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COMPOSITION OF AN OAK-HICKORY FOREST IN CENTRAL PENNSYLVANIA FOLLOWING GYPSY MOTH DEFOLIATION

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ABSTRACT

We studied the effect of gypsy moth, *Lymantria dispar*, defoliation on forest composition of a mid- to late-successional oak-hickory (*Quercus-Carya*) forest in Huntingdon County, PA. We hypothesized that there would be significant changes in average basal area, average tree height, species composition, trees per hectare, and tree density between pre-defoliation and post-defoliation forests. We tested this hypothesis by re-conducting a forest composition study done in 1978, prior to defoliation of the forest. We found that average basal area in ‘01 (2.04 dm^2) was significantly less than in ‘78 (3.64 dm^2) ($W = 16.0$, $df = 4$, $P = 0.02$). Trees per hectare in ‘01 (78.10) showed a slightly significant increase from ‘78 (43.00) ($W = 36.0$, $df = 4$, $P = 0.09$). We found no significant difference between average tree heights among species in ‘78 (12.23 m) and ‘01 (12.47 m) ($W = 28.5$, $df = 4$, $P = 0.92$), importance values among the five highest-ranking species between ‘78 and ‘01 ($W = 30.0$, $df = 4$, $P = 0.68$), and basal area per hectare among species between ‘78 (129.40 dm^2) and ‘01 (162.80 dm^2) ($W = 30.0$, $df = 4$, $P = 0.68$). We conclude that gypsy moth defoliation has had little effect on forest composition at the Raystown Field Station.

Keywords: Forest composition, forest succession, Lymantria dispar*, oak-hickory,* Quercus montana*, Raystown Field Station*

INTRODUCTION

Forest succession is an ongoing process in natural ecosystems, which begins with the recruitment of pioneer tree species on cleared landscapes (Peattie 1950, Walker 1999). This is followed by the replacement of those species with climax tree species, which overtop the pioneer species and choke out their sunlight (Hunter 1983). Later on, when climax members of a forest community die, gaps are created in the canopy, allowing sunlight to reach the forest floor, which promotes the recruitment of seedlings of both climax and secondary pioneer species. Often, secondary species are faster growing and more shade tolerant, which gives them the advantage over the climax seedlings to grow up in the already established climax forest (Nichols 1962, Sutherland 2000). In disturbed forests, this pattern of succession is greatly accelerated (Abrams 1992, Nowacki 1994). If a disturbance causes many climax trees to die at the same time, the forest is opened up for a successional change in overall composition from climax hardwoods to secondary hard- and softwoods (Abrams 1992, Walters 1997). Disturbances can range from acid deposition to biological pests (Nowacki 1994, Walters 1997). One such disturbance that is currently of great concern in oak-hickory forests is the gypsy moth caterpillar, *Lymantria dispar* (Nowacki 1994).

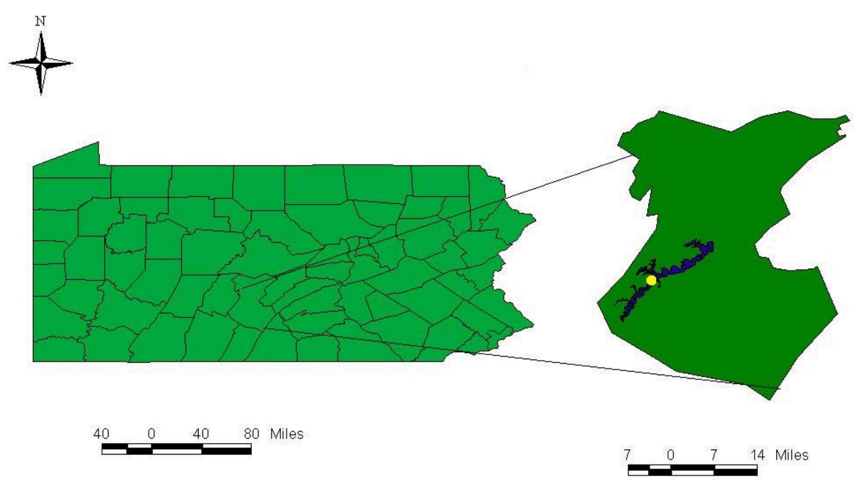
The gypsy moth caterpillar was introduced to the United States in 1868 (Elkinton 1996). Since then it has spread west, reaching central Pennsylvania in the early 1980s (Yohn, pers. comm.). Oak (*Quercus*) foliage is the most favored food of this caterpillar pest, though it will feed on most species of trees (Elkinton 1996, Hunter 1983). The gypsy moth caterpillar defoliates huge expanses of timber foliage as it moves across an area, threatening the health of the mature oak-hickory forests it encounters (Nichols 1962). Several factors contribute to the survival rate of defoliated trees, including how severely the trees were defoliated, how many successive years the trees were defoliated, what time of the growing season the defoliation took place, how many other secondary pathogenic organisms were present during the time of defoliation, geography and geology of the site on which the trees are located, and the amount of precipitation reaching the trees during the time of defoliation (Abrams 1992, Nichols 1962, Statler 1983). Survival of trees also ultimately depends on the susceptibility of the individual species under disturbance (Fajivan 1996). If trees do not survive, accelerated succession will likely take place, especially in areas where caterpillars have killed off large areas of climax tree species (Fajivan 1996).

Gypsy moth defoliation has occurred twice at the Raystown Field Station in central Pennsylvania, in 1982 and in 1999 (Yohn, pers. comm.) A tree survey conducted at the station during 1978, prior to the first infestation (Phillips, unpublished study), found the trees of greatest importance within this section of forest included mostly chestnut oak (*Quercus montana*) and white oak (*Quercus alba*). It is the purpose of our study to determine whether the forest composition at the Raystown Field Station has changed since 1978.

FIELD SITE

Our study area was located on a north-facing ridge at the Raystown Field Station, Huntingdon County, PA, that varied between 45^o and 15^o slope. Our study encompassed a mid- to late-successional oak-hickory forest (Fig. 1).

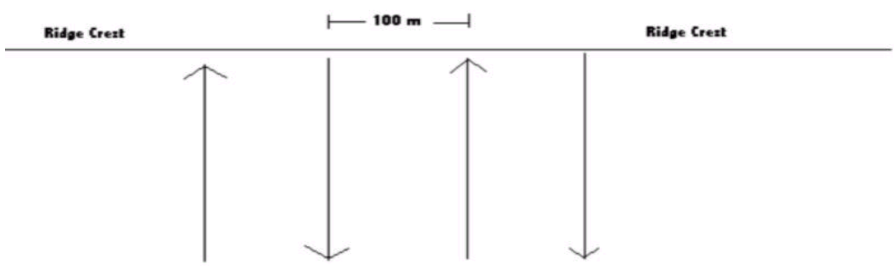
Figure 1. Location of Raystown Field Station (dot), Huntingdon County, PA.



METHODS AND MATERIALS

We established 11 transects through the forest, spaced 100-m apart and running perpendicular to the crest of the ridge (Fig. 2). We randomly established four survey points within 100-m to the right or left of each transect in a manner similar to Phillips and Hauenstein. At each point we identified the four closest living trees to each of the four cardinal compass points. For each of those four trees, we recorded species, basal area (dm^3) using a dbh (diameter at breast height) tape, tree height (m) using a Sunto clinometer, and distance to survey point (m). We also made qualitative observations of the canopy and forest floor, including estimated canopy height and relative thickness, gaps in the canopy, relative amount of woody debris and snags, and average height and species of saplings at each point.

Figure 2. Diagram of forest transects, spaced 100 m apart and running perpendicular to crest of a ridge at the Raystown Field Station, Huntingdon County, PA.



We collected data on four days during early October, 2001. We compared average basal area between ‘78 and ’01 by using a Mann-Whitney U test (Minitab). We used an α level of 0.05 and consider differences to be significant if $P \leq 0.05$. We compared average tree height, importance value, trees per hectare, and basal area per hectare for each species between years in a similar manner.

RESULTS

We found oaks in our plot ranged in basal area from 11.0 dm^2 to 47.0 dm^2. We found all red-type oaks (“oak 4” in Phillips and Hauenstein, unpublished study) to be less than 30.6 dm^2. Chestnut oaks (*Quercus montana*) made up 30% of the species composition of the plot, while red-type oaks (oak 4) made up 16.5%, Virginia pine (*Pinus virginiana*) made up 13%, and white oak (*Quercus alba*), 12%.

Average basal area in ‘01 (2.04 dm^2) was significantly less than in ‘78 (3.64 dm^2) (W = 16.0, df = 4, P = 0.02). Trees per hectare in ‘01 (78.10), however, showed a slightly significant increase from ‘78 (43.00) (W = 36.0, df = 4, P = 0.09). We found no significant difference between average tree heights among species in ‘78 (12.23 m) and ‘01 (12.47 m) (W = 28.5, df = 4, P = 0.92), importance values among the five highest-ranking species between ‘78 and ‘01 (W = 30.0, df = 4, P = 0.68), and basal area per hectare among species between ‘78 (129.40 dm^2) and ‘01 (162.80 dm^2) (W = 30.0, df = 4, P = 0.68).

Importance values of the five highest-ranking species varied between ‘78 and ‘01 with chestnut oak being the highest in both ‘78 (IV=29.64) and ‘01 (IV=39.64) and white pine (*Pinus strobus*) being the lowest in both ‘78 (IV=6.63) and ‘01 (IV=10.04). Red-type oak measured from sixth in importance value in ‘78 (IV=3.64) to second in ‘01 (IV=17.33) (Table 1).

Table 1. Importance values for tree species recorded on a north-facing slope at the Raystown Field Station in Huntingdon County, PA in 1978 and 2001.

Tree Species		**Importance Value '78**	**Importance Value '01**
Chestnut Oak	*Quercus montana*	39.64	29.64
Red-type (Oak 4)	*Quercus rubra*	3.64	17.33
Virginia Pine	*Pinus viginiana*	11.98	12.63
White Oak	*Quercus alba*	21.03	12.31
White Pine	*Pinus strobus*	6.63	10.04
Red Maple	*Acer rubrum*	0	5.94
Sugar Maple	*Acer saccharum*	0.89	3.81
Black-type (Oak 2)	*Quercus velutina*	8.50	3.22
Shagbark Hickory	*Carya ovata*	0.74	1.22
Pignut Hickory	*Carya glabra*	0	1.20
Bear-type (Oak 3)	*Quercus ilicifolia*	3.36	0.72
Scarlet Oak	*Quercus coccinea*	0	0.63
Chokecherry	*Prunus virginiana*	1.34	0.59
Bitternut Hickory	*Carya cordiformis*	0	0.58
Eastern Hemlock	*Tsuga canadensis*	1.49	0

DISCUSSION

Average basal area decreased significantly from ‘78 to ’01, possibly because the older, more mature trees measured in ‘78 have since died from gypsy moth defoliation, and allowed younger trees to grow in their place. Large, dead standing and fallen trees observed at our site support this theory. There was a slightly significant increase in trees per hectare from ‘78 to ’01, supporting the notion of a younger forest replacing an older forest. A young forest is composed of smaller trees that do not require as much resources per individual and are thus able to grow closer together. As a forest matures, dominant trees will require more resources leading to neighbor mortality and thus a decrease in tree density.

We found no significant difference in tree height from ‘78 to ‘01, presumably because when the mature trees died, the younger trees put their effort into rapid vertical growth, trying to reach the canopy quickly so as to not be deprived of sunlight early on (Fajivan 1996). Had we conducted this study several years earlier, a significant difference in height may have been recorded.

The importance values of some individual species changed from the previous study. Phillips and Hauenstein (unpublished study) determined three oak hybrid species as various combinations of red oak (*Quercus rubrum*), black oak (*Quercus velutina*), and bear oak (*Quercus ilicifolia*). Based on their determination process, we categorized our red- and black-type oaks by bark type and general leaf shape (Petrides 1998) and were thus able to divide them into three groups comparable to the three hybrids of ‘78. The decrease in importance value of chestnut oak (*Quercus montana*) and white oak (*Quercus alba*) and the increase of red-type oak (Phillips, unpublished study) as well as the unchanged importance value of Virginia pine (*Pinus virginiana*) suggest a disturbed forest (Table 1). We noticed large clusters of gypsy moth egg casings on many trees in this forest plot, especially on chestnut oaks, perhaps indicating a preference for this species because of its deeply grooved bark that may offer some protection to the developing young. White oaks also had some casings, though not as many, and red-type oaks had nearly no egg casings. Relative abundance of egg casings per tree species may indicate a preference of gypsy moths for certain tree species and may have caused the decrease in chestnut oak and white oak importance values and the increase in red-type oak importance value. The unchanged importance value of Virginia pine also supports the theory of disturbance. For shade-intolerant Virginia pine to survive in a mature hardwood forest, it must receive ample light from gaps in the canopy. We noticed gaps in the present forest canopy, averaging 1-2 per data collection point, due to fallen dead trees. Although most of the canopy allowed little direct light to pass through, saplings were still present over most of the forest with the exception of the maple (*Acer*)/Virginia pine-covered far-eastern tip of the site where no saplings were found. Chestnut oak, white oak, and red-type oak saplings were present over much of the forest floor in varying heights (mostly 0.5-1.0 m with an occasional stand 2.0-3.0 m) and white pine (*Pinus strobus*) saplings were moderately abundant but no Virginia pine saplings were observed.

We found no significant change in basal area per hectare between ‘78 and ’01. Although there were more trees per hectare represented in ‘01, the average basal area per tree was less. This redistribution of basal area into smaller trees is further evidence of a disturbed forest.

Overall, we feel the decrease in average basal area, yet increase in trees per hectare, as well as importance values and sapling status indicate this forest is recovering from disturbance, yet maintaining its composition as an oak-hickory forest. Although white oaks and chestnut oaks have decreased in importance value, red-type oaks have increased enough to maintain an oak-hickory composition.

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