New England Water Works Association
ORGANIZED 1882.

Vol. LI. September, 1937. No. 3

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SILVICULTURAL AIDS IN THE CONTROL OF THE GYPSY MOTH IN WATERSHED FORESTS.*

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The gypsy moth (*Porthetria dispar* L.) was accidentally introduced from Europe into New England, in the vicinity of Boston, in 1868, and for nearly fifty years it has been one of our most important forest and shade tree pests, occasioning the expenditure of many millions of dollars by public and private agencies in an effort to control its spread.

Damage to trees is caused by the feeding of the larvae (caterpillars) on the foliage. Thrifty trees of the broad-leaved (hardwood) species are never killed by a single defoliation, but the loss in vigor caused by repeated stripping may pave the way for other pests, and lead eventually to a considerable mortality. With conifers, however, (with the exception of larch) a single complete defoliation proves fatal, since they lack the deciduous character of the broad-leaved species and the ability to refoliate following the loss of their leaves. I recognize that in watershed forests there are other than timber or esthetic values involved, and that large colonies of insects in the caterpillar stage are highly undesirable irrespective of any actual damage to the trees or the mere unsightliness of bare branches during a few weeks in early summer.

When first hatched, the caterpillars are extemely small and, with the aid of a fine silken thread which they spin, they may be blown long distances with the wind, thus providing a means of wide dispersion in certain directions. In Figure 1 it will be noted that the farthest spread from the initial point of establishment has been toward the northeast, presumably due to the prevalence of westerly winds during the hatching season. Dispersion is also made possible by vehicular traffic on the highways, by railroads, the shipment of nursery stock, ornamental trees and any materials on which eggs or caterpillars may be carried, as well as by the slower method of normal spread from the edges of heavily infested

*In the preparation of this paper the author has borrowed freely from the following publications: Silvicultural Control of the Gypsy Moth, by C. Edward Behre, A. C. Cline and W. L. Baker, Bull. 157, Mass. Forest and Park Assoc., 1936; and A Study of the Gypsy Moth in the Town of Petersham, Mass., in 1935, by W. L. Baker and A. C. Cline, Jour. of Forestry, August 1936.

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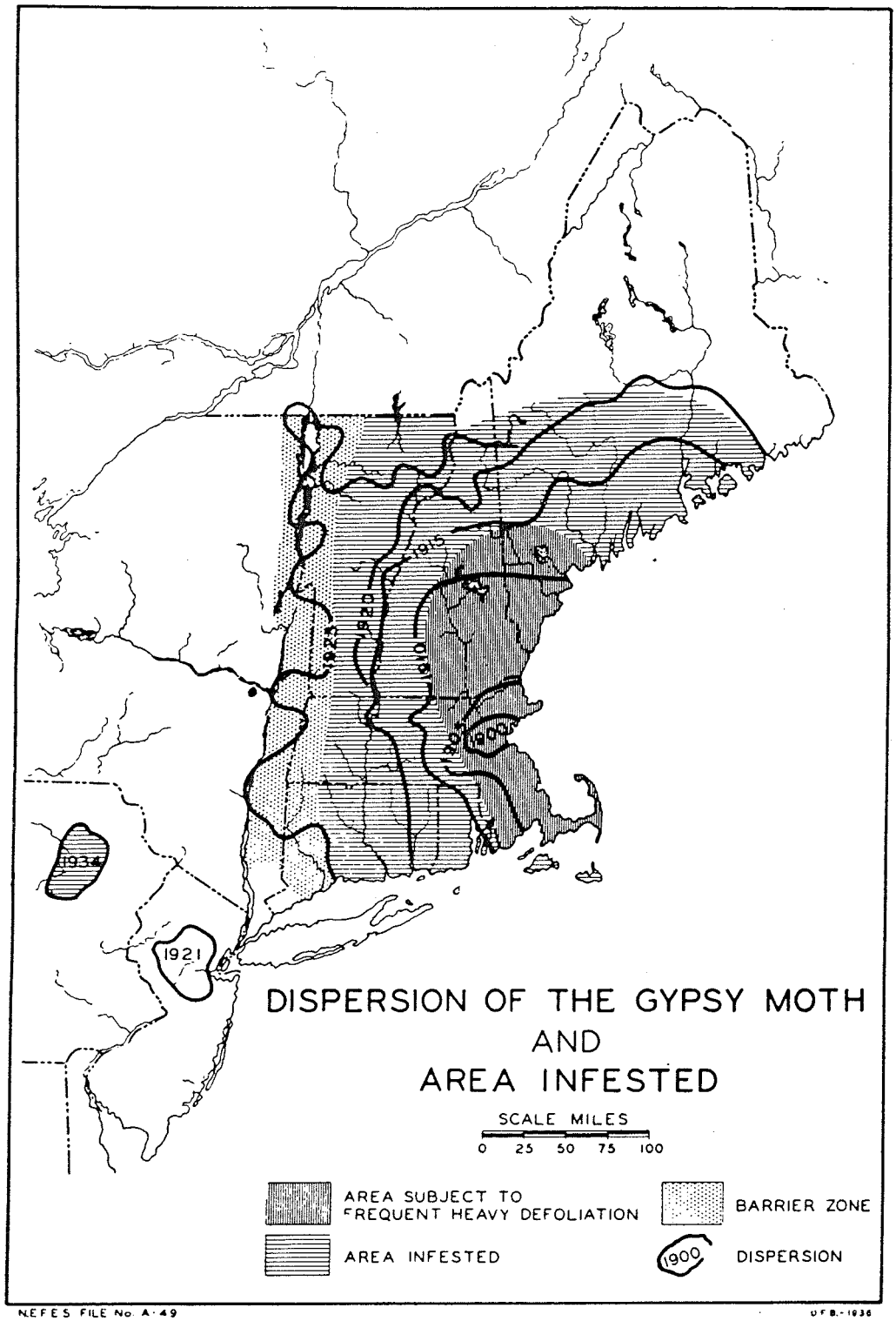


Figure 1

FIG. 1.

areas. The latter takes the form of short migrations by the larger caterpillars crawling in search of food, after the trees on which they spent their earlier lives have been defoliated. Fortunately, the female moth is unable to fly; otherwise, spread would be even more rapid.

Extent of Infestation. As with all forest insects, the extent of infestation by the gypsy moth in a given year has varied widely with the character and distribution of its food supply, climate, natural enemies and numerous other factors, which taken together cause the irregular ups and downs in moth populations, commonly referred to as cycles. Cycles may be thought of as being both regional and local. Unfavorable climatic conditions regional in extent, such as a winter sufficiently cold (about 25° F. below zero) to kill egg masses that are not beneath the snow or otherwise protected, or an excessively dry spell at the time when the caterpillars are just emerging and need moisture to sustain life until food is found, may cause a region-wide decline in moth populations requiring a succession of more favorable seasons for rebuilding to the former abundance. On the other hand, a single colony in a given locality may be cyclic because at its peak there is not enough edible food to go around; thousands of caterpillars die from starvation or the "wilt" disease, and several years may be required for the colony again to build up to a condition of congestion and inadequate food supply.

All stands within an infested region are not equally susceptible to attack. Even within localities rated as most heavily infested, individual trees and whole stands may repeatedly escape defoliation. The reason for this is found in the discriminating feeding habits of the caterpillars, which show a decided preference for the foliage of certain species of trees.* Among these highly favored food species the most important and common are the oaks, gray birch and poplar. Others are apple, alder, basswood, willow and hawthorn.

Many of you undoubtedly have observed the severity of attack on Cape Cod, where oak is so predominant, and farther inland where stands of oak, gray birch and poplar, either pure or mixed, occur interspersed with other types of forest growth. In this connection an explanation of the increasingly heavy infestations in recent years in central Massachusetts lies in the enormous increase in these highly favored food trees following the clear-cutting of thousands of acres of second growth white pine during the past thirty years. For it so happens that "old field" white pine is nearly always followed by hardwoods in which the oaks, gray birch and poplar are prominent species.

On the other extreme, the list of least favored species, some of them scarcely ever fed upon, includes ash, locust, tulip poplar, black walnut, red cedar and balsam fir, while those occupying an intermediate place

*For complete list of tree species arranged according to preference see "Silvicultural Control of the Gypsy Moth" by C. Edward Behre, A. C. Cline and W. L. Baker, Bull. 157 of the Mass. Forest and Park Assoc., 1936.

as host species comprise the maples, birches (except gray birch), hickories, elm, black cherry and hornbeam. The leaves of these last-named are edible, but are not favored, and stands composed of such species will not support a heavy infestation. In addition to these three classes of food plants, there is a group made up chiefly of the pines, spruces, hemlock and beech, which are definitely unfavorable as food for the young caterpillars but favorable for the older ones.

Since we cannot control the climate, and forest entomologists inform us that the introduction and propagation of parasitic enemies is not expected to prevent further epidemic outbreaks from time to time, it remains that by far the most promising method of indirect or natural control is through altering the forests themselves, that is, by reducing the abundance of the highly favored food species. And such a policy is greatly strengthened by the fact that most of the highly favored food species and many of the highly susceptible stands are undesirable from a forestry standpoint—either inferior species or slow-growing, low grade stands that should be replaced by something of greater economic value.

With few exceptions, the fine forests that the first white settlers found here contained much smaller percentages of favored food species than the secondary types of growth that have followed as a result of farm abandonment, clear-cutting or fires. The more exacting hardwood species, many of them resistant to gypsy moth attack, which require shade and moisture for successful growth have given way to light-demanding species, usually of short-lived or inferior character, but capable of growing under conditions of full exposure and comparative dryness. And, with the repeated clear-cutting of second growth stands, the growing stock becomes progressively deteriorated, the proportion of highly favored food trees is increased and with it the susceptibility of the stand to defoliation. So you see that much of our present trouble is due to the neglect of our forests, of failure to hold the weeds in check and to encourage the development of the better trees. Indeed, it may be said that our forests are like gardens that have been allowed to go to weeds.

Silvicultural Control. Silvicultural control in the form of such operations as weedings, improvement cuttings and thinnings, may at present supplement and perhaps in time wholly replace the direct or artificial methods of controlling the gypsy moth. Creosoting egg masses, banding trees and spraying foliage, now so commonly practiced, is most assuredly an extremely costly effort to control this pest, which is established over a large territory and shows no signs of decrease. On the contrary, infestation reached a new peak in central Massachusetts in 1935, and recently new gypsy moth colonies were discovered near the Hudson River in New York State. Not only are these artificial control measures so expensive when effectively applied that their cost would soon exceed the forest values they aim to protect, but at best they are only palliative. They are designed

to reduce infestations as they arise, without respect to the biological conditions that largely control the development and spread of moth populations. They do not get at the source of the trouble, which is the food supply. Reason compels us now to look upon the gypsy moth in New England as a native insect, like the tent caterpillar or the white pine weevil; it is futile to attempt its extermination. All we can and should hope for is a reasonable degree of control at a reasonable cost.

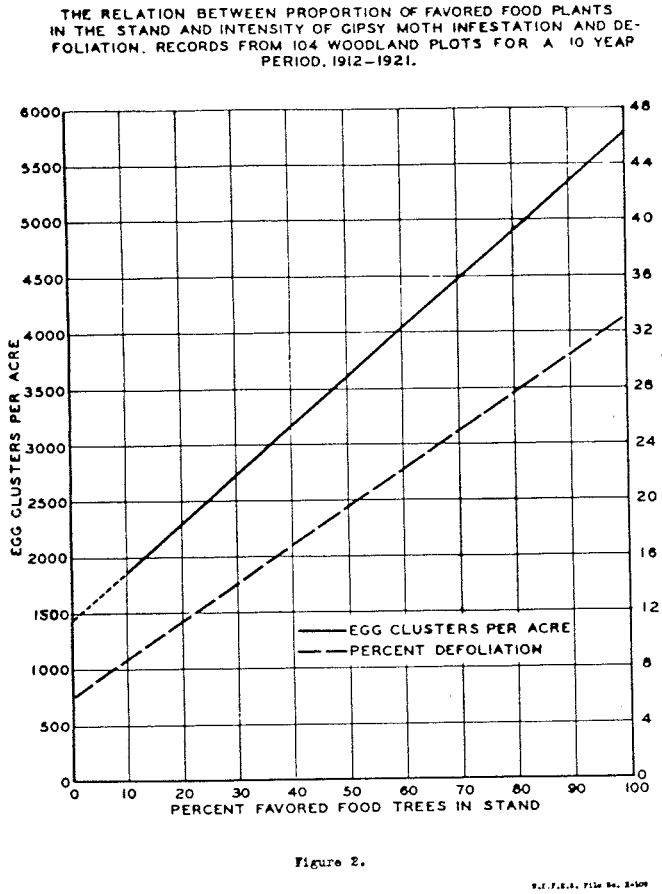


FIG. 2.

In order to bring some factual information to bear on my arguments for silvicultural control, I wish to show a graph which brings out the relation of defoliation to the character of the stand in respect to the proportion of favored food trees present (Fig. 2). This is based on 104 woodland sample plots established by the U. S. Bureau of Entomology and Plant Quarantine in various parts of the infested region. You will observe a direct relationship, that is, the higher the proportion of favored food trees in the stand, the greater the per cent. of the foliage volume consumed by the caterpillars.

I wish to present also a table (Table 1) based on a study of the gypsy moth in the town of Petersham, in 1935*, which shows that in every one of 81 cases where stands were completely defoliated highly favored food species comprised over 50 per cent. of the stand, and in more than one-half

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 RANGE OF STAND.		
	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

TABLE 2.—COMPARISON OF DEFOLIATED STANDS WITH THE MARGINS OF ADJOINING STANDS.

Plot No.	AVE. PERCENTAGE OF FAVORED FOODS.		AVERAGE PERCENTAGE OF DEFOLIATION.*					
			Favored Foods.		Unfavored Food.		All Trees.	
	Defoliated Area	Margin of Adjoining Stand.	Defoliated Area.	Margin of Adjoining Stand.*	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

*The per cent. of the total foliage volume of the stand consumed by caterpillars.

the cases over 75 per cent. of the stand. These defoliated areas, occupied mostly by oak, poplar and gray birch, pure or in mixture, do not cover wide stretches in Petersham, but are scattered about, a few acres here and there, usually very definitely associated with past farming or logging practices, or with areas of poor soil on ridge tops or other unfavorable

*A Study of the Gypsy Moth in the Town of Petersham, Mass., in 1935, by W. L. Baker and A. C. Cline, Jour. of Forestry, August, 1936.

sites. Thus heavy infestation was not general throughout the forested sections of the Town, but was strictly limited to those stands composed very largely of highly favored host species. This is further evidenced by Table 2, which shows a comparison of heavily defoliated stands with the margins of adjoining stands of different species composition. Invariably it was observed that the heavy stripping ceased abruptly where highly favored species gave way to unfavored species.

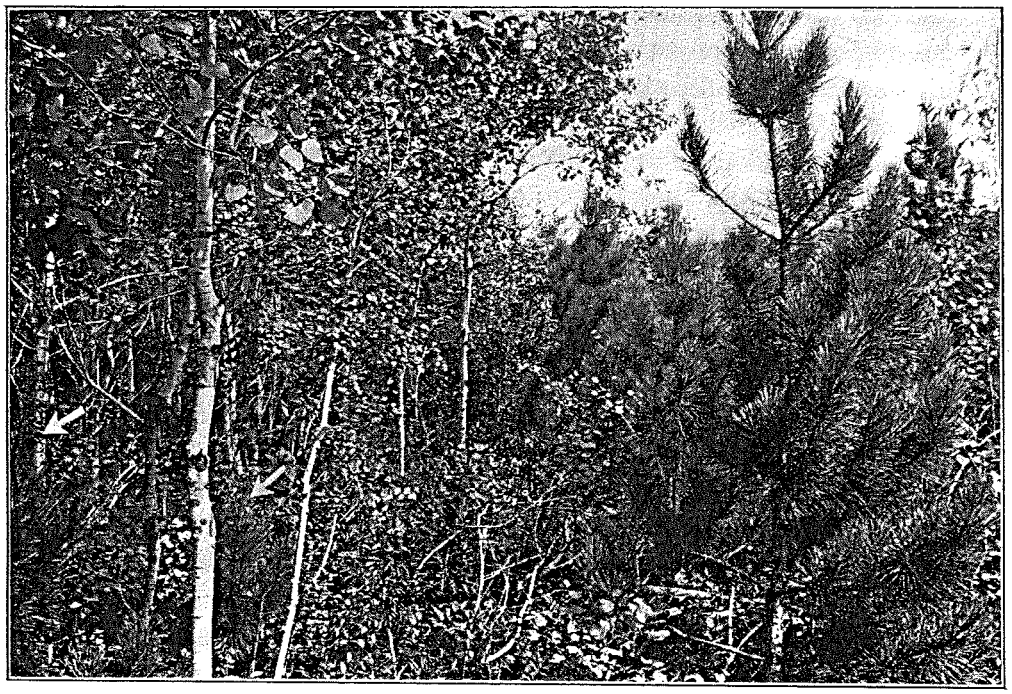
Recommended Methods of Control. Now to come to the methods of silvicultural control that I should like to recommend. First let us consider coniferous plantations. Fortunately, newly hatched caterpillars cannot feed on pine or spruce. They must succeed in reaching one of the favored hardwood host species or larch in order to survive. It is only after they have passed the second molt, at which time they have attained a length of about ½ in., that they may attack these two commonly planted conifers. Unless hardwoods of favored food species have been permitted to grow up in the plantation, the only hazard lies in adjoining hardwood stands containing high proportions of host species. Reducing the proportion of such species to below 50 per cent. of the total in a marginal strip about 100 ft. wide will ordinarily prevent defoliation of the planted conifers to any serious degree. If the adjoining stand should happen to be made up wholly of highly favored food trees, it will be necessary to clear a protective strip of similar width, which later may be extended to include the entire area of highly susceptible growth. Such clearings may then be safely planted with conifers or with mixtures of conifers and unfavored hardwoods.

Similarly, natural stands of conifers may be protected. Oftentimes, on abandoned fields and pastures, or on light sandy soils, pine is found growing underneath or among gray birch, poplar and oak. Security demands the cutting of such hardwoods when immediately overtopping the pine, or of thinning or cutting a protective strip in exactly the same manner as in safeguarding a plantation. Such a treatment ordinarily will take the form of what is known as a release cutting, often practiced by landowners in the case of pine overtopped by gray birch on abandoned farms, and one of the most profitable silvicultural treatments in common use.

Mixed stands of conifers and hardwoods lend themselves to protective treatments in the form of thinnings or group cuttings to reduce the proportion of highly favored food species to safe limits. Here the chief concern is to prevent the stripping of the conifers. Reduction of highly favored hardwood foliage to at least one-half the foliage volume of the conifers will in most cases assure adequate protection. In highly susceptible stands thinning may have to be supplemented by group cuttings of highly favored food trees, the openings so made being later planted to conifers or resistant hardwood species.

In hardwood or conifer-hardwood mixtures containing high proportions of such resistant species as ash, maple, yellow and black birch, tulip poplar or black cherry, little or no protective cutting will be needed. Several of these are exacting species that occur abundantly only on the better soils, which explains the comparative freedom of the better quality mixed hardwood stands from gypsy moth attack. The Berkshire region and extensive areas in north-central New England support stands of this character.

In southern New England pure stands of oak, highly susceptible to attack, are of common occurrence on light soils and exposed sites. Fre-



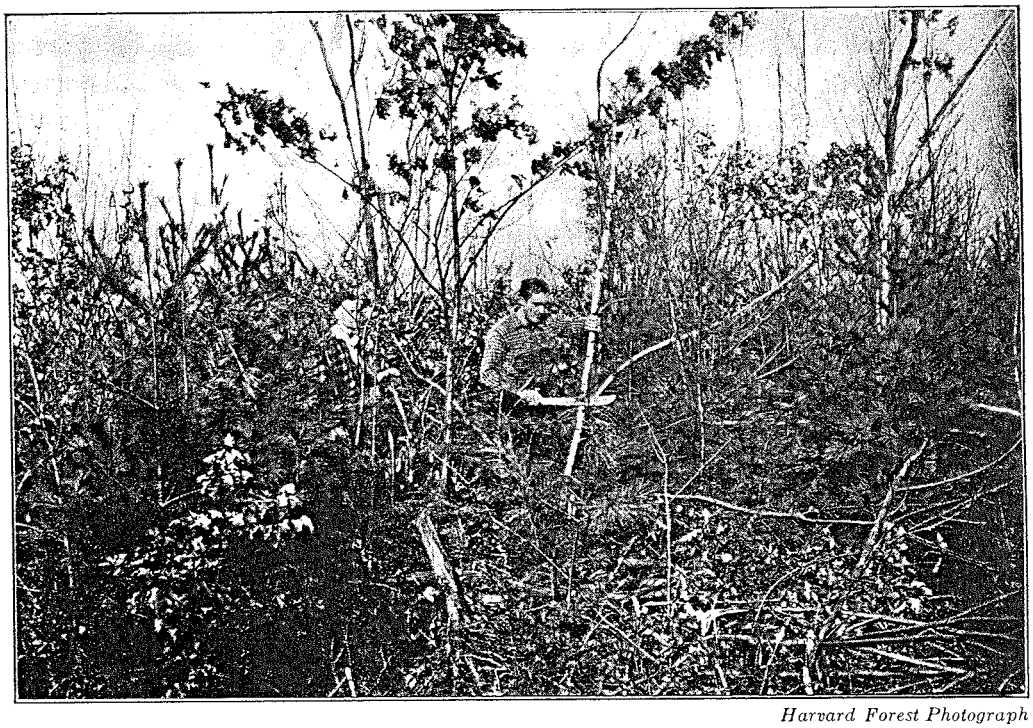
Harvard Forest Photograph.

FIG. 3.—A STAND OF HIGHLY FAVORED FOOD SPECIES, POPLAR, ADJOINING A RED PINE PLANTATION.

Cutting the poplar will both safeguard the red pine from stripping and save marginal pines now being suppressed. (See arrows.)

quently, they are of stump sprout origin, slow-growing, scrubby, and of no value other than for cordwood. Such stands might well be clear cut and the land planted to conifers. Oak stands of good quality, on the other hand, are not to be so drastically treated, but should gradually be altered by way of encouraging any available unfavored hardwood species, even to the extent of including species of second-rate commercial importance, such as red maple and black birch. Frequently, unfavored species occur in the understory, and they in time may be given a dominant place in the stand by a judicious cutting of some of the poorest oaks in the

overstory. Otherwise, small group clearings may be made over a period of years, and these openings planted to resistant hardwood species. The periodic application of group cuttings will eventually serve to convert the stand into a relatively immune group selection (all-aged) form in which oak will be limited to somewhat less than 50 per cent. of the total. More or less natural reproduction of resistant species generally becomes established in group clearings, thus permitting some saving in the cost of planting. All areas of young growth, whether planted trees or natural reproduction in small openings or on extensive clear cuttings, must be weeded in order to free the most desirable stems from overtopping stump



Harvard Forest Photograph

FIG. 4.—A MIXED STAND OF WHITE PINE AND HARDWOODS ON CUTOVER LAND.

Cutting out gray birch and rank-growing red oak stump sprouts improves the stand and at the same time reduces the gypsy moth hazard. Both are forest weeds and also highly favored food species.

sprouts and other inferior elements. In developing high quality mixed hardwood stands from small sapling growth, as many as two or three weedings may profitably be carried out over a period of ten to fifteen years. In these, no attempt should be made to eliminate the oak, but only to prevent its becoming the dominant species in the young stand.

In the aggregate, a considerable area in New England supports stands entirely or predominantly of inferior species, such as gray birch, poplar, and scrub oak—all highly susceptible to gypsy moth attack. On watershed forests, as well as on any others, good management demands the complete

removal of such worthless growing stock and its replacement with stands of prospectively high value. Clear-cutting followed by the planting of conifers, unfavored hardwoods, or mixtures of both, is plainly the one and only silvicultural treatment that will serve to control the gypsy moth and at the same time to restore the land to productive use.

Conclusion. In conclusion, let me say that I am not recommending the immediate abandonment of the direct methods of control, through creosoting or spraying, in favor of the indirect methods, but rather a gradual transition from the one to the other. Alteration of the forest composition may proceed slowly or rapidly, depending upon the character of the growing stock, as well as upon the availability of funds for silvicultural work. It is plainly seen, however, that as the proportion of unfavored host species is increased, the need for direct methods of control is correspondingly lowered, until the time finally is reached when the forest growing stock may be said to be "moth proof." Lastly, I wish to emphasize that the elimination or reduction of the highly favored food species will generally conform to desirable silvicultural practices from the timber crop production standpoint. Under New England conditions silvicultural control has this added advantage of serving the objectives of forest improvement, with little of no extra expense directly chargeable to insect pest control.*

*Members of the New England Water Works Association may obtain upon request and without charge copies of the bulletin "Silvicultural Control of the Gypsy Moth" by C. Edward Behre, A. C. Cline and W. L. Paker, published by the Massachusetts Forest and Park Association, 1936. Requests should be addressed to Mr. Harris A. Reynolds, Secretary, Massachusetts Forest and Park Association, 3 Joy Street, Boston, Mass.