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SILVICULTURAL TREATMENTS AND LOGGING COSTS FOR MINIMIZING GYPSY MOTH IMPACTS

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SUMMARY:

Gypsy moth defoliation is a serious threat to eastern hardwood forests. Felling and skidding costs for harvesting timber in silvicultural thinnings designed to reduce the impacts of the moth were evaluated. Cost of felling the nonmerchantable component of the thinnings to achieve treatment objectives are reported, along with a discussion of the economic feasibility of treatment application.

KEYWORDS:

Timber harvesting, skidders, chain saws, production, gypsy moth

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INTRODUCTION

The gypsy moth, *Lymantria dispar* Linnaeus, is a serious defoliating pest to the hardwood forests of the Eastern United States. Since the time of its accidental release in 1869 near Boston Massachusetts, the moth has advanced its range beyond the New England States to its current range spanning from southern Quebec and Ontario to the North, south to the North Carolina-Virginia border, and into Ohio and Michigan to the west. Based on historic rates of spread, the gypsy moth is predicted to further enlarge its range, and in the next 25 years will cover South Carolina and into Georgia to the south, spread west across Tennessee, Kentucky, Indiana, Illinois, and into eastern Iowa, Missouri, and Wisconsin.

During the initial establishment of the moth, the impact on the forested ecosystem may be profound, with alterations of stand composition (Campbell 1979), reduced tree growth, and increased tree mortality (Kegg 1971). The effects of defoliation depend on the amount of foliage that is removed, the relative health and vigor of the tree at the time of defoliation, the number of consecutive defoliations, available soil moisture, and the species of the host. Healthy trees can usually withstand one or two consecutive defoliations. Trees that have been weakened by previous defoliations or other stresses such as drought are often killed by a single severe defoliation, or may become more vulnerable to attack by disease organisms and other insects such as Armillaria fungus or two-lined chestnut borer.

Although gypsy moth populations decreased considerably during most of the 1980's, from their peak in 1981 when an estimated 13.8 million acres suffered defoliation, populations are again increasing in many areas. In 1990 the gypsy moth again chewed its way through an estimated 7.4 million acres of hardwood forest in the northeast.

To date the most commonly used method to control the damage caused by moth outbreaks has been aerial application of pesticides. Although aircraft are able to treat large areas of forested land in a relatively short period of time, the success of pesticide applications can vary depending upon degree of coverage, weather conditions, timing, and a number of other variables. Even under ideal conditions, only a limited number of acres can be sprayed each year, and stands may require spray applications for several years depending on population levels in subsequent years.

If we are to be successful at managing and limiting the extent of the damage caused by the moth, we must resist the temptation of continuing to only treat stands once they have been infested by the moth, and begin to manage them through alternative measures that will help to make stands less prone to moth attacks. Manipulation of stand composition and structure has been proposed as one way of creating stands that are less hospitable to the moth.

Silvicultural Alterations

Application of silvilcultural treatments to forested stands have been proposed in an attempt to control moth populations, and the subsequent defoliation damage they cause. A variety of interrelated factors determine the vulnerability of forested stands to defoliation damage. Among the most important factors are the abundance of preferred food species, site and stand factors, and tree health and vigor. Stands that are predominately oak, the favored host species, that have been weakened by other stress factors often incur repeated severe defoliations. Trees growing under stressed conditions posses an abundance of structural features such as holes, wounds, and bark fissures that provide habitat and shelter for larvae, increasing their ability to survive. By reducing or eliminating the food or habitat availability, forested stands that may otherwise be vulnerable to attack may instead survive the advancing spread of the moth with minimal adverse impacts.

Guidelines for applying silvicultural thinning treatments to reduce stand susceptibility to defoliation and minimize losses following defoliation have been developed by the U.S. Forest Service. Two such thinning treatments, designed to manipulate species composition and stand structure, were applied to the stands in this study. Both thinning treatments are recommended for use in fully stocked stands which are more than 15 years from maturity. Application conditions differ in respect to the proportion of preferred host species present in the stands to which they are applied.

In stands where greater than 50 percent of the basal area is in preferred host species (oaks), presalvage thinnings are recommended. Presalvage thinnings are designed to reduce the mortality that would occur following defoliation by removing individual trees that are most likely to die from the defoliation induced stresses, based on vulnerability ratings. The major objectives of the thinning treatment are to reduce stand vulnerability by increasing stand and tree vigor, and to remove structural features or refuges used by moth larvae and pupae. Guidelines for determining both stand and tree vulnerability utilize parameters such as tree species, vigor, crown condition, and other stand and site characteristics. Priorities for marking trees to be removed are (highest to lowest): 1) oaks with poor crowns; 2) non-oak species with poor crowns; 3) trees with abundant structural features or refuges, and 4) trees with fair crowns.

In stands where less than 50 percent of the basal area is in preferred host species, sanitation thinnings are recommended. Sanitation thinnings are designed to reduce stand susceptibility and prevent the spread and establishment of the moth, while further reducing defoliation potential by removing trees that are current or prospective sources of infestation. The major objectives of this thinning treatment is to reduce stand susceptibility, increase stand and tree vigor, and improve habitat for the natural enemies of the gypsy moth. Guidelines for rating susceptibility are based predominately on species composition, but may also include such factors as tree vigor and moth predator and parasite population levels. Priorities for marking trees to be removed are (highest to lowest): 1) preferred food species; 2) trees with abundant structural features or refuges; 3) trees with poor crowns, and 4) trees with fair crowns.

Many land managers and researchers assume that first instar dispersal is responsible for the initiation of gypsy moth outbreaks and their apparent spread from one area to another. This assumption has major implications for managing moth populations because it suggests that suppressing defoliating populations by aerial spraying in one area will prevent their expansion into surrounding areas (Leonard 1971). Liebhold and McManus (1991) on the other hand have suggested that dispersal is an unlikely cause of the commonly observed expansion of defoliated areas. Instead, they hypothesize that spread patterns are caused by the spatial distribution of resistant tree stands and that, on a regional scale, spatially separate populations function largely independent of one another. This conclusion suggests that suppressing rising populations in one area is unlikely to have an affect on the development of outbreaks in adjacent and surrounding areas, which in turn supports the theory of managing individual stands to reduce their susceptibility and vulnerability to attack as the best means of controlling potential defoliation impacts. It is likely that mixtures of species are, in general, more secure against pests than would be the case with pure stands. If the food supply of some pest does not include all of the species of a mixed stand then it is diluted in ways that may inhibit population buildups (Smith 1986). Because species composition within a stand plays such a significant element in managing the vulnerability to moth defoliation, manipulation of species composition would seem to be the most obvious and practical path to take in an attempt to reduce defoliation potential.

STUDY OBJECTIVES

The investigation was undertaken as a case study to determine productivity and costs associated with harvesting timber under thinnings designed to reduce the impacts of gypsy moth defoliation. Continuous time and motion study and modeling techniques were used to calculate both felling and skidding productivity levels and cost estimates for harvesting the merchantable sawtimber. In addition to harvesting the merchantable component of the thinnings, an analysis was also performed which takes into consideration the additional costs of felling the nonmerchantable component of the stands in order to fulfill the treatment prescriptions. Determining the costs associated with the additional felling of the nonmerchantable marked stems is an important component in the overall economic feasibility of their application. The silvicultural implications of applying an additional cultural treatment to the nonmerchantable component of the stands as a separate treatment following a commercial harvest are also discussed.

STUDY AREA

The study took place on the West Virginia University Experimental Forest, Monongalia and Preston Counties, West Virginia. A total of 16 stands of mixed Appalachian hardwoods, laid out in a randomized paired plot design of thinned and control plots were selected for the overall investigation. Of the eight stands that were thinned, six stands each receiving one of the two thinning treatments were included in this study. Treated stands ranged in size from 22.6 to 31.2 acres for a total treated area of 165.6 acres. Initial stand attributes for each are given in table 1.

METHODS

Productivity and Cost Calculations

Felling. Productivity rates for felling both the merchantable and nonmerchantable marked timber were estimated using Sarles' (1984) equations. The equations yield estimates of delay free felling productivity based on tree volume and spacing between successively felled trees. Estimates of scheduled felling times used in the cost analysis were then calculated by factoring in a saw utilization rate of 60 percent which agrees with rates reported in the literature (Sarles *et al.* 1984, Jones 1983, Miller 1984, Werblow and Cubbage 1986). A simple machine rate analysis, based on the guidelines and procedures developed by Miyata (1980), Brinker *et al.* (1989), and Miyata and Steinhilb (1981), was used to calculate production costs for felling both merchantable and nonmerchantable timber in the treated stands.

Skidding. Skidding of the merchantable timber was achieved through conventional ground based skidding practices with rubber-tired cable skidders. Complete time and motion data including both productive and nonproductive elements was recorded for each of the machines used in each of the thinned stands. In addition to the timed elements recorded, additional skidding parameters such as skid distance, turn volume, number of stems per turn, and a number of other variables were recorded and used in the calculation of skidding productivity and in the cost analysis.

The same machine rate analysis procedure that was used in calculating felling costs was used to calculate production costs for the skidders used in the treated stands. Using machine rates, observed scheduled and productive machine times from the time motion data, and volumes of wood skidded, production costs per cunit and total were determined for each of the thinned stands.

RESULTS

Felling and Skidding Merchantable Timber

Merchantable felling costs were calculated based on the actual number of trees and volume skidded from each thinned stand. These values along with Sarles (1984) equations and the machine rate procedure were then used to compute production rates and costs. Felling costs were similar for both treatments and averaged $2.51 and $2.63 per cunit of wood felled for the sanitation and presalvage treatments, respectively (Table 2).

Skidding costs were estimated using the appropriate machine rates and productivity levels for each of the machines used in a stand. Again, skidding costs were similar across all stands and between the two treatments. Using average values from the three stands included in each treatment, costs including labor were estimated at $7.78 and $8.04 per cunit of wood skidded for the presalvage and sanitation treatments, respectively (Table 3).

Felling nonmerchantable timber

Although demands exist for quality Appalachian sawtimber stumpage, markets are scarce and at times nonexistent for pulpwood. The scarcity of pulpwood markets in the mountain region make thinnings economically infeasible or at best marginal (Sarles *et al.* 1984). Consequently, many logging contractors working in stands marked for thinning simply cut and utilize the sawtimber, while the marked poletimber is left standing. Although this practice may be the most economical from a loggers point of view, the practice may not achieve the desired silvicultural results. The thinning prescriptions discussed here require that the pulpwood component be addressed in order to achieve the desired outcome. Little information exists on the productivity and costs of harvesting these thinnings in a commercial setting. Such information is essential to the development of marking systems that are both silviculturally effective and economically feasible to apply.

The contractor harvesting the timber in this investigation was strictly a sawtimber producer. Consequently, all of the poletimber and a good deal of the marginal sawtimber in the 12 and 13 inch size classes remained standing following the commercial harvest. In order to fulfill the treatment prescriptions, a follow-up operation to fell these remaining marked stems had to take place.

Costs of felling the residual marked poletimber in order to fulfill the treatment objectives ranged from $27.17 to $46.02 per acre. Although the average diameter and distances between the successively felled trees were quite similar across all six stands, the wide variation in per acre costs was due primarily to the number of stems to be felled in each stand. On a treatment basis however, costs were similar and averaged $34.88 and $37.88 per acre for the sanitation and presalvage thinnings respectively (Table 4).

DISCUSSION

The economic feasibility of applying the two thinning treatments to the stands was evaluated. The contractor who harvested the timber in this study was not responsible for felling any of the material which he considered nommerchantable, therefore the cost of felling the residual marked poletimber was charged against the gross stumpage value in order to arrive at a net sale value. As can be seen in Table 5, stumpage values can be significantly reduced as a result of having to fell the nonmerchantable component of the thinnings as a separate operation. Perecent reduction in gross stumpage value ranged from a low of 17.1 percent to a high of 91.6 percent for stands 11 and 9, respectively. The differences in gross and net values are primarily a function of the amount and value of merchantable timber which offsets the nonmerchantable felling costs. Based on treatment averages for the three stands thinned under each thinning technique, percent reductions in stumpage values were similar and averaged 37.7 and 42.9 percent for the sanitation and presalvage treatments, respectively.

Whether or not forest landowners are willing to accept the reduced revenues resulting from the costs of felling the nonmerchantable timber in return for a more moth resistant and healthier stand is hard to predict. Some individuals may simply want the highest short term return and therefore not work with the nonmerchantable component, while others may see the long-term benefits of the silvicultural treatments outweighing the short-term revenue losses.

CONCLUSION

Eliminating the gypsy moth is an unlikely solution for the future due to its current range and continued advancement. Rather than try to eliminate and eradicate the pest as we have in the past, which has largely been discarded as futile, we must instead come to grips with the reality that it is here to stay and concentrate our efforts on learning how to diminish its impacts and increase our abilities to manage population densities at levels we can tolerate. Through the use of silvicultural treatments such as the sanitation and presalvage thinnings discussed here, we may be able to create stands which are in a better condition to weather out moth attacks while sustaining minimal adverse impacts. The thinning treatments may also leave previously threatened stands in a condition where additional suppression tactics are unnecessary, eliminating the need to apply pesticides on a yearly basis.

Although the results of this case study suggest that both thinning treatments can be economically applied without a negative cash flow, only time and additional research will yield the necessary data that will indicate whether or not silvicultural thinnings can be used as an effective control measure against the defoliation impacts of the gypsy moth.

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Table 1. Initial stand characteristics.

Stand	Trees /ac	Total BA	Preferred BA	Species %	Suscept. Rating	Vulner. Rating
1	369	145.8	62.5	43	Moderate	Moderate
3	274	143.5	58.5	41	Moderate	Moderate
6	235	148.5	20.0	14	Low	Moderate
9	405	143.5	79.5	55	High	Moderate
11	391	141.5	74.5	53	High	Moderate
15	370	131.0	89.5	68	High	Moderate

Stands 1,3,6 sanitation thinnings
Stands 9,11,15 presalvage thinnings

Table 2. Merchantable timber felling summary.

Stand	# Trees	Merch. Vol(ft^3)	SMH[a]	Cost/ Cunit	Total Cost
1	326	18168	38.4	2.38	432.39
3	217	9380	22.5	2.70	253.08
6	208	9848	22.6	2.58	253.80
9	144	5190	13.6	2.95	152.97
11	367	17530	38.0	2.44	427.96
15	222	8487	21.4	2.84	240.86

[a]SMH = Scheduled man hours at 60% saw utilization
Stands 1,3,6 sanitation thinnings
Stands 9,11,15 presalvage thinnings

Table 3. Skidding cost summary.

Stand	Vol(ft^3)	Cost/ Cunit[a]	Total Cost
1	18168	8.24	1496.28
3	9380	7.80	731.74
6	9848	7.91	779.18
9	5190	7.87	408.51
11	17530	7.69	1349.37
15	8487	7.91	671.28

[a]Includes labor and benefits
Stands 1,3,6 sanitation thinnings
Stands 9,11,15 presalvage thinnings

Table 4. Nonmerchantable felling summary.

Stand	Trees /ac	Avg. DBH	SMH[a]	Cost /ac[b]	Total Cost
1	50.5	8.2	75.2	32.21	972.74
3	63.6	8.7	99.4	41.23	1286.42
6	44.8	9.0	63.4	30.51	820.68
9	72.1	8.5	80.4	46.02	1040.02
11	41.7	8.4	50.6	27.17	654.68
15	64.1	8.2	95.1	40.23	1231.00

[a]SMH = Scheduled man hours at 60% saw utilization
[b]Includes Labor and benefits
Stands 1,3,6 sanitation thinnings
Stands 9,11,15 presalvage thinnings

Table 5. Gross and net stand value summary.

Stand	Gross Stumpage Value	Nonmerch. Felling Cost	Net Stumpage Value	Percent Reduction
1	3974.10	972.74	3001.36	24.5
3	2051.81	1286.42	765.39	62.7
6	2154.64	820.68	1333.96	38.1
9	1135.08	1040.02	95.06	91.6
11	3829.26	654.68	3174.58	17.1
15	1855.12	1231.00	624.12	66.4

Stands 1,3,6 sanitation thinnings
Stands 9,11,15 presalvage thinnings