A STUDY OF THE GYPSY MOTH IN THE TOWN OF PETERSHAM, MASS., IN 1935[1]

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FOR many years the gypsy moth (*Porthetria dispar* L.) has been recognized as one of the most destructive forest-insect defoliators in the Northeast. Since it first attracted notice in Medford, Mass., 45 years ago, it has spread in all directions until at the present time a considerable portion of New England is infested. In 1923 a "barrier zone" from 25 to 30 miles wide was established in the western part of New England, from the Canadian border to Long Island Sound. In this zone the Bureau of Entomology and Plant Quarantine in cooperation with the New York State Department of Conservation has carried on an intensive eradication program to prevent the insect from spreading westward. A rigid quarantine to prevent the accidental carrying of the insect beyond the known infested areas has also been in effect for many years.

In some years in New England the number of acres defoliated, in varying degrees of intensity, has run into hundreds of thousands. The sections most seriously affected for many years are York and Cumberland Counties in Maine; Rockingham, Strafford, Hillsboro, Merrimack, Belknap, and Carroll Counties in New Hampshire; and Barnstable, Plymouth, and Bristol Counties in Massachusetts. There are, however, large areas east of the barrier zone where the insect has been present for many years but has never reached outbreak numbers. Observations have been made over a sufficient period, and over areas sufficiently large, to indicate that the insect can find conditions favorable for its increase to destructive numbers only in certain types of forest growth. It has long been known that it will thrive on the foliage of some species of trees, and will die where confined to the foliage of others. About 20 years ago data on feeding habits were collected and formed the basis for a table showing the various species of trees, grouped according to preference.[4]

Furthermore, the preference for certain types of foliage is not constant for all the larval instars. For example, oak foliage is desirable throughout the entire larval period, maple is not favored in any instar but will be fed on in the absence of more favored food, white pine is refused by the early instars but is very palatable to the larger larvae, while ash is refused by all instars. In cases of heavy defoliation in mixed stands composed of both favored and unfavored species, where there is sufficient favored food for the larvae to develop through the earlier instars the unfavored species are sometimes completely defoliated by the older larvae. This has given rise to the belief that any and all species are favored. The fact is that, unless some of the highly favored species are present in or near a stand of less favored species, no appreciable feeding on the latter will result. In New England those species highly favored by larvae of all ages are the oaks, poplar, gray birch, alder, willow, and apple.

The purpose of the present investiga-

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[4]Mosher, F. H. Food plants of the gypsy moth in America. U. S. Dept. Agr. Bull. 250, 39 pp., illus. 1915.

tion was twofold: (1) to study the reactions of the insect to its food supply in an area never before heavily defoliated, in order to determine whether it had increased to outbreak numbers irrespective of food plants, or only in concentrations of favored food; and (2) to determine to what extent any discriminating food habits of the insect that might be discovered would permit the application of silvicultural measures of control in a particular locality.

Data bearing on this phase of the gypsy moth problem have been obtained over a number of years. In 1917 Clement and Munro[5] concluded that control could be effected by the removal of all the highly favored species from a stand. It was suspected then that the removal of only a portion of the favored trees would prevent injurious defoliation, but at that time there was not sufficient evidence to warrant definite recommendations. Much of the information that has been made available more recently was obtained from a large number of $^1/_5$-acre sample plots, established by the Federal Gypsy Moth Laboratory in 1911-12, distributed from southeastern Massachusetts to south-central New Hampshire and southwestern Maine and representative of a great variety of forest-cover types. Each tree over 3 inches in diameter breast high was individually observed and recorded by number. At first 264 plots were established, but after 10 years, owing to the death of trees due to defoliation, fire, cutting, etc., the number of useful plots was reduced to 104. Figure 1 shows the relation between the percentage of favored food trees in the plots and the intensity of infestation as measured both by egg masses and by defoliation. It is based on 104 plots and the 10-year period from 1912 to 1921.

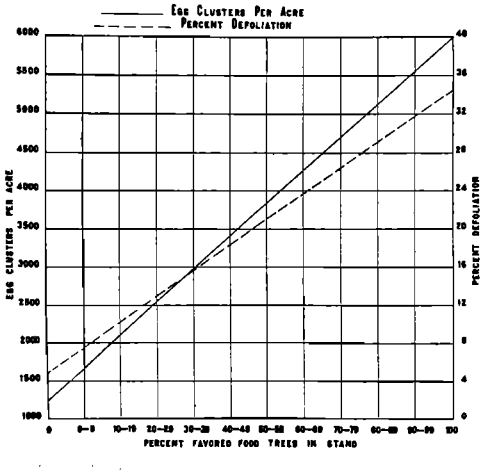

Fig. 1.—The relation between proportion of favored food plants in the stand and intensity of gypsy moth infestation and defoliation. Records from 104 woodland plots in various parts of the infested area in New England for the 10-year period 1912-1921.

This graph shows beyond reasonable doubt that the food supply is a controlling agent of the gypsy moth. The importance of this cannot be overemphasized. For one thing, it means that an enormous amount of mixed woodland growth may be infested but not seriously injured, and that it should be unnecessary to remove all favored food trees in such mixed growth to bring about adequate control.

Study of Outbreak at Petersham

Since silvicultural practice, as well as forest-cover type, varies in different localities, it is desirable from a forest-management standpoint to make intensive local observations, to serve as a basis for specific cutting plans for stand improvement. An exceptional opportunity for making such observations was offered in central Massachusetts in 1935, when the first epidemic outbreak of the insect occurred in that section.

[5]Clement, G. E., and Willis Munro. Control of the gypsy moth by forest management. U. S Dept. Agr. Bull. 484. 54 pp., 1917.

Petersham was selected as the town for study, first because of its location with respect to the 1935 outbreak, and second because the Harvard Forest was situated within its boundaries. The study was started independently by the Harvard Forest, and concluded as a cooperative project of that institution and the Bureau of Entomology and Plant Quarantine.

Petersham proved to be an ideal town for studying the outbreaks, because of the nature of its forested land and its hilly terrain. It is characteristic of a considerable portion of north-central Massachusetts and the neighboring towns of southern New Hampshire. The rolling nature of the countryside made it possible to see every heavily defoliated (browned)[6] area in the town from one vantage point or another. Land history was such that many contrasting cover types were present, temporary as well as permanent, numerous small stands of favored food trees being intermingled with stands of strikingly different composition. A forest type map of the town, which covers about 22,000 acres, would show approximately 5,000 separate stands.

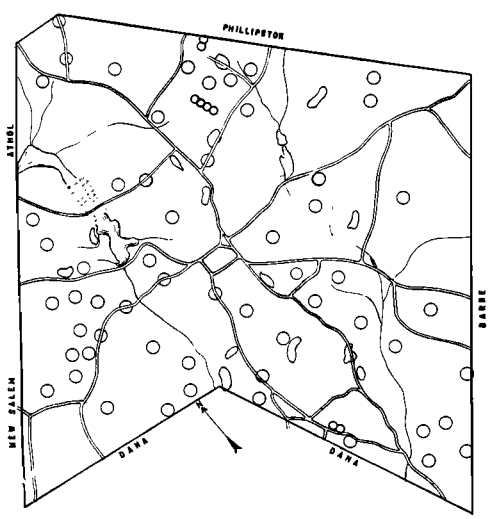

Fig. 2.—Areas in Petersham, Mass., defoliated by the gypsy moth in 1935.

The defoliated areas were located and plotted on a topographic map. (Fig. 2.) There were 82 such areas, and 81 of these were visited and studied by the authors. During the course of travel to and from these areas constant watch was kept for gypsy moth larvae, and invariably some were found wherever favored food trees were growing. This indicated that the insect was generally present throughout the entire town, although complete or nearly complete defoliation of the favored food occurred only in the 82 areas.

In these areas the stand composition and the average percentage defoliation of all species were determined by ocular estimation. It was impossible, and unnecessary from a practical standpoint, to measure these factors precisely, because the study had to be made within the 2-week period when defoliation was at its maximum and refoliation had not begun.

TABLE 1

OCCURRENCE OF CERTAIN TREE SPECIES IN HEAVILY DEFOLIATED AREAS IN THE TOWN OF PETERSHAM, 1935

Species or combinations of species in stand	Number of cases where species comprised indicated percentage of stand		range
	50-75 per cent	75-100 per cent	50-100 per cent
White oak	0	0	0
Red oak	2	0	2
Poplar (2 species)	8	4	12
Gray birch	13	21	34
Gray birch and poplar	18	39	57
Gray birch, oaks, and poplar	20	56	76
Gray birch, oaks, poplar, and alder	....	....	81

[6]Although certain individual trees in these areas, primarily those unfavored as food for the gypsy moth, were not completely defoliated, the general effect was a severe browning. From a distance such browned areas were strikingly different in appearance from their greener surroundings.

The data obtained from these areas are summarized in Table 1. They show that heavy defoliation was invariably associated with a high percentage of favored food trees in the stand.

The results show conclusively that concentrations of species favored as food by all larval instars accounted for the conspicuous defoliated areas in the town of Petersham. Complete defoliation was not observed in any instance where favored food trees constituted less than 50 per cent of the stand. In 56 out of the 81 defoliated areas oak, gray birch, and poplar comprised more than 75 per cent of the stand, thus showing the importance of these three species in creating a suitable environment for the gypsy moth.

Invariably it was observed that the heavy defoliation was limited to stands or portions of stands composed wholly or largely of favored food trees, and that it ceased abruptly with changes in composition of adjoining stands. In addition to the information from the 81 defoliated areas, data were also obtained from the lightly defoliated margins of some of the adjoining stands. A comparison of composition and defoliation under the two conditions is shown for 12 cases in Table 2. Marked differences in composition are at once evident. Favored food trees comprised an average of 89.5 per cent of the defoliated stands, but only 19.3 per cent of the margin of the adjoining stands. The little defoliation that occurred in the latter was limited to a narrow margin, evidently due largely to migrants from the defoliated stand of favored trees. In several cases where narrow strips of unfavored species separated heavily defoliated stands of favored species, the former showed only a trace of feeding—further proof of the discriminating feeding habits of the moth.

Recommendations for Control Program

The findings of this study in the Petersham area, taken into consideration with defoliation records and experiments on host preference over a period of years, warrant the following specific recommendations for the control of the gypsy moth

Table 2

Comparison of defoliated stands with the margins of adjoining stands

	Average percentage of favored foods		Average percentage of defoliation					
			—Favored food—		—Unfavored food—		—All trees—	
Plot No.	Defoliated area	Margin of adjoining stand	Defoliated area	Margin of adjoining stand[1]	Defoliated area	Margin of adjoining stand	Defoliated area	Margin of adjoining stand
11	86	12	87	33	37	5	80	9
16	86	21	91	91	58	11	86	28
24	87	15	100	24	54	6	94	8
38	92	19	100	10	47	0	96	2
39	95	1	100	0	100	0	100	0
40	97	32	85	44	75	6	84	18
41B (NE)	91	10	99	36	50	17	95	19
41B (W)	91	16	99	37	50	15	95	17
42	90	51	96	26	34	3	90	14
51	91	35	100	14	72	9	98	11
71	83	5	100	100	54	11	92	15
72	87	15	87	8	55	5	83	6
Mean	89.7	19.3	95.3	35.3	57.2	7.3	91.1	12.2

[1]In certain plots, notably nos. 16 and 71, where favored food trees in the margins of adjoining stands suffered heavily from defoliation, it was due to scarcity of these trees in the composition and their greater occurrence at the extreme edge of the margin next to the defoliated area.

through a program of silvicultural treatment, where conditions are similar to those in Petersham.

Coniferous Plantations.—As previously stated, the older larvae find coniferous foliage a desirable food. Since conifers, with the exception of larch, lack the ability to refoliate following complete defoliation, and since plantations represent a comparatively large investment in new growing stock, the protection of plantations of conifers is placed first on the list of priorities in treatment.

In Petersham both gray birch and poplar commonly seed into old fields and pastures, either before or after plantations are established. On cut-over lands these species are often supplemented by sprouts of red and white oak. The newly hatched caterpillars are able to develop on any and all of these hardwood species. Following complete defoliation the larvae, if they have reached the third instar, can easily migrate to the conifers and defoliate them. Thorough clearing of the planting site prior to planting and timely weeding thereafter will serve the needs of both silviculture and protection. Severe damage to coniferous plantations is usually due to neglect to weed. Nothing is to be gained in any event by allowing a good plantation to be whipped and suppressed by overtopping hardwoods of little or no value, and not intended as part of the crop. It is true, of course, that a hardwood "filler" has proved advantageous in improving the quality of conifers, but in a properly managed stand such a filler is kept below the conifers and not above. Even so, where it is made up largely of gray birch, it may be advisable to remove it. Loss of quality in the butt log is of less importance than defoliation of the tree.

Underplantings. — Underplanting has been used very little locally, but where it has, conditions are usually favorable for moth attack. This is because gray birch and poplar are among the species commonly thought suitable for an overstory. Here the treatment is plainly one of cutting the birch or poplar overstory, even though it may be furnishing protection to the conifers against the white pine weevil and may be too small to make cordwood. Conifers growing directly beneath a canopy of favored food trees are liable to be seriously defoliated. At the same time, it is recognized that sudden and complete release from partial suppression may result in damage to the conifers from snow or ice. In some cases releasing may require two steps, the first one reducing favored-food-tree foliage as much as possible without jeopardizing reasonable security against bending and breaking with snow or ice loads, with the final removal cutting a few years later, when the conifers have strengthened their stems sufficiently to withstand the elements.

Coniferous Understories of Natural Origin.—From the standpoint of control, conditions here are much the same as those discussed under "Underplantings". Frequently pine and gray birch seed simultaneously into old fields and pastures, but the birch soon overtops the more slowly growing pine, arrests its growth by whipping off the buds, and in time often completely suppresses it. The obvious treatment is the cutting of the birch before suppression of the pine has reached a critical stage, and before a moth colony becomes established.

Almost without exception, both coniferous plantations and natural coniferous reproduction, whether on old fields or cut-over land, contain more or less weed hardwoods of the favored food species, and their prompt elimination is demanded both as sound silvicultural practice and as a protective measure.

Isolation Strips.—Several cases of defoliation were observed at the margins of coniferous plantations growing next to stands composed wholly or largely of gray birch, poplar, alder, or oak. It is

evident that the removal of favored food trees from within plantations or young coniferous stands of natural origin must be supplemented by cutting a protective strip wherever such hardwoods occupy adjoining areas. On the basis of several observations, it would seem that, under conditions at Petersham, a cleared strip about 100 feet wide should be sufficient to prevent any serious defoliation along the margin of the coniferous stand.

Mixed Stands of Pine and Better Hardwood.—In a few cases noted, some defoliation of pine occurred because of its association with red and white oak. Such mixtures are found on the lighter soils, or on exposed southern slopes and ridge tops. It is not a common condition in Petersham. In middle-aged or maturing stands of this composition, the pines generally were not defoliated to such an extent that they would die, except perhaps where they formed a minor element in the mixture. In some cases, however, defoliation might be severe enough to warrant protective treatment, and this would take the form of a cutting to reduce the quantity of oak foliage. It is believed that a reduction to about one-half that of the pine will assure safety of the latter from heavy defoliation, but further observations are needed on this point. Where conditions of ownership and merchantability warrant the complete elimination of the oak, any sizeable opening made by cutting might be planted to conifers, thus forming a groupwise coniferous mixture of two or more age classes.

On the Harvard Forest, young groupwise mixtures of conifers and better hardwoods, including in some instances a substantial proportion of red oak, may require protective treatment. Since, on the heavy soils where such mixtures are being developed, there is a large variety of hardwoods available for the crop, the treatment will consist of a reduction in the proportion of oak and a corresponding increase in that of such species as white ash, hard maple, and paper birch. This alteration in composition can be done in the course of weedings and improvement cuttings regularly carried out in such stands. It is probable that reduction of oak foliage to somewhat less than half the total for all hardwoods in a given group will afford adequate security to the neighboring coniferous group. Because of the strong tendency of red oak to crowd out other valuable hardwood species, a reduction in the proportion of this species, especially through cutting the coarser individuals, is considered desirable from the standpoints of high-quality crop production and a well-balanced mixture, regardless of its protective value.

Stands of Mixed Better Hardwoods.—With a few exceptions such stands in the town of Petersham fall within the so-called Transition Hardwoods type, which is composed of a considerable variety of commercial species representative of both the Northern Forest and the Central Hardwood Forest. Since the death of chestnut, however, red oak is the most aggressive species in the mixture, and in many stands of middle age or older it predominates to the extent of occupying a larger proportion of the crown canopy than all associated species combined. For the most part the latter are unfavored food species. To avoid recurrent defoliation of the oak, particularly where it occurs in groups, with at least a resultant slowing down in growth, some alteration in stand composition is indicated. Under local conditions it is believed that a reduction in the volume of oak and other favored foliage to an upper limit of one-half of the total for the main canopy will afford satisfactory protection. Depending upon age, density, and relative proportions of favored and unfavored species, such a reduction will require one or more cuttings annually over a period of years. These may well be combined

with the ordinary types of improvement cuttings and thinnings applicable to such stands.

Stands of Favored Weed Species.—Stands of gray birch or poplar, or mixtures of the two, occur commonly throughout the town. As shown in Tables 1 and 2, these provided the chief sources of infestation. Though neither species is sufficiently valuable to warrant much concern over its protection, there are places where the owner may wish to avoid further trouble. Plainly the only possible method of silvicultural control is clear-cutting followed by planting. On the best soils hardwoods of unfavored species or mixtures of such hardwoods and conifers may be used; on the lighter soils, conifers alone. Such complete conversion from weed hardwoods to valuable saw-timber species is, of course, a part of the usual plan of management on the organized forests.

The conditions cited above are the ones commonly found in Petersham. They are by no means representative of the entire region infested by the gypsy moth. It is believed, however, that measures of indirect control through silvicultural treatment must be worked out locally, and that the observations of the past season in this town and the conclusions drawn therefrom contribute toward this end.