Forest Stand Conditions After 13 Years of Gypsy Moth Infestation

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Abstract: Of 603 central Pennsylvania plots that were established in 1978 to measure the short-term impact of repeated gypsy moth (*Lymantria dispar*) defoliation, 228 were selected for continued study in 1985. Individual observations of defoliation and tree vigor were continued through 1992. Although two gypsy moth outbreaks occurred across central Pennsylvania from 1978 to 1990, only 22% of the plots were defoliated severely for more than one year. Net change in basal area/acre from 1978 to 1990 (including both accretion and ingrowth) ranged from +70 to -92% depending on defoliation severity and frequency. Oak species were defoliated disproportionately and had higher mortality rates than non-oak species. Eighty-eight percent of ingrowth trees were of commercial hardwood species (3.3% oak), 4.3% were of commercial softwoods, and 7.1% were of noncommercial species. Regeneration surveys conducted in 1989 and 1992 showed that 77 and 65%, respectively, of the regeneration plots within stands with severe mortality (> 30% basal area/acre) are adequately stocked with commercial hardwood species; 16 and 25% of the regeneration plots in 1989 and 1992, respectively, were fully stocked with oak species. As of 1990, 77.6% of the plots contained fully stocked or overstocked overstories despite two waves of gypsy moth infestation and resultant mortality. As of 1990, residual stands still contain a viable oak component (1990 ave. = 58% basal area/acre in oak), though ingrowth and advanced regeneration data indicate that future stands may have more red maple, birch, and black gum stems, and thus be better able to withstand future gypsy moth infestations.

BACKGROUND

In 1978, a network of 603 plots was established by the USDA Forest Service in advance of approaching gypsy moth populations in central Pennsylvania to monitor impacts and to refine susceptibility and hazard-rating procedures developed in northeastern Pennsylvania by Herrick and others (1979). A total of 201 stand locations was established between State College, Lewistown, and Carlisle in the heart of Pennsylvania's oak forest. Three permanent, 1/10th-acre plots were established at each location. Data were collected on 26 variables in order to predict stand and tree predisposition to defoliation and mortality. Measurements were taken annually through 1982 with the cooperation of the USDA Forest Service, Northeastern Area State and Private Forestry (NA S&PF), Forest Insect and Disease Management staff. Data were collected in 1983 and 1984 by the Pennsylvania Department of Environmental Resources' Bureau of Forestry staff through a memorandum of understanding with NA S&PF. In 1985, the USDA Forest Service's Forest Inventory and Analysis unit took the final measurements on the plots and added new ingrowth stems to the data set.

At the request of the Pennsylvania Gypsy Moth Advisory Committee (February 1986 meeting), the Forest Service agreed to continue monitoring a subset (228 plots) of the original plots to accumulate more data on the long-term impact of defoliation and mortality. Seventy six of the original plots that received at least one defoliation in excess of 60% were included in the subset in order to achieve the objectives of assessing long-term impacts. The balance of the subsample was equally divided between plots that had only been defoliated moderately (30 - 60%) and those that had never been defoliated more than 30% since 1978. The subset of plots is located in a six-county area in central Pennsylvania and fall within the boundaries of the Tuscarora and Bald Eagle State Forests. This area is part of the Ridge and Valley physiographic province and includes primarily mixed oak forests, including some of the most extensive and highest quality oak forests in Pennsylvania (Pennsylvania Bur. of For. 1983). USDA Forest Service Research Work Unit 4557 (Silvicultural Options for the Gypsy Moth) in Morgantown, WV, was responsible for planning, organizing, and coordinating continued data collection on the subset. The Advisory Committee secured agreements from the private sector as well as the Pennsylvania Bureau of Forestry to provide personnel to assist in the collection of field data. Under this cooperative arrangement, data have been collected annually on this subsample through 1992. This paper describes changes in overstory stand conditions from 1978 to 1990 as well as results from regeneration surveys conducted in 1989 and 1992 on the subsample.

METHODS

During plot establishment in 1978, all trees greater than 3 inches dbh on each 1/10th-acre plot were tallied. Measurements of tree defoliation and vigor (two of the original 26 variables measured in 1978) were continued on the subset from 1986 to 1990 to monitor long-term impacts. Defoliation was recorded to the nearest 10% for each tree from 1978 through 1990 except for 1985. Plot-level defoliation estimates were used in 1985 based on Pennsylvania Bureau of Forestry aerial sketch mapping for that year plus individual-tree defoliation subsamples that were taken on approximately 15% of the plots for a concurrent study. On both a tree- and plot-level basis, defoliation less than 30% is classified as low, defoliation between 30% and 60% is considered moderate, and defoliation exceeding 60% is severe. Stems that had grown larger than 3 inches dbh were added to overstory tallies in both 1985 and 1990. Stand stocking was calculated based on stocking guides developed by Roach and Gingrich (1968) that incorporate basal area, average stand diameter, and number of stems. Regeneration data were not collected in 1978, but regeneration surveys were conducted in 1989 and 1992 to evaluate understory conditions in response to overstory mortality. Relative frequencies of live stems of all woody species tallied in overstory, ingrowth, and regeneration sampling are listed in Appendix A.

INITIAL OVERSTORY STAND CONDITIONS

Average stand age in 1978 was approximately 70 years (range = 33 - 161 years). The average tree diameter over all plots in 1978 was 7.0 inches for all species and 8.4 inches for oak species. The basal area/acre (stems $\geq$3 inches dbh) of all species in 1978 ranged from 29 to 184 ft^2/acre with a mean of 87 ft^2/acre (Figure 1). The initial distribution of oak basal area ranged from 0 (six plots contained no oak) to 143 ft^2/acre with a mean of 60 ft^2/acre, representing a range of 0 to 97% oak basal area/acre with an average of 68%. In 1978, 28.1% of the plots were overstocked, 56.1% were fully stocked, and 15.8% were considered understocked.

DEFOLIATION HISTORY

Defoliation patterns over the plots from 1978 through 1990 generally mirror defoliation patterns over the six-county area throughout which the plots are distributed (Figure 2). Gypsy moth defoliation reached outbreak levels in 1981 when 34% of the plots received severe (greater than 60%) defoliation and again in 1986 when 18% of the plots received defoliation in excess of 60%. Twenty six of the plots were included in the Pennsylvania gypsy moth suppression program in 1986 because high egg mass counts indicated that heavy defoliation was imminent. The percentage of plots receiving severe defoliation in 1986 would likely have been closer to 30% if these plots had not been sprayed for gypsy moth control.

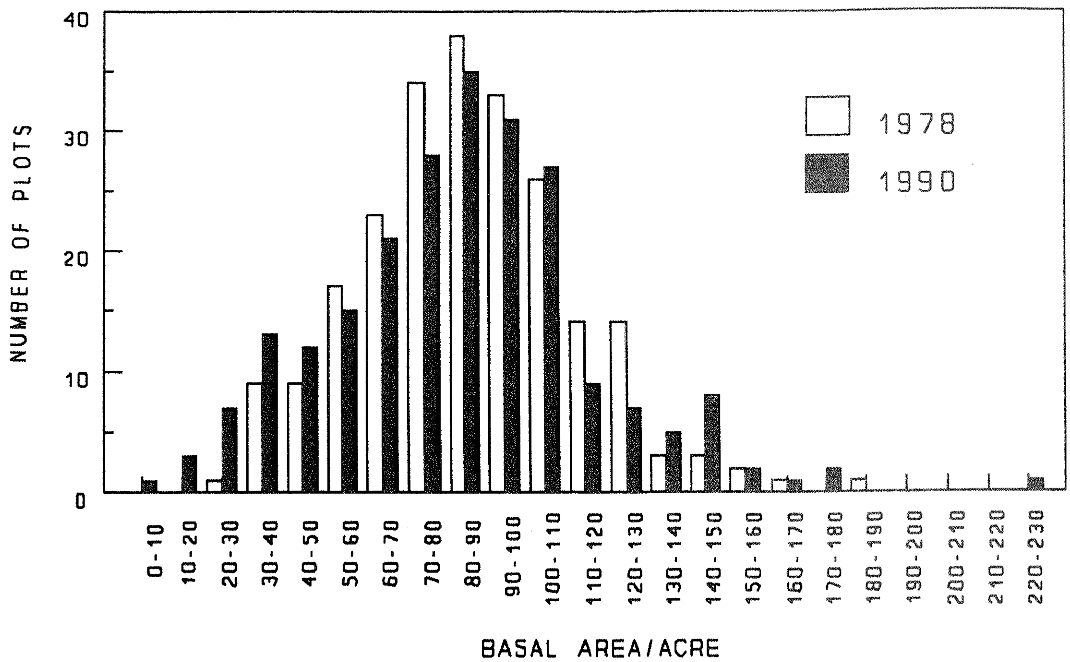

Figure 1.—Live basal area/acre for all species in 1978 and 1990.

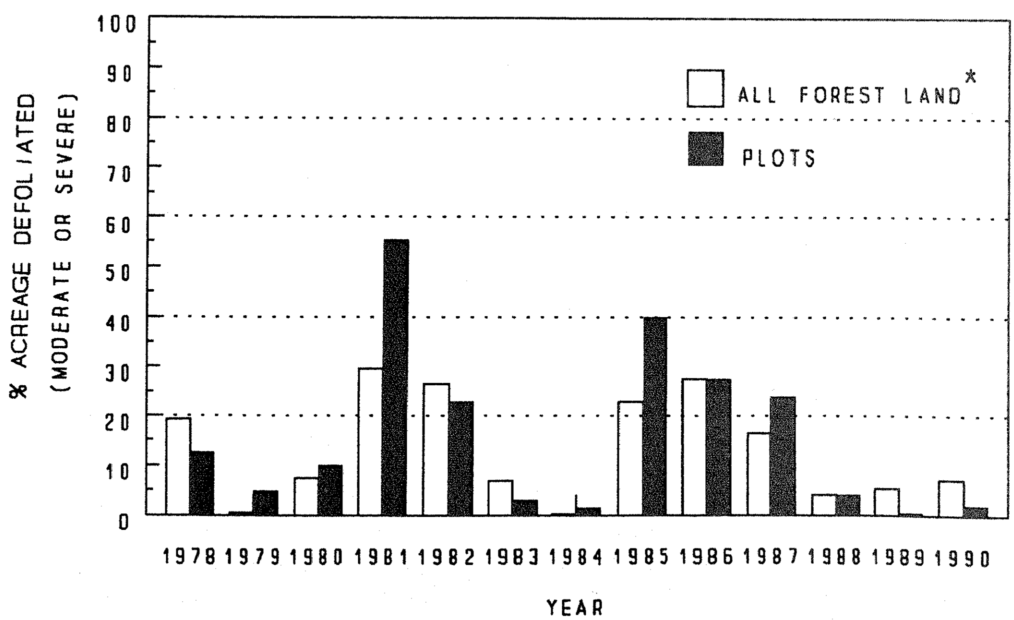

Figure 2.—Percent forested acreage receiving moderate or severe defoliation from 1978 to 1990.

*6-county area has 916,000 acres of forest land (Powell and Considine 1982).

Defoliation classes were established and calculated for each plot based on its defoliation history to assess the impact of defoliation on the forest. These classes take into account the severity and frequency of defoliation (Table 1). Tables 2 and 3 indicate the number of plots that fell within each of these defoliation classes during two time frames: from 1978 to 1985 and from 1985 to 1990. From 1978 to 1985, 30% of the plots received no defoliation greater than 30% (defoliation class 0). Another 13% of the plots received only one moderate defoliation (defoliation class 1). The other 57% of the plots received at least one year of heavy defoliation or two years of moderate defoliation, or more (defoliation classes 2 and greater). From 1985 to 1990, 42% of the plots were placed in defoliation class 0. Twenty-two percent of the plots were placed in defoliation class 1. The other 36% of the plots were placed in defoliation classes greater than 1.

Table 1.—Defoliation classes assigned to individual plots based on the number and severity of defoliations (H=high, M=Moderate)

CLASS 0	No defoliation >30%
CLASS 1	1 year M
CLASS 2	1 year H (or) 2 years M
CLASS 3	1 year H & 1 year M (or) 3 years M
CLASS 4	2 years H (or) 1 year H & 2 years M (or) 4 years M
CLASS 5	2 years H & 1 year M (or) 1 year H & 3 years M (or) 5 years M
CLASS 6	3 years H (or) 2 years H & 2 years M (or) 1 year H & 4 years M
CLASS 7	3 years H & 1 year M (or) 2 years H & 3 years M
CLASS 8	4 years H (or) 3 years H & 2 years M (or) 2 years H & 4 years M
CLASS 9	4 years H & 1 year M

MORTALITY

The likely effect of repeated defoliation is mortality. Mortality from gypsy moth defoliation has been described in various forests throughout infested areas (Baker 1941; Campbell and Valentine 1972; Corliss 1955; Fosbroke and Hicks 1989; Fosbroke and others 1991; Kegg 1971, 1973; Nichols 1961; Quimby 1990; Stephens 1971, 1981; Twery 1991). The vastly different parameters used in these studies to report mortality preclude comparison, but they agree that mortality (consisting primarily of *Quercus* spp.) is high in areas recently invaded by the gypsy moth. In this study, the average percent change of plot live basal area consistently increased with increasing defoliation frequency and intensity (Tables 2 - 3). This relationship was observed from 1978 to 1985 as well as from 1985 to 1990, the time frames used to bracket the two defoliation episodes separately. The average percent change was calculated both with 'no growth', where basal area change was based on initial tree diameter only, and with 'growth', where beginning and ending tree diameters were used, thereby modifying the net basal area change by diameter growth of the remaining live trees. The tables show that although the average percent change increases with the severity and intensity of defoliation, growth of the residual trees modifies this impact; in fact, in plots that received one year of defoliation or less from 1978 to 1985, a positive value in overall basal area change is reflected. Gottschalk (1989) found that overall mortality is directly influenced by the frequency and intensity of defoliation to a much greater degree than by stocking or recent cutting activities; although we have no data to draw conclusions about the effect of recent cutting activities, these data do support his conclusion that defoliation frequency and intensity directly affect mortality.

Table 2.—Mean percent change in basal area of all trees on a plot within a defoliation class, 1978-85

Class	No growth SE[2]	No growth % Change	Frequency	Modified by growth[1] % Change	Modified by growth[1] SE[2]
0	1.12	-8.4	67	+9.1	1.50
1	1.89	-9.5	30	+7.5	1.88
2	1.61	-13.5	51	+1.4	1.93
3	2.35	-18.6	31	-5.3	2.57
4	4.42	-23.5	20	-10.5	5.26
5	4.99	-37.2	5	-22.7	6.15
6	7.58	-46.3	9	-35.8	8.34
7	7.65	-62.0	6	-55.5	8.54
8	7.30	-50.5	5	-43.7	7.41
9	7.77	-77.5	4	-71.6	9.21

Table 3.—Mean percent change in basal area of all trees on a plot within a defoliation class, 1985-90

Class	No growth SE[2]	No growth % Change	Frequency	Modified by growth[1] % Change	Modified by growth[1] SE[2]
0	0.45	-3.2	94	+7.6	1.61
1	1.19	-5.4	49	+4.5	1.14
2	2.69	-11.7	31	-2.5	3.05
3	4.72	-25.6	14	-16.9	5.34
4	5.12	-23.1	20	-14.6	5.19
5	9.40	-26.6	9	-18.8	8.68
6	11.52	-59.7	4	-56.8	12.52
7	.	-88.1	1	-81.2	.

1 Growth includes only accretion on residual trees and not ingrowths.
2 SE = Standard error of the mean.

By 1990, live basal area/acre ranged from 10 to 224 ft^2/acre, with an average of 84 ft^2/acre (Figure 1). On average, overstory stocking levels after 13 years of gypsy moth infestation did not change substantially. There was a reduction in the percentage of both overstocked stands (28.1 to 27.2%) and fully stocked stands (56.1 to 50.4%), while the percentage of understocked stands increased by 5% from 15.8 to 22.4%. These stocking levels are comparable to data from the Pocono Mountains in eastern Pennsylvania (Gansner and others 1983); these results also support Herrick and Gansner's (1988) conclusion that overall stocking levels on the original 603 plots from 1978 to 1985 did not change substantially.

We classified overstory mortality into three classes based on basal area loss per acre as of 1990: low (less than 15%), moderate (15 to 30%) and severe (greater than 30%). The severity of net overall mortality ranged up to a 92% loss in basal area per acre depending on the frequency and severity of defoliation. However, the net effect of this mortality on the oak component across all the plots is not evident when all species are combined (Figure 1). Mortality is distributed disproportionately among species; species preferred by the gypsy moth (*Quercus* spp.) were more heavily defoliated (Gansner and Herrick 1985) and subsequently had higher basal area losses than non-oak species (Figure 3). Sixty-five percent of all stems that died from 1978 to 1990 were oaks; the species with the next highest stem mortality was sassafras (7.7% of all stems), followed by flowering dogwood (6.3%) and red maple (5.1%). Even after growth and ingrowths are included, 110 plots (48%) had some degree of oak mortality; 41 plots (18%) had oak mortality in excess of 30 ft^2 of basal area/acre (Figure 3). By contrast, 205 plots (90%) accrued a net increase in live basal area of non-oak species, while only 112 plots (49%) recorded a similar net increase in oak live basal area (Figure 3). Overall, non-oak species were defoliated less severely and less frequently, suffered less mortality, and are growing at better rates than oak (Gasner and Herrick, and Figure 3).

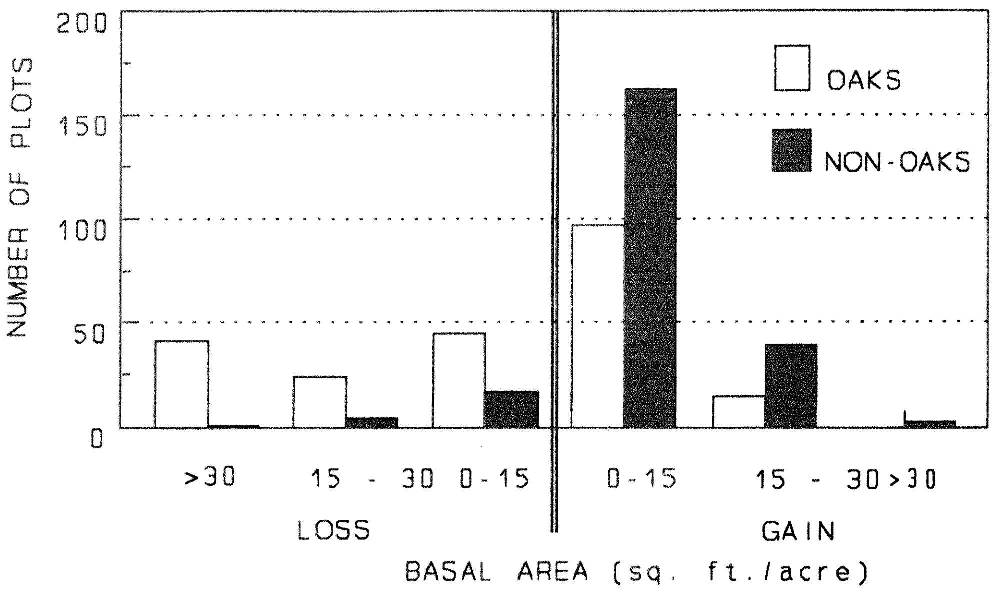

Figure 3.—Net change in live basal area/acre for oak and non-oak species from 1978 to 1990.

STAND RECOVERY

Following tree mortality in general, forest stands recover as other plants occupy the growing space. Some space will be occupied by crown and root expansion of existing canopy trees. Some will be claimed by growth of small, previously established plants into measurable sizes, and some will be occupied by new individuals that establish after an opening is created. Within this study, species composition is shifting in response to mortality on several fronts: survival and growth of residual overstory trees, the recruitment of ingrowth stems into stands, and the establishment of new regeneration in the understory.

Residual Stands

Despite severe mortality among oaks, the percentage of oak basal area in overall stand composition on average was 58% in 1990 over all mortality classes (Figure 4a). Even within the severe mortality class, the percentage of oak basal area remained above 43% in 1990 (Figure 4d). However, there is a relative increase in non-oak species, whether expressed as a percentage of live basal area (Figure 4) or as the number of stems per acre (Figure 5). Chi-square analysis between species distribution in 1978 and 1990 by mortality class (Figures 4 - 5) showed no significant changes within all mortality classes combined or within the low mortality class, whether expressed as a percentage of live basal area or percent of stems. Stands within the moderate and severe mortality classes showed significant changes in percent basal area distribution of all species ($X^2 = 27.97$ and 129.22, respectively, df=8, $P < 0.005$). When expressed as percent of stems, these two classes also showed similar changes ($X^2 = 58.33$ and 91.37, respectively, df=8, $P < 0.005$). This shift among oak and non-oak species is enhanced as overstory mortality increases (Figures 4 - 5). Red maple by far shows the greatest percent increase, followed by sweet birch and black gum. The response by red maple to both defoliation and mortality is consistent with observations by Collins (1961), who found that red maple in the understory responded with increased growth and higher survival rates under recently defoliated oak stands, primarily due to increased light intensity.

Ingrowth

The species mix of newly recruited ingrowth stems in 1985 and 1990 augments the increasing abundance of non-oak species in the overstory following gypsy moth defoliation and mortality (Table 4, Figure 6). On average, red maple is once again the most numerous species, representing 48% of all new stems, followed by black gum (16.5%), sweet birch (13.6%), oaks (3.3%) and sassafras (3.2%). Softwoods, although a small component of our sample, have increased from 1985 to 1990. Yellow-poplar similarly increased in frequency from 1985 to 1990, up from 0.4% in 1985 to 5% of new ingrowths in 1990. The distribution of ingrowth stems is relatively uniform across all mortality classes. The mean number of ingrowth stems added to plots within the low, moderate, and severe mortality classes is 5.1, 5.9, and 4.5, respectively.

Table 4.—Composition of ingrowth stems across all plots by species group and inventory year

	1985	1990
Commercial hardwoods	91.0%	82.0%
Oaks	3.6%	2.6%
Non-oaks	87.9%	79.3%
Softwoods	2.8%	8.0%
Noncommercial species	5.7%	10.0%

NOTE: 783 ingrowth stems added in 1985 on 228 plots.
343 ingrowth stems added in 1990 on 198 plots.

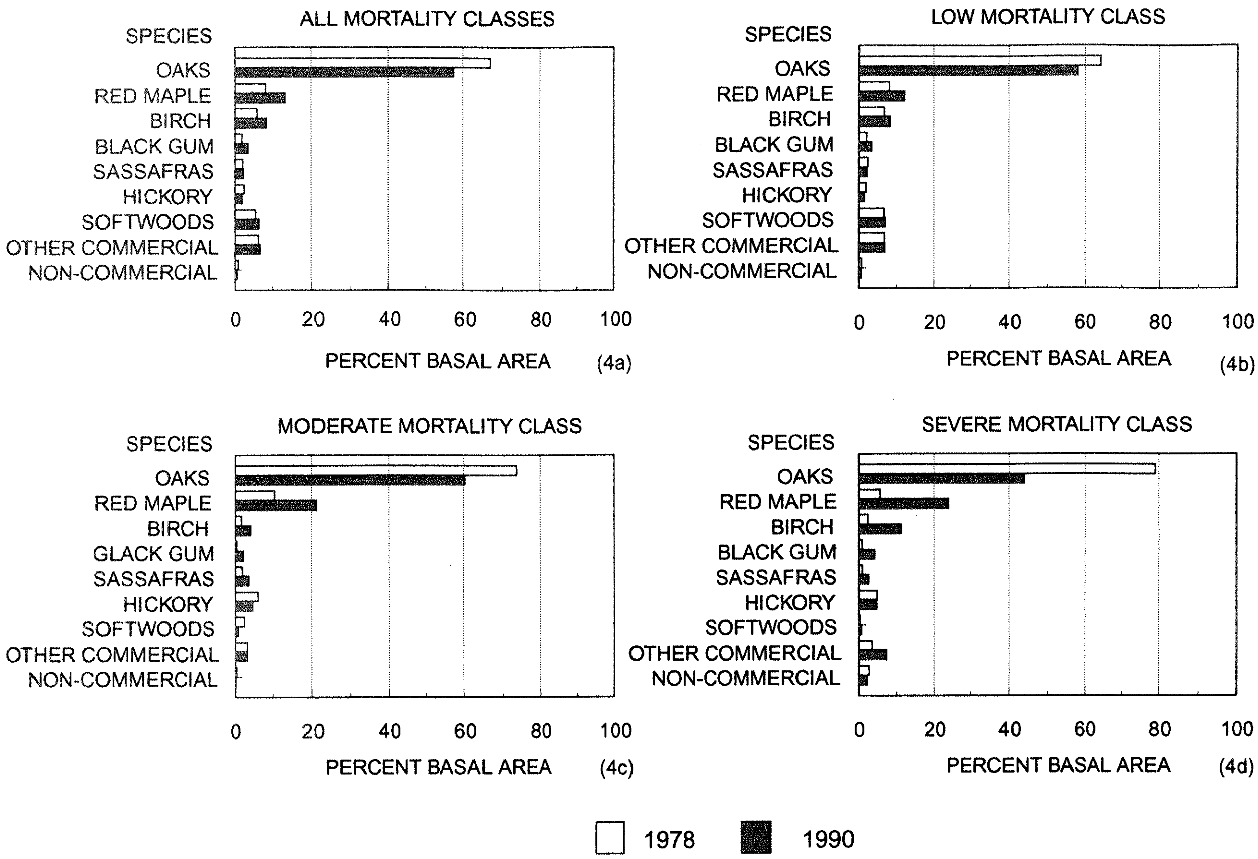

Figure 4. Percent live basal area/acre in 1978 and 1990 by mortality class.

Figure 4.—Percent live basal area/acre in 1978 and 1990 by mortality class.

Advanced Regeneration

The development of advanced regeneration in the understory is more volatile than ingrowths in response to severe defoliation and mortality. New seedling establishment is more dependent on abundant seed, whether new or stored in the litter, as well as on the proper conditions for establishment and development; seedlings also are more susceptible to deer browsing than ingrowth trees.

The species mix of new seedlings is similar to that of the ingrowth stems that are responding to changing growing conditions in this study. Species composition of regeneration stems is also consistent with observations by Ehrenfeld (1980); stem recruitment in this study is almost exclusively from those species that existed in the original stand. Hix and others (1991) also found that one to three years after gypsy moth-caused overstory mortality, new species were not being established among regeneration stems. In 1989, nearly 51% of the regeneration stems sampled (excluding blueberry, *Viburnum* spp. and laurel) were red maple, 12.2% were oaks, 5.2% were sassafras, 4.4% were birches, and 2.3% were black gum. In 1992, there was a decline in the total number of regeneration stems sampled; however, red maple still made up the greatest percentage of stems (49.4%), followed by all oaks (11.5%), birches (10.9%), sassafras (2.8%), and black gum (0.9%) (Figure 7). Six to seven years after severe overstory mortality, Allen and Bowersox (1989) sampled understory vegetation beneath understocked stands in the Ridge and Valley physiographic province; although they found similar percentages of red maple stems (42%) and all oak stems (14%), they had a greater percentage of birch stems (25%) than we found in this study. Hix and others (1991) found that red maple was the most common commercial tree species present one to three years following overstory mortality in the Ridge and Valley physiographic province.

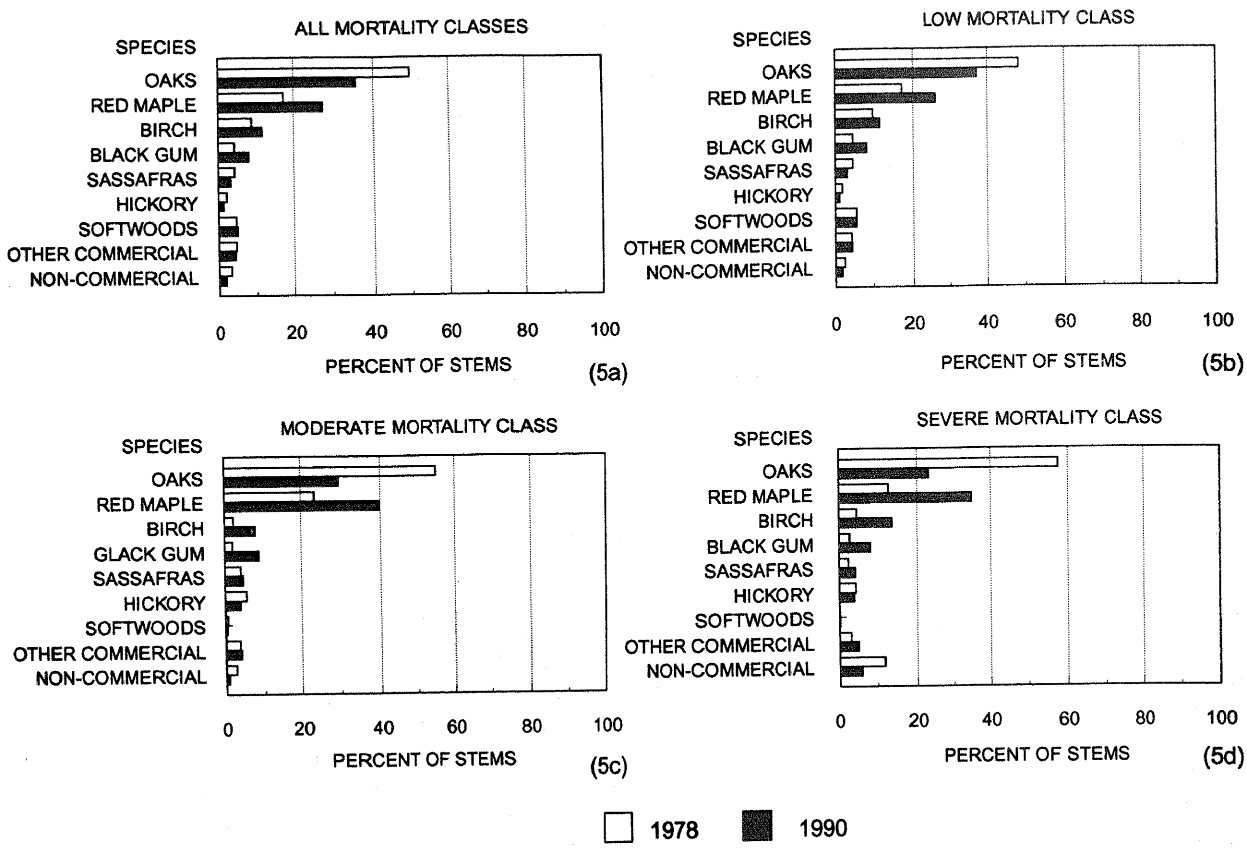

Figure 5.—Percent of live stems in 1978 and 1990 by mortality class.

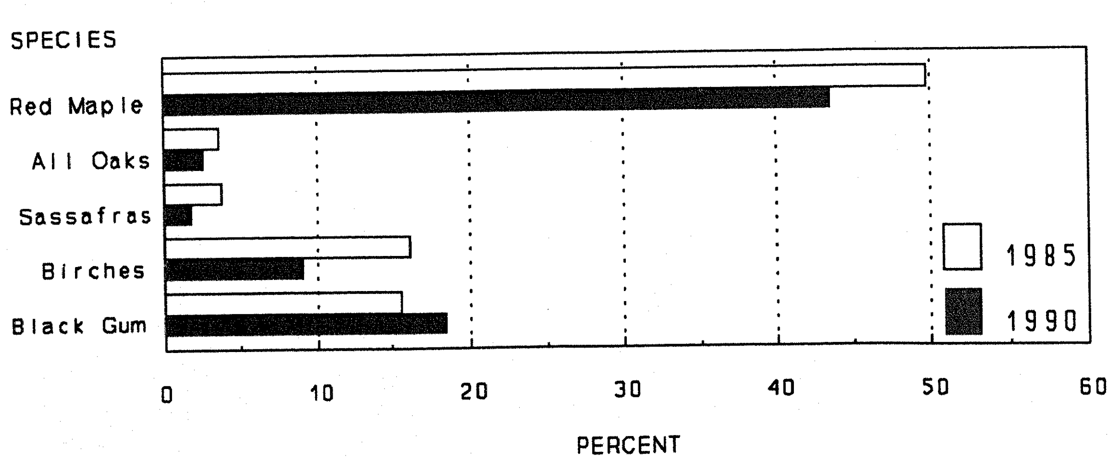

Figure 6.—Percentage of ingrowth stems for selected species in 1985 and 1990.

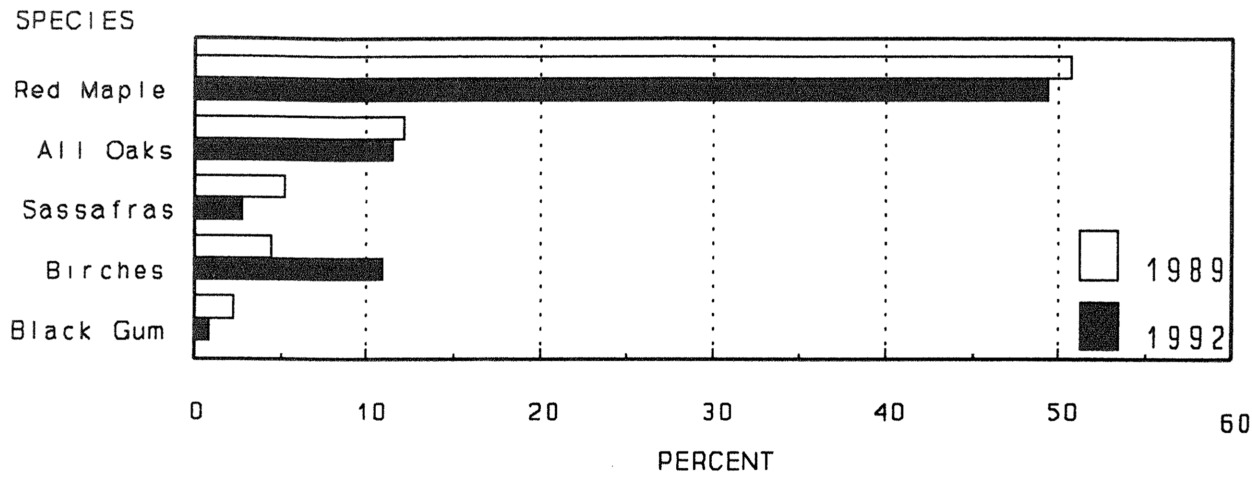

Figure 7.—Percentage of regeneration stems for selected species in 1989 and 1992.

To determine the potential influence of these stems in continued stand development, we used regeneration stocking criteria developed to predict the probable future success of both oak and commercial regeneration stems (Marquis and Bjorkbom 1982; Sander and others 1976, 1984). Not surprisingly, the number of regeneration plots that met any of the fully stocked criteria generally increased within a given year as mortality increased, though the difference between the severe and moderate mortality classes was minimal (Tables 5 - 6). Because of the general decline in the total number of seedlings sampled in 1992, fewer plots met the stocking guideline criteria for full stocking in that year. It is encouraging that the number of plots considered "fully stocked" with oak regeneration in areas that had severe mortality increased from 16 to 25% between 1989 and 1992. Allen and Bowersox (1989) also evaluated regeneration stocking success; six to seven years after severe overstory mortality had occurred, 83% of their plots were considered fully stocked with commercial species. Nineteen percent of their regeneration plots were considered fully stocked with oak species.

Table 5.—Percentage of regeneration plots meeting any success criteria for all commercial stems

	1989	**1992**
All mortality classes	43%	32%
Severe mortality	77%	65%
Moderate mortality	72%	69%
Low mortality	33%	25%

Table 6.—Percentage of regeneration plots meeting any success criteria (oak stems only)

	1989	1992
All mortality classes	6%	5%
Severe mortality	16%	25%
Moderate mortality	17%	15%
Low mortality	3%	2%

CONCLUSIONS

Although two gypsy moth outbreaks occurred across central Pennsylvania from 1978 to 1990, only 22% of the plots were defoliated heavily for more than one year. Twenty-six percent of the plots never received defoliation greater than 30% over the 13-year period. In any given year, the percentage of plots that received severe defoliation never exceeded 34%. Basal area mortality was not distributed uniformly and ranged from 3 to 90%. Seventy-six percent of the plots had low mortality (< 15% basal area/acre) and 7% had moderate mortality (15 - 30% basal area/acre), while only 17% of the plots had severe mortality (> 30% basal area/acre). The percentage of stands at or above full overstory stocking in 1990 was 78%, only a 6% drop from 1978. Growth occurred primarily on non-oak species (red maples, black gum and sweet birch) as they responded to the defoliation and mortality of oak. Non-oak species are rapidly replacing basal-area losses and increasing in frequency within the stands. Oak is still a major component of the stands, however; the mean percentage of oak basal area in the overstory dropped from 68% in 1978 to only 58% in 1990.

Overall, the integrity of these mixed oak forests has been sustained with little impact over the majority of the study area, where mortality was light and scattered. To the manager of a large state forest or the owner of a large tract of commercial timberland, losing 30 to 50% of the basal area in a few stands is not catastrophic. For one of the 490,100 small woodland owners in Pennsylvania to suffer such a loss could indeed be catastrophic from a timber management perspective. Nearly 30% of small woodland owners have aesthetics as their major management objective, however (Birch and Dennis 1980). Hollenhorst and others (1993) found that as basal area mortality approached 30 to 40% at southwestern Pennsylvania sites within the Central Appalachian Plateau physiographic region, scenic preferences and appeal for visitation increased; once basal area mortality exceeded this range, however, these ratings dropped abruptly. Based on this criterion, 83% of the plots have not suffered from the standpoint of visual appeal.

At some level of mortality, regardless of the owner, forced liquidation of stands may be the only recourse from a timber management perspective. Between 1985 and 1990, 30 of our 228 plots were involved in commercial salvage operations. Stands with severe mortality where logistics or accessibility precluded salvage were left to recover naturally. In areas where severe mortality did occur, losses are quickly being replaced by residual overstory tree growth, by the ingrowth of new stems, and by the establishment of new regeneration.

Although oak has been a strong competitor in lumber production for many years, other species cannot be discounted out of hand. Species that are increasing in abundance within these stands are traditionally lower-value commercial species. Red maple, an opportunistic species often viewed unfavorably from a commercial standpoint, is finding its way into many markets. These range from structural uses, such as timber bridges, to the increasing white wood export market in the Pacific Rim countries. As a result, red maple has been steadily increasing in value for the last five years (Weekly Hardwood Review 1992).

Effects of these changing stand conditions, primarily shifts in species composition, extend beyond the plant communities and commercial considerations to also influence wildlife populations that are sustained by forests as well as other forest uses, such as recreation (Hollenhorst and others 1993). One of the principal contributions of these forests to wildlife is the production of mast. From a mast-production standpoint, many of these stands may well have been improved by undergoing a thinning from below which eliminated many of the poor crowned, unproductive mast-producing trees. Using stand mortality data from these plots, Gottschalk (1990) found that stands with less than 25% mortality initially lose 10% of their acorn production capacity but that growth compensates for that loss, providing a 20% increase in capacity seven years later.

Overall, these stands demonstrate just how resilient the eastern hardwood forest is. In Pennsylvania's 1990 damage appraisal report, John Quimby states, after surveying several forest districts (including the Tuscarora and the Bald Eagle), "District 3 (Tuscarora State Forest) forests appear quite healthy and fully stocked. Oak is still the predominant species in most stands...District 7 (Bald Eagle State Forest)...[has] lots of healthy appearing trees, including oak with white pine coming in almost everywhere. The view from overlooks, roadsides, and the Sand Mountain [fire] tower is one of well-stocked stands of mixed oak" (Quimby 1990). Quimby's observations may be anecdotal, but the data from our study lend some credence to them.

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Appendix A.—Relative frquency of live stems (all stands/mortality classes)

Name	Overstory 1978	Overstory 1990	Ingrowth 1985	Ingrowth 1990	Regeneration[a] 1989	Regeneration[a] 1992
Chestnut oak	32.5	22.5	1.4	0.6	8.9	6.7
Red maple	16.6	26.8	49.7	43.4	50.7	49.4
N. red oak	9.9	9.1	1.5	1.8	2.3	2.5
Black birch	8.9	11.7	15.6	9.0	4.2	10.8
Sassafras	4.7	3.5	3.8	1.8	5.2	2.8
Black gum	4.3	8.5	15.7	18.4	2.3	0.9
Black oak	4.0	1.8	0.6	0.3	0.2	0.7
Hickory spp.	3.0	2.0	0.8	1.2	0.6	0.7
White oak	2.4	1.6	--	--	0.7	0.9
Flowering dogwood	2.1	0.8	1.2	1.5	--	--
Pitch pine	1.8	1.2	0.3	0.3	0.0	--
E. hemlock	1.8	2.3	1.2	3.8	1.3	0.9
Yellow-poplar	1.0	1.2	0.4	4.7	1.1	1.3
Scarlet oak	1.0	0.7	--	--	0.1	0.7
Ash spp.	0.9	1.0	0.3	0.3	1.8	1.2
Striped maple	0.8	1.1	3.3	6.7	6.4	7.1
E. white pine	0.7	1.1	1.2	2.9	0.1	0.2
Black locust	0.6	0.4	--	--	0.1	0.1
Serviceberry	0.6	0.6	0.4	0.6	0.4	2.0
Yellow birch	0.6	0.5	0.6	--	0.2	0.1
Sugar maple	0.5	0.6	0.5	0.6	1.4	1.5
American beech	0.2	0.1	0.4	--	--	--
Bigtooth aspen	0.2	--	--	--	--	--
Basswood	0.2	0.2	--	--	--	--
American chestnut	0.1	0.2	0.9	1.2	0.0	0.1
E. hophornbeam	0.1	0.1	--	--	0.0	0.0
Black cherry	0.1	0.1	0.1	--	0.7	0.6
Elm spp.	0.1	0.1	--	--	3.5	--
Unk. shrub/tree	0.1	0.0	--	--	--	0.2
Virginia pine	0.0	0.0	--	--	0.0	--
Butternut	0.0	0.0	--	--	--	--
Sweetgum	0.0	--	--	--	--	--
White spruce	--	0.1	0.3	0.9	--	--
Pinus spp.	--	--	--	--	0.1	--
Azalea spp.	--	--	--	--	--	0.5
American hazelnut	--	--	--	--	--	0.2
Witch-hazel	--	0.0	--	0.3	3.2	3.8
Spicebush	--	--	--	--	0.8	1.0
Pin cherry	--	--	--	--	0.0	--
Rhododendron	--	--	--	--	3.4	3.2
Am. elderberry	--	--	--	--	0.0	--

[a]Relative frequency of live regeneration stems does not include blueberry, laurel, or Viburnum spp. counts.