volumes on the good stands are approximately twice as great as on the poor stands (Table 3). As a result of larger tree sizes, better tree quality, and lower harvesting costs, projected values on the good stands are approximately three times greater than values on the poor stands. The volume of acceptable growing-stock trees 20 inches d.b.h. and greater is more than six times as great in the good stands compared to the poor stands.

Because there are significant differences in initial timber value on the various stands (due to differing volumes, species composition, and timber quality), there is limited insight to be gained by directly comparing present values of the different stands. To adjust for differences in initial timber value, net present value (NPV) was calculated for each tract. In this method, initial timber value is treated as an opportunity cost and is subtracted from harvest income and discounted future timber value. This is financially appropriate, because partial harvesting in Year 0 followed by a second harvest (or disposal of the property) in Year 20 implies forgoing the income that could be received from liquidating the timber (clearcut harvest or property sale) in Year 0. Essentially, calculating NPV in this manner determines the long-term financial gain (or loss) realized by the landowner as a result of various harvesting techniques (in our case good or poor practices), assuming the initial timber value represents an investment by the landowner.

Table 3.—Initial stand, harvested, and projected future timber volumes and value for four NIPF properties in West Virginia subjected to good (G1 and G2) and poor (P1 and P2) harvesting practices (volumes in board feet per acre, International ¼-inch scale; values in dollars per acre; AGS20 = board-foot volume in acceptable growing-stock trees 20 inches d.b.h. and greater)

	Preharvest stand		Initial harvest		20-year projection		
Stand	Volume	Value	Volume	Value	Volume	Value	AGS20
G1	13,887	$1,831	8,459	$1,274	9,399	$1,192	3,218
G2	11,039	$1,545	5,255	$873	9,996	$1,410	3,486
P1	12,450	$1,892	10,174	$1,730	4,779	$449	543
P2	11,542	$1,400	10,062	$1,314	4,302	$324	716

Net present value profiles for stands G1, G2, P1, and P2 over a 20-year projection period are presented in Figures 2 and 3. The accelerated growth rate scenario (Fig. 3) assumes that stands subjected to good harvest practices will achieve projected 20-year volumes in only 16 years.

For the 20-year projection period, NPV is greater for the stands subjected to good harvest practices (G1 and G2) compared to the stands subjected to poor harvest practices (P1 and P2) for all discount rates less than about 3 percent. Net present value falls more steeply with increasing discount rate for the two good stands compared to the two poor stands, because a larger proportion of total value is realized at the end of the projection period and is therefore subject to discounting. Trends for the two good stands are similar, as are the trends for the two poor stands, suggesting that these trends can be generalized for all stands in this study subjected to good and poor harvest practices.

At discount rates below 4 percent, NPVs of the good stands are positive, indicating that landowners are better off financially by performing a silvicultural harvest versus liquidating their forest. This indicates a real internal rate of return of approximately 4 percent for landowners engaging in silvicultural harvests.

Engaging in poor harvest practices yielded financial gains for landowners at all discount rates below 5 percent, as indicated by the positive NPVs (Fig. 2). The real internal rates of return for the two poor stands are 5 percent and 7 percent.

Assuming accelerated growth for the stands subjected to good harvest practices, NPV is greater for the good stands (G1 and G2) compared to the poor stands (P1 and P2) for all discount rates less than approximately 4.5 percent (Fig. 3). At discount rates below 5 percent, NPVs of the good stands are positive, indicating that landowners are better off financially by performing a partial harvest using silvicultural guidelines versus liquidating their forest. This indicates a real rate of return of 5 percent for landowners engaging in silvicultural harvests.

DISCUSSION

The analysis of the effects of tree grade and d.b.h. on lumber value and, subsequently, stumpage price, clearly indicated that tree quality and size are important considerations when determining standing timber value. Good harvest practices yielded greater sawtimber volumes than poor harvest practices 20 years after the initial harvest. However, the effects on timber value were much greater than the effects on sawtimber volume, due to the significant differences in average tree size and timber quality. In addition, future per unit harvesting costs were higher on tracts subjected to poor harvest practices, as a result of the lower felling and skidding efficiencies incurred on tracts with a lower per acre volume and a smaller average tree volume. This further reduced future stumpage values on these tracts.

Despite their negative impacts on sawtimber volume, timber quality, and harvesting cost of the future stand, poor harvest practices were deemed to be financially attractive to landowners. Although good harvest practices yielded 20-year timber values two to five times higher than poor practices, the much higher initial harvest income generated by poor harvesting resulted in higher net present values at all real discount rates greater than about 3 percent. Landowners engaging in poor harvesting were projected to realize real internal rates of return (IRR) of 5 to 7 percent, compared to 4 percent for

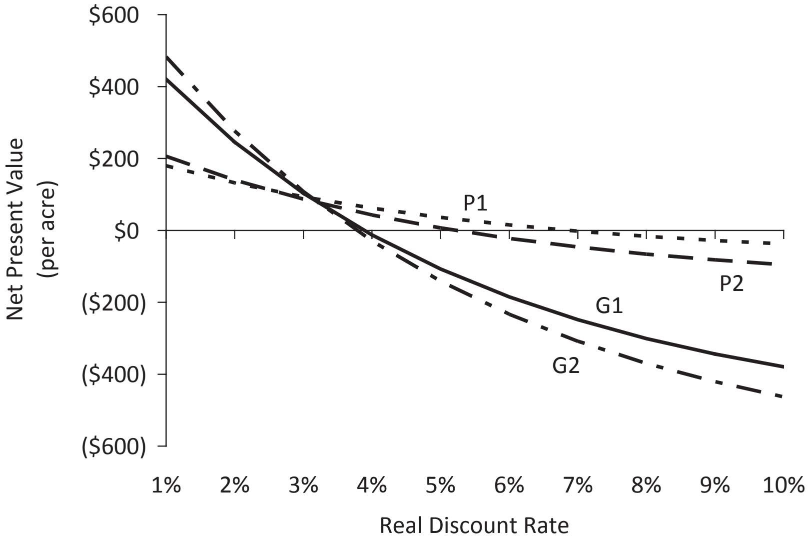

Figure 2.—Net present values for four NIPF properties in West Virginia subjected to good (G1 and G2) and poor (P1 and P2) harvesting practices over a 20-year projection period at real discount rates from 1.0 to 10.0 percent.

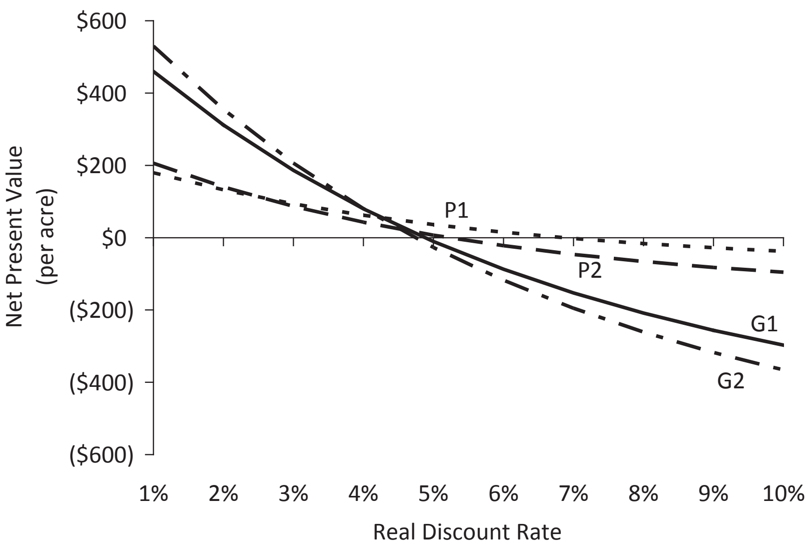

Figure 3.—Net present values for four NIPF properties in West Virginia subjected to good (G1 and G2) and poor (P1 and P2) harvesting practices over a 20-year projection period at real discount rates from 1.0 to 10.0 percent, assuming accelerated growth rates for tracts subjected to good harvesting practices.

landowners who performed good harvests. If good harvest practices result in higher timber growth rates, the real IRR for good harvest practices increases to 5 percent, making them more competitive with the returns from poor harvest practices. These findings are consistent with other research in this area that suggests that silvicultural harvests can yield real returns of 4 to 6 percent (McCauley and Trimble 1972, Reed et al. 1986).

The failure of good harvest practices to outperform poor harvest practices in financial terms, despite being clearly superior from a silvicultural standpoint, is a result of the larger initial income derived from poor harvest practices and the significant discounting of the larger future timber values achieved through good harvest practices. This discounting is accentuated by the relatively long time lapse until subsequent harvest. Timber growth rates in the Appalachian hardwood region will necessitate relatively long-periods between harvests and, subsequently, relatively high discounting of any benefits obtained from silvicultural practices, including harvesting practices.

The applicable discount rate is determined by the market and is not subject to manipulation or management. Simply put, we must accept the discount rates deemed appropriate by the market. If they are high, we must accept the consequence that future values will be highly discounted. If future values occur well into the future, as is the case with forestry, these values may be discounted so highly that they become almost irrelevant.

To overcome the limitations imposed by relatively long discounting periods (i.e., 10 to 15 years between harvests) and relatively high discount rates (i.e., greater than 3 percent real), it is necessary to realize significant premiums for higher quality and/or larger diameter timber to justify silvicultural harvesting from a financial standpoint. Although this study used stumpage prices that accounted for timber quality and tree diameter (as well as harvesting cost), these premiums were generally insufficient to compensate for discounting (a function of time and discount rate) unless fairly low discount rates were assumed. It is impossible to determine if these adjustments reflect premiums actually paid by the market, because actual stumpage price data are relatively scarce and generally reported only by species, with no adjustments for grade or d.b.h. If actual premiums for quality and tree size are larger than those assumed in this study, that would improve the financial performance of good harvest practices relative to poor harvesting practices.

However, it is uncertain whether landowners actually realize any premium for timber that is of superior quality or larger than average diameter. To realize premiums for timber quality and size, if they even exist, sellers must market their timber to maximize competition between buyers. In this situation, savvy buyers will recognize the higher value present in quality timber stands and will offer higher prices accordingly, to outcompete other buyers. Without this, it is unlikely that sellers realize any premium for quality timber. For good harvest practices to financially benefit landowners, there must be a sufficiently large premium for quality timber and landowners must sell their timber to captures this premium. Both requirements are paramount. Unfortunately, there is scant evidence that either of these conditions is prevalent in the state, especially the latter. McGill et al. (2006) found that many West Virginia landowners sold timber through negotiation or on a percentage-of-receipts basis and only about one-third retained the services of a consulting forest to assist with marketing their timber. For landowners with a tendency to negotiate directly with buyers, there is little incentive to practice good harvesting, because they are unlikely to capture the future financial gains of doing so. This provides further incentive to engage in high-grading.

Another issue relevant to the comparison of good and poor harvest practices is their effect on length of time between harvests. In our study, tracts subjected to good harvest practices could reasonably support a subsequent harvest after just 10 years (Moss 2011). It is highly questionable whether tracts subjected to poor harvest practices could support another commercial harvest in 10 years, due to low per acre volumes, a high proportion of less valuable species, and the relative scarcity of quality timber, particularly timber in the larger diameter classes. These factors, coupled with the higher per unit harvesting costs on these tracts, result in stands that are financially unattractive to buyers. Even after 20 years, there is a question as to whether these tracts could attract the interest of buyers in a normal market, unless the timber is sold at a discount. This is consistent with the conclusions drawn by Reed et al. (1986).

The inability to conduct future harvests within 10 to 20 years exposes these tracts to increased market risk (Ferguson 2006). Timber prices exhibit significant fluctuation, both in the long term and the short term, and the sellers' ability to respond to these fluctuations is critical to maximizing financial returns. Landowners in our study who engaged in good harvest practices (e.g., owners of stands G1 and G2) retained the ability to respond to favorable markets in 10 years by conducting another sale. Landowners who engaged in poor harvest practices (e.g., owners of stands P1 and P2) forfeited this option by harvesting their timber so intensely with the initial harvest. They have, in effect, put all their eggs in one basket – the initial harvest. This behavior incurs additional risk. Although these landowners are expected to realize higher rates of return than landowners who engaged in good harvesting practices, they should demand higher returns as a result of their greater exposure to market risk. Therefore, it is inappropriate to conclude that poor harvest practices are financially superior to good harvest practices simply because they resulted in higher rates of return. Unfortunately, because most NIPFs lack the knowledge or skills to adequately access market risk, let alone access how their harvesting decisions affect their exposure to such risk, it is unlikely that they can properly evaluate the financial consequences of their actions. In the absence of knowledge about relative risks, investors universally choose the option with the highest expected return. For landowners in Appalachia, this generally means engaging in poor harvest practices.

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