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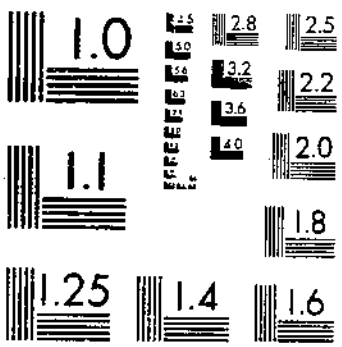

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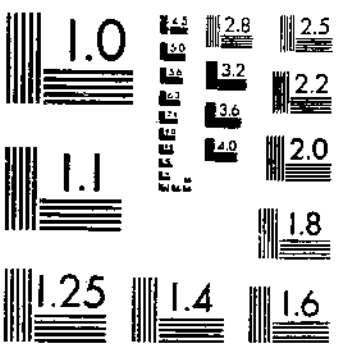

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Gypsy Moth

Appraisal Program and Proposed Plan to Prevent Spread of the Moths

by C. C. Perry

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The gypsy moth control project was transferred to the Plant Pest Control Branch, Agricultural Research Service, effective January 1, 1954.

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Gypsy Moth Appraisal Program and Proposed Plan to Prevent Spread of the Moths

By C. C. Perry, *control specialist, Plant Pest Control Branch,*[1] *Northeastern Region, Agricultural Research Service*

In 1869 the gypsy moth (*Porthetria dispar* (*L.*)), a leaf-eating insect which was one of the prime pests of forest, shade, fruit, and ornamental trees in Europe, was imported into Medford, Mass., by a French scientist who was interested in interbreeding this insect with silkworms. Larvae of the gypsy moth escaped from his home where experiments were in progress, and the insect became established in nearby residential and wooded areas. The history of the early spread of the pest is recorded by Forbush and Fernald (*3*),[2] and the early history and later developments by A. F. Burgess (unpublished material).

The spread of the insect from the immediate vicinity of Medford was slow at first, so that it was many years before any unusual larval population was noted. Just before 1889, however, the insects were so abundant that all the trees on extensive acreages near Medford were defoliated. Local interest in clearing out the pest was aroused and finally a law was enacted by the Massachusetts Legislature on March 14, 1890. This law entitled "An Act To Provide Against Depredation by the Insect Known as the Gypsy Moth" carried an appropriation of $25,000. It is believed to have been the first State law in the United States requiring the extermination of an insect and setting up the legal authority for entering private property for the purpose.

For a time the insect was confined to Massachusetts, but it was found in Rhode Island in July 1901, in Connecticut in July 1905, in New Hampshire in November 1905, in New York in 1912, and in Vermont in 1915. In the fall of 1924, egg clusters were found in the Province of Quebec, about 3 miles north of the United States border. Early in 1920 a severe infestation was found near Somerville, N. J., in a large stand of Koster blue spruce trees that had been imported from Holland in 1911. Prompt and vigorous action was taken and the insect was finally eradicated in 1935 and has never reinfested the State.

Late in July 1932 the gypsy moth was discovered at Pittston, Pa. Scouting immediately after its discovery revealed a heavy infestation in about 14 square miles and local infestations on an additional 95 square miles. However, later surveys disclosed an infested area of approximately 1,000 square miles in the Scranton-Wilkes-Barre area.

[1] Submitted for publication February 25, 1955.

[2] Italic numbers in parentheses refer to Literature Cited, p. 27.

In 1948, 250 square miles of infested territory was found in the so-called Quakertown area in Bucks County. Vigorous action was taken, as with the New Jersey outbreak, and the insect has been virtually eradicated from the State. Minor infestations have appeared from time to time and have been promptly eliminated.

Although much has been accomplished in the control of this damaging insect pest, it has, nevertheless, defied the concerted efforts of man. A host of workers have devoted years of sustained endeavor to combat this pest in northeastern United States, the region where it has ravaged the countryside. These workers have varied from the "bug man" of the earlier days with his can of creosote and brush, the research entomologist with introduced insect parasites and the wilt disease of the gypsy moth, the chemist with his spray formulations, the engineers who have designed effective spray equipment, the trained scouts who have participated in trapping and other surveys, and the efficient inspectors who so successfully have enforced quarantines invoked to prevent the artificial dissemination of the pest, to the skilled aviator who pilots the modern spray-tanks-of-the-air.

In spite of the persistence of the gypsy moth, it has been confined to a limited section of North America. Compared with results against the European corn borer (*Pyrausta nubilalis* (Hbn.)), the Japanese beetle (*Popillia japonica* Newm.), the causal fungi *Cronartium ribicola* Fischer of the white pine blister rust and *Endothia parasitica* (Murr.) P. J. & H. W. Anderson of the chestnut blight or canker disease, the restriction of distribution and damage by the gypsy moth is outstanding. On account of financial and other limitations, the situation falls somewhat short of the accomplished eradication of the Mediterranean fruit fly (*Ceratitis capitata* (Wied.)), the parlatoria date scale (*Parlatoria blanchardi* (Targ.)), and the causal organism of the citrus canker disease *Xanthomonas citri* (Hasse) Dowson.

However, because of the imperative need for preventing spread of the gypsy moth to uninfested forest areas of high value and for protecting presently infested woodlands from repeated and uncontrolled defoliation, an appraisal of the gypsy moth problem was undertaken in 1952 by the Plant Pest Control Branch, then a part of the Bureau of Entomology and Plant Quarantine, for the purpose of preparing a plan to prevent its spread. This bulletin reports the result of this study.

PREVIOUS APPRAISALS

Almost from the time the gypsy moth escaped in Medford, the combative work against this alien pest has been the subject of many inquiries.

The first of the major inquiries was undertaken by the Massachusetts Legislature on January 18, 1900. As noted by Burgess (unpublished material), the depredation by the insect had been so greatly reduced at the end of 1899 because of the intensive control work that had been done, that even slight injury was not easy to find, and further large expenditures did not appear to be warranted to some laymen and taxpayers. The exterminative work in progress since May 19, 1891, was virtually abandoned in February 1900. During the lapse in combative work the insect regained its hold, so that

by 1903 the committee in charge of the work commented that "the moth has now to a considerable extent recovered from attacks upon it by the State which ceased in 1899 and in many places is as abundant as ever." The committee concluded with the statement, "This probably settles the possibility of extermination in the negative for the future. The State has lost its opportunity and must abide by the results."

Confusion persisted until 1905, when through the efforts of a citizens' organization designated as the "Massachusetts Association for the Suppression of the Gypsy and Brown-tail Moths," a law was passed which delegated the responsibility for the management and execution of the work and the liability for expense between the State, municipalities, and the property owners. An appropriation of $300,000 was made to cover expenditures during a 3-year period. An additional $10,000 was appropriated each of the 3 years for experimenting with natural enemies of the moth.

The second major inquiry was undertaken in 1940, when the chief of the Bureau of Entomology and Plant Quarantine requested C. F. Korstian, dean of the School of Forestry of Duke University, and A. G. Ruggles, of the department of entomology of the University of Minnesota, to serve as a special committee to study the gypsy moth and the work carried on by the Bureau for its control. This committee, in its report (*4*) dated February 3, 1941, strongly urged the continuance of the work to prevent the spread of this moth in and adjacent to the barrier zone, particularly to the central hardwood, southern Appalachian, and Piedmont regions. The committee also pointed to the need for research and suggested that considerably larger appropriations were needed for both control and research. The investigators concluded that for every dollar spent now in holding back the westward and southward spread of the pest, many times the amount of the present expenditures will be saved.

In many of the discussions the possibility of exterminating the insect had been stressed. One of the first official plans based on extermination versus control was contained in a Federal-State cooperative program outlined in 1949. The objectives of the program for the ultimate eradication of the gypsy moth were as follows:

1. Eradicate the pest in Pennsylvania.
2. Eliminate the insect west of the Hudson River in New York, and finally from the entire State.
3. Apply control and eradication measures in western New England to prevent westward spread.
4. Enforce prescribed quarantine regulations to prevent long-distance spread into areas cleared by eradication measures and into all uninfested areas.
5. Through demonstrations, encourage the use of airplanes and mist blowers throughout infested portions of New England.

In January 1952 the Special Commission on the Structure of the State (Massachusetts) Government, referred to as the "Baby Hoover Commission" (*5*), recommended that through a change in financing, the Conservation Department undertake a statewide program of aerial spraying on an exterminative basis.

In September 1951 the Secretary of the United States Department of Agriculture appointed a study group to review the insect and plant-

disease control programs of the Department and to make recommendations thereon. As a result of its study of the gypsy moth problem, the committee had this to say in part:

> The study group recommends that the entire infested area be treated for eradication in a period not to exceed 5 years. It is estimated that on the basis of present costs such a 5-year program would cost approximately 25 million dollars, whereas continuation of the present program would cost nearer 100 million dollars over a period of 50 years. In addition to the lower cost of eradication, continuing losses caused by the moth in the intervening period would be avoided by this plan.

The report of the study group (*8*) had a wide distribution and on May 15, 1952, was thoroughly discussed by the Regional Coordinating Committee on Gypsy Moth Control of the Council of State Governments meeting in New Haven, Conn. After a careful consideration of all phases of the report, the committee passed the following resolution:

> *Be it resolved*, That this conference request the Gypsy Moth Control Division of the United States Department of Agriculture to prepare a coordinated and detailed plan for the eradication and/or control of the gypsy moth in the States of the region * * * the program to be a cooperative program between the States and the Federal Government, and *be it further resolved*, That such plan be submitted to the several States of the region for their review and suggestions as soon as possible.

In compliance with this request from the council, the Bureau of Entomology and Plant Quarantine and the Forest Service, in cooperation with the collaborating State pest-control officials, set up an appraisal program to assemble the facts needed for the evaluation of the problem and the determination of future combative policy.

THE 1952 APPRAISAL PROGRAM

The overall plan for the appraisal program in 1952 was divided into four principal phases: (*a*) A survey to determine the limits of the generally infested area and acreages of susceptibility in New England and New York; (*b*) a study to determine the loss caused by the gypsy moth in killing trees, retarding growth, and deteriorating forest stands, and loss in intangible values; (*c*) an ecological study to determine the susceptibility of stands in the vast hardwood forests outside the New England-New York portion of the Northeastern Region; and (*d*) the formulation of an operational plan of procedure for either the eradication or selective control of the insect.

Survey to Determine Limits of the Generally Infested Area and Acreages of Susceptibility in New England and New York

DESCRIPTION OF THE SURVEY

The appraisal survey was designed (*a*) to determine the status of gypsy moth infestation between the limits of repeated defoliation as shown on a 15-year (1934–48) defoliation map and the gypsy moth quarantine line, thus to establish the limits of general infestation, and (*b*) to obtain an estimate of the acreages where conditions of site and forest composition are favorable for defoliation by the insect. These latter acreages will hereinafter be referred to as susceptible areas.

To carry out the fieldwork in the first phase of the survey, the overall area was divided into 14 field districts, the work in each district being under the direction of an experienced gypsy moth control supervisor. The States, in some instances, through their pest-control agencies, participated by furnishing scouts. On an average, 20 spot examinations were made in each town, with the inspection points evenly distributed over the town. The results of these examinations were used as a basis for estimating the percentage of a town classifiable as generally infested. At the inspection points and also in the territory traversed by the scouts in going from one point to another, observations were made as to whether the stands were classifiable as susceptible or resistant to defoliation. Susceptible sites are those on which soils and physiography have produced open, parklike growth in which ground litter and understory is sparse or nonexistent as reported by Bess and coworkers (*2*). These sites are invariably dry and support tree species highly favored by the gypsy moth.

Such an environment is not attractive to small mammals and predaceous insects, which in more dense stands having a deep and moist forest floor exercise control over the infestation buildup through the destruction of larvae found in the ground litter. Survey data procured in the field were entered on county highway maps by townships. Weekly progress reports with pertinent interpretations of special conditions were submitted to project headquarters, and from these reports a comprehensive compilation was made.

The survey confirmed the fact that along most of the northern periphery of infestation extending from the Atlantic Ocean on the east, through Maine, New Hampshire, and Vermont to Lake Champlain on the west, climatic, growth, and site conditions provide a natural barrier to any substantial spread to the north. The situation in this area has remained fairly static for many years. In the Champlain Valley of northwestern Vermont, conditions of susceptibility exist that indicate the possibility of spread to the north.

For a complete picture of the situation in the New England States, it was necessary to develop statistics for that portion of the generally infested area not covered by the 1952 appraisal survey. In this unsurveyed area, trees had been defoliated repeatedly and many killed between 1911 and 1952. The acreage infested within this repeatedly defoliated area was determined from a type map of New England (*7*) prepared in February 1947 by a special committee on silviculture of the New England Section, Society of American Foresters. On this map the committee had recognized and set up the following types: Spruce-fir, northern hardwoods, white pine-transition hardwoods, central hardwoods, pine-oak, and a tension zone between central hardwoods and transition hardwoods.

As a result of a detailed study of this type map in conjunction with defoliation records (especially those for 1952), a significant correlation was evident between four of the types and defoliation. This correlation was so striking that acreage data were developed from the map for all types except spruce-fir and northern hardwoods, which are classifiable as resistant. In other words, the types selected are believed to represent as nearly as could be determined without a detailed survey, the areas of general infestation. It is believed the figures arrived at are reasonable and conservative. The generally

infested area in the unsurveyed territory thus determined amounted to 20,867,700 acres.

The type map could not be used for determining susceptibility, because it is based on stand composition and broad forest types, rather than on site and physiographic characters which determine susceptibility so far as the gypsy moth problem is concerned. Fortunately, however, there were available for the unsurveyed area yearly records of acreages defoliated in each town from 1933 through 1952. From these records a tabulation was made of the maximum defoliation in any one year in each township. This figure was considered to be representative of susceptibility, because within the period covered there were two or more peaks of defoliation, so that the maximum in any one year would be a reasonable basis for judging susceptibility. There would be some exceptions, but it is believed the figures are conservative.

GENERAL RESULTS OF THE APPRAISAL SURVEY

The overall results of the appraisal survey are presented in table 1. These data show, in the field phase, that in the 5 New England States under survey, 11,360 spot examinations were made in 568 townships representing 12,765,081 acres of land. There were 5,040,621 acres infested and 2,246,298 acres classed as susceptible to defoliation. In the repeatedly defoliated areas in the 6 States, computations from the office records showed 20,867,700 acres generally infested and 2,034,296 acres susceptible to defoliation. In the New England States, therefore, 25,908,321 acres were infested and 4,280,594 acres were susceptible to defoliation.

It was not necessary to extend the survey to New York State because of the availability of recent detailed records of both infestation and susceptibility. In eastern New York approximately 3½ million acres were recorded as infested and 1 million acres as susceptible to defoliation.

For the New England-New York area combined, therefore, the appraisal showed a grand total of 29,539,681 acres infested and 5,280,594 susceptible to serious defoliation.

A complete analysis of conditions in each State was included in the final report of this section of the appraisal program.[3]

Appraisal of Damage by the Gypsy Moth in New England, 1933–52

In the second part of the 1952 appraisal program [4] an attempt was made to evaluate damage by the gypsy moth in the New England States from 1933 to 1952, inclusive, in terms of timber and related values. Chief emphasis was placed on stumpage losses due to mortality and to loss in growth as a direct result of gypsy moth defoliation. Consideration was also given to intangible losses which cannot

[3] U. S. BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE. REPORT OF THE GYPSY MOTH APPRAISAL SURVEY IN THE NORTHEASTERN REGION. Unpublished report. February 1953.

[4] HOUSE, W. P. APPRAISAL OF DAMAGE BY THE GYPSY MOTH IN NEW ENGLAND, 1933–52. Unpublished report. December 1952.

be clearly expressed in dollars and cents, but which are essential in arriving at a true picture of the extent of damage.

Timber damage is largely confined to the oak and pine-oak types. It centers primarily on the oaks that suffer varying degrees of mortality, depending on the severity and frequency of the attacks and on factors of site, drought, other insects, diseases, and late frosts. A single, complete defoliation will rarely cause severe mortality in the oaks unless complicated by a second defoliation due to a late frost, overmaturity, drought, or other reasons. It generally takes more than one successive year of heavy stripping for mortality to be marked—except sometimes when mature black oak stands are heavily defoliated for the first time. Resistance to killing is greatest in white and chestnut oaks and least in the red, scarlet, and black oaks in that order. White pine and hemlock are sometimes killed, but not so prevalently as the oaks. Killing of other favored food species such as grey birch and aspen is not considered serious, since these species have little economic value in the area of gypsy moth infestation. Although trees of all sizes are killed, in assessing mortality losses in the 1952 study, only mortality on dominant, codominant, or intermediate trees was considered.

It was apparent in studying the problem of losses to timber that insufficient data were available to permit accurate statistical analyses. Although excellent basic work had been done, the system of reporting the annual gypsy moth damage in acreages defoliated to different degrees did not lend itself to the evaluation of volume of timber losses. No clear means was found whereby the basic research on mortality and growth loss could be related directly to the annual defoliation records.

It would therefore have been desirable to have carried out an intensive program of field investigation to develop really sound data. However, time was limited and it was necessary to use available data supplemented by a limited amount of field research for the best estimate possible. Because of the dearth of data and the necessity of relying often on assumptions based on opinion rather than on proved fact, an effort was made to be conservative in evaluating doubtful relationships.

The method of investigation involved two main steps. The first was to study existing data on mortality, growth losses, and defoliation. Mortality percentages derived from existing data were applied to the areas reported annually as 75 or 100 percent defoliated for the 20-year period. The acreage of the areas so reported is shown in table 2 and figure 1.

The second step involved the examination in the fall of 1952 of areas representative of those of repeated heavy defoliation and of those appearing on the annual records as 75 and 100 percent defoliated. Estimates were made on the spot of mortality, stand volumes, and stumpage values in order to check computations and to reach average figures applicable to the defoliated areas. The field examination also provided an opportunity to gain a better understanding of some of the intangible values affected by gypsy moth defoliation.

TABLE 1.—*Area infested by the gypsy moth in the New England States and New York*

State	Number of townships surveyed	Number of sites examined	Number of acres surveyed	Number of townships infested	Number of acres infested [1]	Number of acres susceptible to defoliation
DATA FROM 1952 APPRAISAL SURVEY						
Maine	247	4, 940	5, 147, 843	172	1, 929, 640	723, 551
New Hampshire	80	1, 600	2, 166, 504	51	946, 753	162, 525
Vermont	145	2, 900	3, 804, 078	96	1, 281, 904	599, 791
Massachusetts	44	880	804, 288	44	721, 715	241, 789
Connecticut	52	1, 040	842, 368	26	160, 609	518, 642
Total	568	11, 360	12, 765, 081	389	5, 040, 621	2, 246, 298
DATA FROM FOREST TYPE MAP IN AREA NOT COVERED IN 1952						
Maine	147	----------	6, 231, 640	147	6, 231, 640	482, 784
New Hampshire	166	----------	4, 396, 607	166	4, 396, 607	531, 118
Vermont	16	----------	2, 863, 376	16	2, 863, 376	88, 480
Massachusetts	264	----------	4, 338, 765	264	4, 338, 765	898, 443
Connecticut	117	----------	2, 360, 192	117	2, 360, 192	14, 524
Rhode Island	39	----------	677, 120	39	677, 120	18, 947
Total	749	----------	20, 867, 700	749	20, 867, 700	2, 034, 296

TOTAL SURVEYED AND NOT SURVEYED

Maine	394	----------	11, 379, 483	319	8, 161, 280	1, 206, 335
New Hampshire	246	----------	6, 563, 111	217	5, 343, 360	693, 643
Vermont	161	----------	6, 667, 454	112	4, 145, 280	688, 271
Massachusetts	308	----------	5, 143, 053	308	5, 060, 480	1, 140, 232
Connecticut	169	----------	3, 202, 560	143	2, 520, 801	533, 166
Rhode Island	39	----------	677, 120	39	677, 120	18, 947
Totals:						
New England	1, 317	----------	33, 632, 781	1, 138	25, 908, 321	4, 280, 594
New York	----------	----------	----------	----------	3, 631, 360	1, 000, 000
New England, New York	----------	----------	----------	----------	29, 539, 681	5, 280, 594

[1] From very light to very heavy populations.

TABLE 2.—*Acres defoliated by the gypsy moth in New England, 1933–52*

State	Number of acres defoliated		Percent of all acres defoliated 75 and 100 percent	Acres defoliated all degrees	
	75 percent	100 percent		Number	Percent by states
Maine	218, 007	36, 327	15	1, 570, 520	24
New Hampshire	380, 065	87, 530	25	1, 851, 820	29
Vermont	5, 880	3, 824	6	148, 283	2
Massachusetts:					
Plymouth and Barnstable Counties	241, 088	189, 978	51	858, 706	14
Other counties	544, 367	586, 737	59	1, 944, 948	30
Total all Massachusetts	785, 455	776, 715	56	2, 803, 654	44
Connecticut	3, 028	4, 098	37	19, 081	.3
Rhode Island	15, 755	3, 695	41	46, 641	.7
Total	1, 408, 190	912, 189	36. 4	6, 439, 999	100

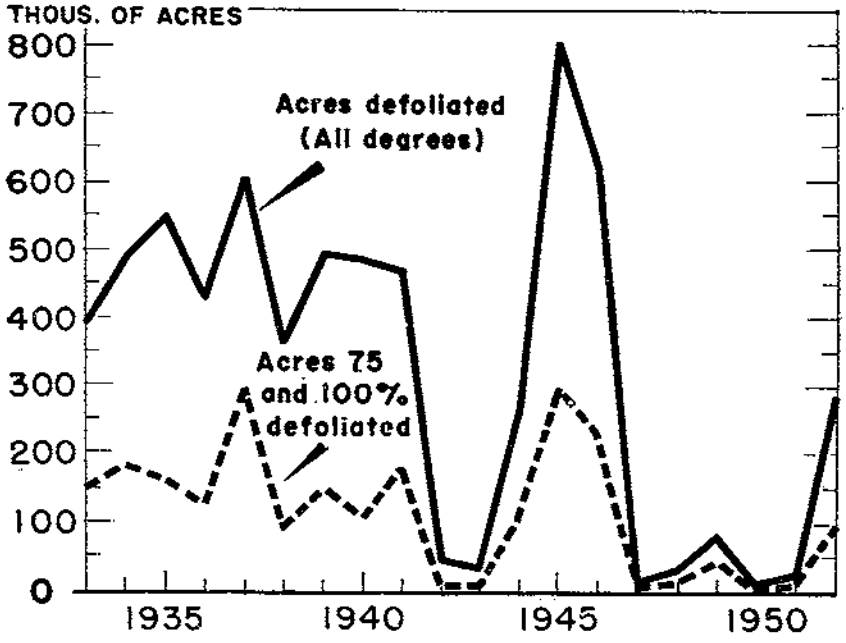

FIGURE 1.—Acres in New England defoliated in varying degrees by the gypsy moth, 1933–52.

MORTALITY LOSSES

Assessing the part played by the gypsy moth and that played by the two-lined chestnut borer (*Agrilus bilineatus* (Weber)), by diseases, overmaturity, prolonged drought, and frost damage present real problems. It was generally considered, however, that in areas of repeated heavy defoliation the moth, in most cases, is the primary cause of mortality.

A comprehensive study of mortality and growth losses was made from 1912 to 1921 in eastern New England by J. N. Summers and coworkers (unpublished). Losses from defoliation were reported by Minott and Guild in 1925 (*6*), and by Baker in 1941 (*1*). The study of Summers and coworkers was based on careful observation of more than 186 areas considered at that time to be representative of the infested area. A mortality loss of 33.13 percent was found over the 10-year period. Despite the basic soundness of this study, it was so far removed in time from the 1933–52 period that its applicability to present-day conditions is doubted. There is also evidence that killing is greater during the early years of heavy infestation than after the pest has been long established. Moreover, it was not possible to determine clearly how representative the 186 areas were of conditions throughout the 1933–52 infested area.

Work carried out by Tierney in 1947 [5] in the Connecticut River

[5] TIERNEY, G. C. DEATH OF TREES FOLLOWING DEFOLIATION BY GYPSY MOTHS IN CONNECTICUT VALLEY TOWNS OF MASSACHUSETTS. Unpublished report. August 28, 1947.

Valley area of Massachusetts offered a better chance of correlating mortality percentages with conditions in the last two decades. It also permitted use of the detailed defoliation records of the last 20 years in a more accurate portrayal of recent damage. These data were therefore used as a basis for the current estimates. His study was based on 34 areas, totaling 2,734 acres, on which detailed history of past defoliation by years was available for the period 1935–46. The percentage of mortality for each of the areas was estimated by him in 1947. Since one of the areas did not have detailed information comparable with the others, only 33 areas, totaling 2,584 acres, were used in computing percentages.

Examination of Tierney's data revealed that the average mortality for the entire 2,584 acres, when weighted to adjust for the acreage of the individual areas, was about 37 percent—a remarkable correlation with the Summers' 10-year mortality loss of 33.13 percent in a different area and almost 20 years earlier. The high incidence of 75- and 100-percent defoliation suggested that a practical relationship might exist between the effect of the gypsy moth on Tierney's study areas and on those defoliated 75 and 100 percent elsewhere in the infested area.

In the 1935–46 period 2 years was the average time during which 75- or 100-percent defoliation was recorded for each of Tierney's areas. In other words, a mortality of just under 37 percent resulted from an average of 2 years of 75- or 100-percent defoliation. If the relationship between conditions on Tierney's areas and on all areas having such defoliation were a direct one, it could be assumed that 1 year's defoliation of either 75 or 100 percent would cause half as much mortality as 2 years', or approximately 18 percent. This probably would not be true of a single year of heavy defoliation with none in the previous or following years. However, the pattern of Tierney's plots, as well as the experience of many other entomologists, suggested that there was a high incidence of repeats in the heavier defoliation classes in the same area in the same 2-year period and the average mortality loss of 37 percent was the net result of this pattern. Dividing by half to base the mortality on a single year was necessary, because that was the only way to utilize the annual defoliation records which do not show whether there were repeats or not, only the total acres defoliated.

Inspection of 84 representative, heavily defoliated areas during the field phase of the 1952 study provided some indication of the relation between Tierney's damaged areas and those elsewhere. The inspected areas were known to have had a history of heavy defoliation over a long period of years and, as nearly as possible, to be representative of areas shown as 75 or 100 percent defoliated in annual reports. Estimates of the mortality evident on these areas showed an average mortality of 24 percent. Most of the areas were defoliated from 75 to 100 percent for the 2 years, and the average annual mortality was probably between 12 and 18 percent.

Although the average of mortality percentages on the areas was slightly lower than those found by Tierney, it was clear in the 1952 study that it was not always possible to appraise the full extent of damage that occurred early in the 20-year period. Consequently, it is believed that the percentage mortality losses derived from Tierney's study, based as it was on detailed knowledge of specific areas, can

safely be applied to most of the areas defoliated 75 or 100 percent and still be conservative.

Exceptions were made in Connnecticut and Rhode Island where, as it has been demonstrated by men familiar with the problem, a degree of unexplained resistance has existed, so that mortality losses have been considerably under the average for other areas of New England. To approximate this difference a mortality percentage of one-half of the 18, or 9 percent, was used in these States.

In the 1952 study, therefore, it is believed that on the average for every acre reported as 75 or 100 percent defoliated in the last 20 years, a mortality of 18 percent of the volume was primarily due to the gypsy moth.

Having derived an expectable mortality loss of 18 percent, it was necessary to determine to what stand volumes and stumpage values this loss applied. The volumes and values were obtained from estimates of foresters and others familiar with forest conditions in the gypsy moth-infested areas. In addition, estimates of volume and values had been made on each of the 84 areas visited in the course of the field study. The result of these two sources is an approximation of what might reasonably be assumed are the average cordwood and saw-timber volumes and values in the absence of exact figures.

The lowest figure used was for southeastern Massachusetts, with an average of 3 cords per acre having a stumpage value of 50 cents per cord. The highest figure was for Maine, with 9 cords of wood and 750 board-feet per acre having a value of $1.50 per cord and $12 per thousand board-feet.

Over large areas the value of small hardwood stumpage was only nominal and on many nonexistent. However, over the areas covered it was not felt that growing wood could be completely discounted, even though often its worth in terms of present markets was questionable.

Thus, from computations using these factors of mortality percentages, estimated stand volumes, and stumpage values, the loss through mortality during the period 1933–52 amounted to 2,279,819 cords and 128,951 thousand board-feet of merchantable timber, having a total estimated value of $4,223,556. A statistical record of the loss including the average volumes and stumpage values used for each State is shown in table 3.

LOSSES IN TIMBER GROWTH

Loss in diameter growth due to gypsy moth defoliation is a much less spectacular manifestation of damage than death but is an important one so far as timber production is concerned.

Comprehensive studies were made of growth losses in eastern New England in the 1912–21 period (*1, 6*).

Summers (unpublished), in projecting the growth-loss data from the individual areas studied in the 1912–21 period to the larger area infested in 1924–31, devised a method which, in the lack of anything more accurate, was used in the 1952 study. This method is based on the assumption that the net result of a year's defoliation to a given percentage on 1 acre is the same percentage loss of the normal growth on that acre.

The average annual percentage of defoliation for the 6,439,999 acres defoliated in all degrees in New England in 1933–52 is shown in table 4. It is assumed that on each of these acres there was a growth

TABLE 3.—*Estimated mortality losses from gypsy moth to merchantable timber in the New England States, 1933–52*

State	Number of areas examined in 1952	Number of acres defoliated 75 and 100 percent	Estimated volume per acre before mortality		Percent mortality	Volume of mortality				Estimated stumpage value per		Estimated value of stumpage killed		
						Per acre		Total						
			Cords	M board-feet		Cords	M board-feet	Cords	M board-feet	Cord	M board-feet	Cord	M board-feet	Total
Maine	12	254,334	9	0.75	18	1.62	0.135	412,021	34,335	$1.50	12	$618,031	$412,020	$1,030,051
New Hampshire	16	467,595	7	.5	18	1.26	.090	589,170	42,084	1.50	12	883,755	505,008	1,388,763
Vermont	6	9,704	8	.5	18	1.44	.090	13,974	873	1.50	12	20,961	10,476	31,437
Massachusetts:														
Barnstable and Plymouth Counties	19	431,066	3	.....	18	.54	.....	232,776	.....	.50	.....	116,388	.....	116,388
Other counties	26	1,131,104	5	.25	18	.90	.045	1,017,994	50,900	1.00	12	1,017,994	610,800	1,628,794
Total all Massachusetts	45	1,562,170	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,745,182
Connecticut	5	7,126	8	.5	9	.72	.045	5,131	321	2.00	12	10,262	3,852	14,114
Rhode Island	.....	19,450	5	.25	9	.45	.225	8,753	438	1.00	12	8,753	5,256	14,009
Total	84	2,320,379	.....	.....	.....	.....	.....	2,279,819	128,951	.....	.....	$2,676,144	$1,547,412	$4,223,556

TABLE 4.—*Estimated losses in timber growth from gypsy moth infestation in the New England States, 1933–52. Normal annual growth rate was estimated to be ½ cord*

State	Acres defoliated, all degrees	Average annual percent defoliation per acre	Average annual growth loss per acre		Total growth loss for area defoliated, cords	Value per cord [1]	Total value of stumpage killed (from table 3)	Combined value mortality and growth losses
			Percent	Cords				
Maine	1, 570, 520	35. 6	35. 6	0. 178	280, 000	$2. 00	$1, 030, 051	$1, 590, 051
New Hampshire	1, 851, 820	39. 9	39. 9	. 20	370, 000	2. 06	1, 388, 763	2, 150, 963
Vermont	148, 283	31. 4	31. 4	. 157	23, 200	2. 00	31, 437	77, 837
Massachusetts:								
Barnstable and Plymouth Counties	858, 706	52. 7	52. 7	. 264	227, 000	. 50	116, 388	229, 888
Other counties	1, 944, 948	57. 0	57. 0	. 285	554, 000	1. 64	1, 628, 794	2, 537, 354
Total all Massachusetts	2, 803, 654				781, 000		1, 745, 182	2, 767, 242
Connecticut	19, 081	46. 5	46. 5	. 232	4, 400	2. 50	14, 114	25, 114
Rhode Island	46, 641	46. 7	46. 7	. 234	10, 900	1. 64	14, 009	31, 885
Total	6, 439, 999				1, 469, 500		4, 223, 556	6, 643, 092

[1] Obtained by incorporating M board-feet/acre stand volumes and values into cord volumes and value per acre.

loss equivalent to the average defoliation percentage found for each acre defoliated.

These defoliation percentages were derived by averaging the total acre-years in each defoliation class and weighing them by the number of acres reported in each class for every year. Thus, in Maine on an average the defoliation was found to be 35.6 percent for each of the 1,570,520 acres that were reported defoliated in all degrees. Some of the relationships between the different classes of defoliation are shown in figure 1.

The total loss in growth estimated by these methods for all the New England States in 1933–52 was found to be 1,469,500 cords having a value of $2,419,536 (table 4).

The values found for mortality losses are recapitulated in table 4 from table 3. The total estimated loss from both mortality and growth was $6,643,092.

MORTALITY TO WHITE PINE

Although white pine is not a favored food species for the younger stages of gypsy moth larvae, it is sometimes favored by the later stages, and in areas of extremely heavy feeding, stripping of white pine and of hemlock is not uncommon.

During the field phase of the 1952 study, a number of mature pine and hemlock were found that had died after heavy defoliation. Their volumes and values have been included in the estimated losses due to mortality of merchantable oak timber already outlined, and therefore do not warrant separate treatment.

Of greater possible importance is the loss of white pine in the reproduction and intermediate classes due to gypsy moth defoliation. Evaluation of damage is complicated by other factors that affect the ability of white pine reproduction to succeed when overtopped by hardwoods. Observation in the field suggested that defoliation of pine in the understory was not uncommon in the pine-oak types, but generally there was considerable question whether the pine would have survived normal suppression.

It is evident from past records and reports and from conversations with men long familiar with gypsy moth work, that killing of young pine has been serious on some areas observed in the last 20 years. These observations give little indication of the total acreages included or the chance that the pine would have had in surviving natural suppression. Therefore, while there is no clear evidence of the extent of large-scale destruction of pine reproduction, the convictions held by many men long associated with gypsy moth work bear considerable weight.

The evidence available with respect to white pine is therefore not conclusive. Detailed field studies of the problem will be necessary to develop a clearer relation between gypsy moth damage and suppression from natural causes and to permit a more accurate evaluation of the part played by this insect in the mortality of white pine reproduction.

DAMAGE TO SITE

An important type of intangible damage and loss that is not adequately represented in estimates of timber lost through mortality and decreased growth, is the damage to the forest site by repeated

heavy gypsy-moth feeding. It is important because it involves other considerations such as fire hazard, water protection, and recreational, esthetic, and wildlife values that are not readily assessable in terms of dollars and cents.

Of great importance is the continued effect of heavy gypsy moth damage to a site, not only during periods of heavy infestation but between and after them. In combination with past damage by fire, overgrazing, overcutting, and other poor agricultural practices, the gypsy moth has helped to keep large areas unproductive and to promote further deterioration. Drying out and destruction of humus by exposure to intense sunlight through light-crown canopies and retardation of desirable reproduction reach far beyond the years covered in the 1952 study. Even were the gypsy moth completely controlled in the next few years, the effects of this deterioration could be expected to continue for many years in limiting the production of timber crops and in lowering other forest land values.

Large acreages are now dominated by low-value wood that has little foreseeable future value as timber and that will long retard the development of a new and better forest. Even were it possible to assess accurately the part the gypsy moth has played in land abuses, it would still be impossible to evaluate the actual value of the lost timber. For that reason and because of the damage already done, the real losses at least equal and probably far exceed those from the more tangible forms of damage assessed in the 1952 study.

EFFECT ON ESTHETIC AND RECREATIONAL VALUES

Losses in esthetic and recreational values are harder to pinpoint than timber losses. In times of heavy defoliation, especially in residential areas and in areas of high esthetic value, the gypsy moth causes great distress to people who take pride in the appearance of their properties. High-value ornamental trees that are irreplaceable over several lifetimes are killed, the defoliated trees are unsightly, and crawling caterpillars invading their homes are a nuisance.

Probably as good an indication as any of the nuisance value ascribed to gypsy moth damage is the amount of money that the citizens of the States, counties, and towns have willingly voted to raise at their own expense to mitigate the nuisance. This action was probably not directed at timber production on the hundreds of thousands of acres of undeveloped land, but rather at controlling the damage to the shade trees and the nuisance in residential and recreational areas. In New England alone, the expenditure of almost $20 million in the last 20 years primarily for local protection suggests some of the importance that persons have put on the esthetic values involved in gypsy moth infestation. This amount includes $640,330 raised and spent in Barnstable and Plymouth Counties to carry out a widespread DDT-spraying program on an exterminative basis in 1949 and 1950. It does not include the considerable amount spent for spraying by private owners. Important also is $2,024,394 spent by New Jersey and Pennsylvania to clean up isolated outbreaks, and $3,142,184 spent by New York on gypsy moth work during the 1933–52 period. These figures give some indication of the desire of the taxpayers of those States to avoid a recurrence of what has happened in New England.

Ecological Studies in Eastern United States Outside the New England-New York Area

In the discussion of the gypsy moth problem in retrospect, reference was made to the great concern about the effect of the possible spread of the insect to the vast hardwood forests of the eastern United States beyond the present infested area. The third phase of the 1952 appraisal program was an ecological study to determine the susceptibility of these forests to gypsy moth damages. This study represents the first attempt to really arrive at some definite indication of the problem should the pest extend beyond its present limits of infestation.

In organizing the 1952 survey, it was decided that a group of foresters and entomologists working together would be in the best position to make an appraisal of susceptibility, and accordingly two foresters—A. F. Hough and E. W. Littlefield—and two entomologists—P. B. Dowden and W. V. O'Dell—were assigned to the survey. The group was divided into two teams, each taking a portion of the area for its working territory. The routes of both teams, covering an estimated 11,000 miles, are shown in figure 2. One team

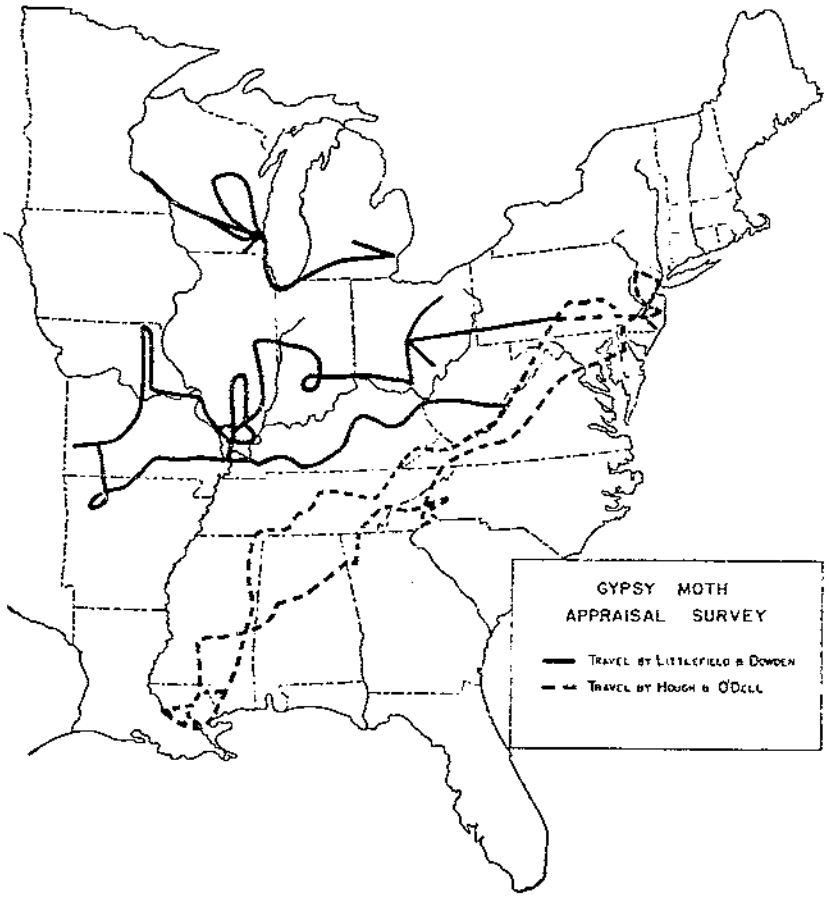

FIGURE 2.—Route traveled in gypsy moth appraisal survey.

covered Pennsylvania and New Jersey and the remainder of the region of the Northeastern Forest Experiment Station and that of the Southeastern and Southern Forest Experimentation Stations. The second team covered the region included in the Central States and the Lake States Forest Experiment Stations. This plan was adhered to with minor modifications and both teams followed the same general procedure. Travel, except in the Lake States, was entirely by automobile. The results of this survey were reported by Dowden and coworkers.[6]

SURVEY METHODS

With each team the first stop was made at the headquarters of the forest experiment station, where the project was discussed with the director and members of his staff, and pertinent statistical data were assembled with the help of the station personnel. Visits were then made to experiment station research centers, State foresters' offices, and in some instances to national forest headquarters, forest schools, agricultural experiment stations, and field offices of the Bureau of Entomology and Plant Quarantine.

Insofar as practical, an itinerary was worked out for a general inspection of the principal forest types, with emphasis, of course, on the types containing a high proportion of oak, and upon sections where there was a prevalence of dry sites. A slightly different approach was taken by the respective teams with regard to field inspections. The team covering the Appalachians and southern part of the territory placed more reliance upon general observations and the local knowledge of State and Forest Service personnel, in addition to the detailed breakdown of statistical data available at the experiment stations. The other team stopped to take specific observational data at representative inspection points over much of the traveled route.

GENERAL CHARACTER OF THE FORESTS IN THE SURVEY

All personnel participating in the survey were deeply impressed by the extent and continuity of the oak forests in the territory through which they traveled, and by the highly susceptible character of a large proportion of the stands observed, in comparison with those with which they were familiar in the Northeast.

The Allegheny plateau with its composition of northern hardwoods seems to present a natural barrier, which undoubtedly would hinder if not actually inhibit the spread of the moth directly westward from its present limits of infestation in eastern New York. Gradual spread to the south and west would therefore probably have to occur through a narrow area extending along the southern boundary of New York from the Hudson River to the Port Jervis, N. Y.-Milford, Pa., area. There seem to be no major features of physiography or forest type in this area or southward along the Atlantic Coastal Plain in New Jersey to prevent a gradual spread southward. Southwesterly from eastern New York through the middle Atlantic States susceptible woodlands become increasingly common.

In New Jersey the scrub-oak stands of the Coastal Plain appear to be fully as susceptible as those of Cape Cod, Mass. East of the Alle-

[6] DOWDEN, P. B., O'DELL, W. V., HOUGH, A. G., AND LITTLEFIELD, E. W. REPORT OF SPECIAL GYPSY MOTH SURVEY, 1952. Unpublished report. February 1953.

gheny front in Pennsylvania and southward through the ridge and valley section into the northern Blue Ridge and the southern Appalachians, there is an abundance of dry and relatively poor sites occupied by oak types that are highly susceptible.

The incidence of susceptibility increases southward and westward, probably reaching a peak in Tennessee, where approximately 74 percent of the total forest is susceptible. Southward in the Coastal Plain of Delaware, Maryland, and Virginia the forest type changes to resistant pure conifers, mixed conifer-hardwoods, or moist-site hardwoods. These resistant types are found in the ever widening Coastal Plains of the South Atlantic and Gulf Coast States.

In the Central States the chief areas of susceptibility lie in the unglaciated sections in southeastern Ohio, southern Indiana, southern Illinois, Kentucky, and the Ozarks, and the driftless area of southeastern Wisconsin and southeastern Minnesota. An exception is the region of heavy postglacial deposits in southern Michigan, where the coarse-textured soils with their excessive drainage support oak stands of the xerophytic type, and where the usual heavy grazing has been sufficient to bring them into the susceptible category. Susceptible areas are shown in figure 3.

SUSCEPTIBLE AREAS BASED ON FOREST SURVEY

It was thought, originally, that a tabulation might be made of the acreage in the different forest-cover types, on the basis of the classifications susceptible, borderline, and resistant (*2*). This proved impractical for two reasons: first, because the types recognized in the forest survey are based on a somewhat broader grouping than those listed by the Society of American Foresters and, in addition, are not uniform from one experiment station region to another; and secondly, because a number of the forest-cover types used in the New England-New York grouping are not represented in the regions under investigation. A basis for computing areas of susceptibility was therefore established by taking the forest survey figure (or nearest comparable figure from other sources) for types in each State in which oak was predominant and applying to this a percentage for poor sites based chiefly on physiography. It was in arriving at this percentage that the assistance from the experiment stations proved particularly valuable. Where the forest survey data were set up on punchcards, it is felt that the computed values are correct within precise limits; the other values must be accepted as broad estimates only. A compilation of these data are shown in table 5.

The most striking figure is the total of 100,115,000 acres classified as susceptible to gypsy moth damage. The percentage of forested area so classified is also of great importance, particularly when it is noted that more than half of the acres fall in that category in New Jersey, Pennsylvania, Virginia, West Virginia, Ohio, Illinois, Kentucky, Tennessee, and Missouri. In Massachusetts, the most severely affected State in the infested area, less than half of the forest area is characterized by site or stand conditions that would have been rated susceptible, as defined in this 1952 survey.

In reviewing the data on susceptible areas, it is extremely important to bear in mind that, although not represented here statistically, there

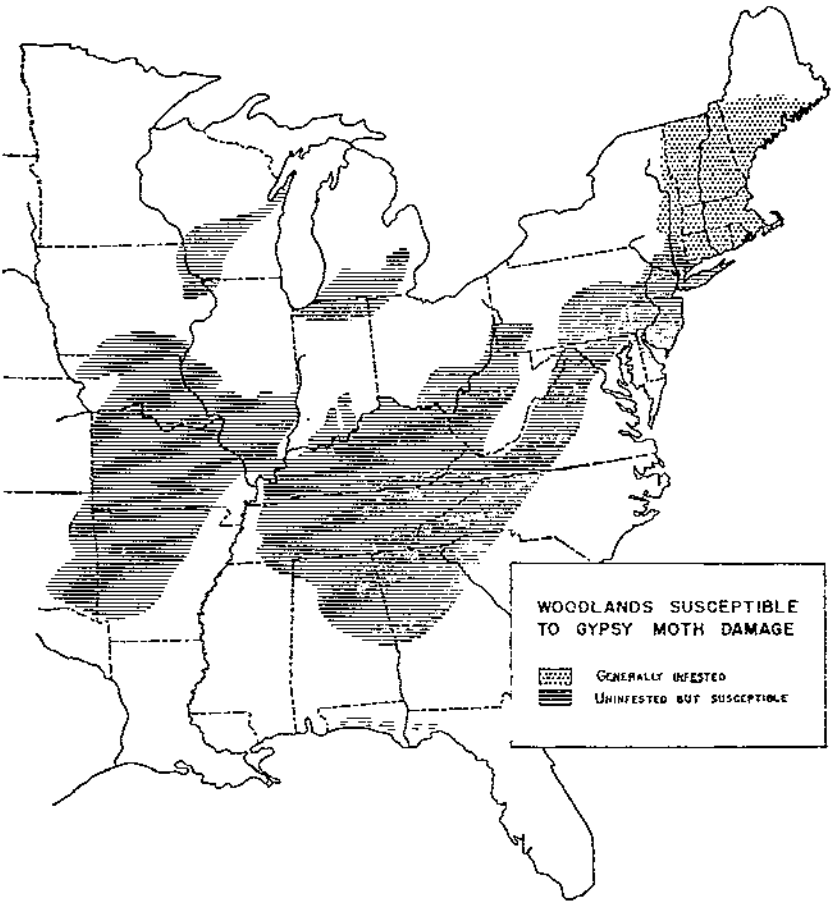

FIGURE 3.—Woodlands generally infested and uninfested but susceptible to gypsy moth damage.

are very significant degrees of susceptibility within the generally susceptible areas. Cases in point are the southwestern Ozarks and central Tennessee, where all the factors favorable to the development of gypsy moth abundance—high proportion of favored food species, dry sites, poor stocking, and a history of land abuse—are represented to a degree considerably above the general average for the region and far beyond anything, except very locally, in the Northeast. Another point is that throughout the prairie and semiprairie areas, which are generally less than 15 percent forested, there do exist many thousands of acres of oak woodlands, many of which are in themselves highly susceptible. The bur oak groves, for instance, which are so typical of much of this section, are probably among the most favorable spots imaginable for gypsy moth, because of the lack of forest floor and the fact that the individual trees attain full crown development.

TABLE 5.—*Acres of forest land in 5 U. S. Forest Service regions shown according to susceptibility and resistance to gypsy moth damage*

Region and State	Susceptible, 1,000 acres	Resistant, 1,000 acres	Total, 1,000 acres	Susceptible, percent
Northeast:				
Delaware	160. 0	282. 0	442. 0	36. 2
New Jersey	1, 599. 8	748. 2	2, 348. 0	68. 1
Maryland	1, 380. 4	1, 538. 6	2, 919. 0	47. 3
Pennsylvania	10, 130. 0	5, 098. 0	15, 228. 0	66. 5
West Virginia	5, 141. 8	4, 755. 2	9, 897. 0	52. 0
Total	18, 412. 0	12, 422. 0	30, 834. 0	59. 7
Southeast:				
Virginia	10, 200. 4	4, 447. 5	14, 647. 9	69. 7
North Carolina	7, 176. 6	11, 223. 2	18, 399. 8	39. 0
South Carolina	3, 024. 5	8, 918. 1	11, 942. 6	25. 3
Georgia	4, 514. 6	16, 917. 9	21, 432. 5	21. 1
Florida	2, 481. 4	20, 565. 6	23, 047. 0	10. 8
Total	27, 397. 5	62, 072. 3	89, 469. 8	30. 6
South:				
Alabama	3, 514. 4	15, 346. 0	18, 860. 4	18. 6
Mississippi	1, 778. 1	14, 754. 4	16, 532. 5	10. 8
Louisiana	2, 459. 5	13, 734. 8	16, 194. 3	15. 2
Texas (east)	1, 644. 3	8, 908. 3	10, 552. 6	15. 6
Arkansas	7, 206. 3	12, 158. 0	19, 364. 3	37. 2
Oklahoma (southeast)	1, 446. 2	1, 514. 8	2, 961. 0	48. 8
Tennessee	9, 290. 3	3, 317. 3	12, 607. 6	73. 7
Total	27, 339. 1	69, 733. 6	97, 072. 7	28. 2
Central: [1]				
Ohio [2]	1, 878. 0	1, 830. 0	3, 708. 0	50. 6
Indiana	1, 653. 0	2, 392. 0	4, 045. 0	40. 9
Illinois	2, 360. 0	1, 581. 0	3, 941. 0	59. 9
Kentucky	6, 713. 0	4, 733. 0	11, 446. 0	58. 6
Missouri	12, 481. 0	2, 593. 0	15, 074. 0	80. 9
Total	25, 085. 0	13, 129. 0	38, 214. 0	65. 6
Lake States: [1]				
Michigan	291. 0	17, 509. 0	17, 800. 0	1. 6
Wisconsin	1, 092. 0	14, 108. 0	15, 200. 0	7. 2
Minnesota	498. 0	16, 502. 0	17, 000. 0	2. 9
Total	1, 881. 0	48, 119. 0	50, 000. 0	3. 8
All regions	100, 114. 6	205, 475. 9	305, 590. 5	32. 8

[1] Figures are based on commercial forest area only, since area in noncommercial and reserved is insignificant. Data are not available for Iowa.

[2] Figures are from "Ohio's Forest Resources," which lists mixed oak as 1,360,000 and oak-hickory as 518,000 acres.

This consideration of the third phase of the appraisal program can lead only to the following conclusions:

An extremely large and more or less contiguous area exists in the Appalachian, Southern, and Midwest portions of the United States within which there are frequently found forest stands susceptible to gypsy moth infestation as measured by the criteria established by

Bess et al. (2). Both the abundance and the degree of susceptibility of such stands increase westward from the Alleghenies and Appalachians, reaching a maximum in the unglaciated portions of the Ohio Valley, in central Tennessee, and in the Ozarks.

The ecological barrier imposed by the central New York uplands and their extension into the Allegheny plateau does not appear to have any counterpart further west or south. The effect of this natural barrier in arresting or materially slowing down the westward spread of the gypsy moth is, moreover, largely neutralized by the continuity of susceptible oak types from southeastern New York into the other sections.

Plan of Operations—Eradication or Prevention of Spread

The fourth and final phase of the appraisal program was related to the preparation of a plan of operations in compliance with the request of the Regional Coordinating Committee on Gypsy Moth Control of the Council of State Governments and was based on the facts recorded in the three separate studies hereinbefore described. Because of the expressed reluctance of a number of States to undertake an eradication program and in view of stated doubts as to the practicability of such an effort, together with a recognized current need for economy in governmental operations, a program of gypsy moth eradication was not recommended. However, because of the necessity of preventing its spread and protecting presently infested woodlands from repeated and uncontrolled defoliation, the Bureau of Entomology and Plant Quarantine proposed the following seven-point program for achieving these objectives:

1. Establish a barrier zone along the perimeter of the gypsy moth-regulated area in Connecticut, New York, and Vermont extending from Long Island, N. Y., to the Canadian border, as illustrated in figure 4. The proposed zone is continuous except for a break extending through the eastern Adirondack Mountains, where growth, site, and climatic conditions are unfavorable and therefore provide a natural barrier against the establishment and spread of gypsy moth infestation.
2. Operate a cooperative survey and eradication program within the barrier zone as the principal means of preventing further expansion of the infested region.
3. Operate a cooperative survey and control program with States in infested territory immediately east of the barrier zone, to detect and suppress gypsy moth outbreaks that threaten a spread into the barrier-zone area.
4. Conduct cooperative trapping surveys with States and other governmental units in territory west and south of the barrier zone, promptly eradicating any infestations that become established in such areas.
5. Provide Federal technical assistance, to the limit of available funds, to States in the infested region in the development of control techniques and programs designed to prevent economic and esthetic losses from continued defoliation in this general area.
6. Strengthen quarantine operations through close coordination of control and regulatory activities and expansion of inspection and certification services insofar as appropriated funds will permit. Regu-

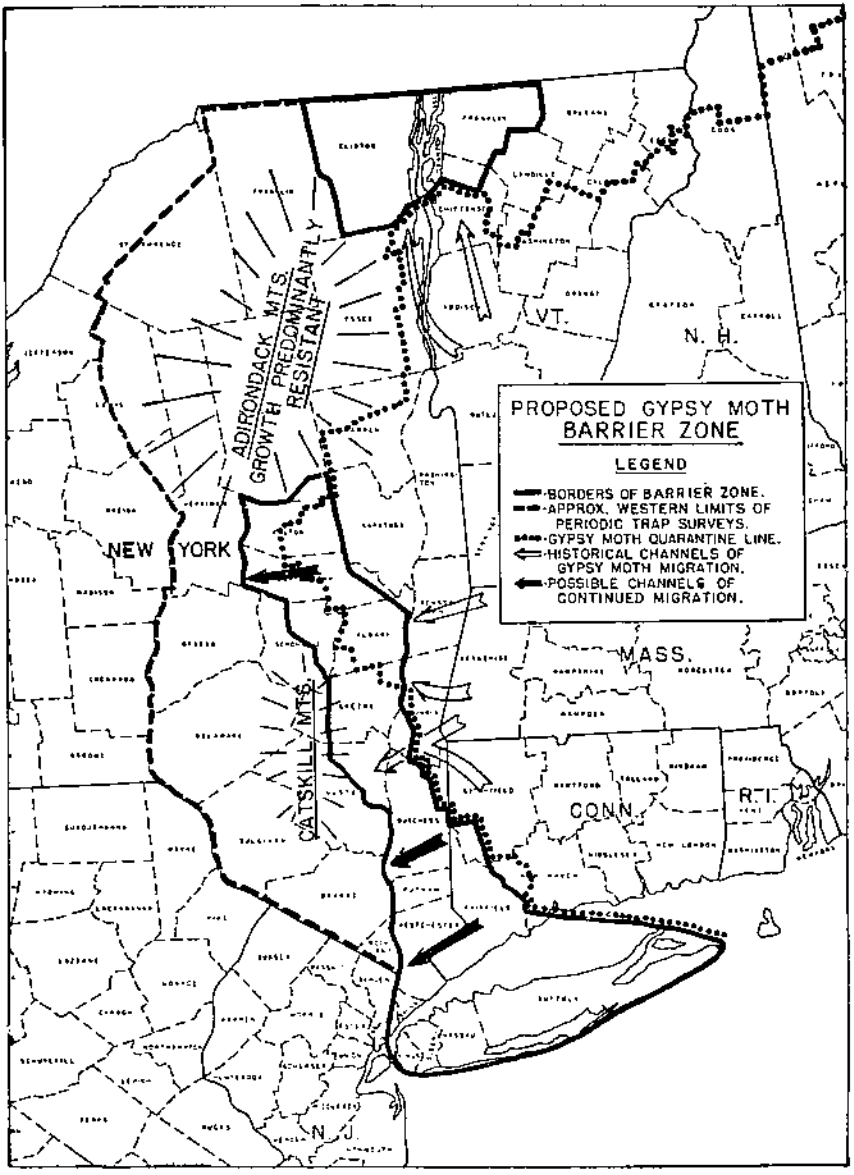

FIGURE 4.—Barrier zones proposed in gypsy moth appraisal survey.

latory functions will include the preparation and distribution of illustrated leaflets and posters as part of an educational program to disseminate information on this public enemy.

7. Establish study plots in the generally infested region to obtain additional information on the epidemiology of the gypsy moth. Annual observations in these areas should provide valuable information on the expectable occurrence of defoliation and would provide

an opportunity to correlate and study factors that may have an influence on cyclic fluctuations of moth abundance. Cooperative assistance in making these studies is to be solicited from the affected States.

The above-mentioned proposals are designed basically to prevent further spread of the gypsy moth to the extensive susceptible forestland to the west and south of the barrier zone. They include not only quarantine enforcement but such control effort as may be needed.

Inasmuch as a number of States are considered in the total program, the Federal Government should assume full responsibility for control and regulatory activities where the objective is to prevent further spread of the gypsy moth. It should also assume responsibility for overall coordination, management, technical direction, and administration as needed and agreed upon. Certain phases of the program do not lend themselves to clear-cut cooperation between the Federal and State Governments. These special phases include the following: (*a*) Surveys to delimit the boundaries of infestation and to discover any outlying incipient outbreaks; (*b*) pupal collection for sex-attractant material for trapping surveys; (*c*) technical assistance to States, counties, towns, and communities within the generally infested area as to plans for suppressive work; and (*d*) eradication of outlying incipient infestations in cooperation with the States concerned.

The remainder of the total effort under this plan appears clearly to be cooperative between the Bureau of Entomology and Plant Quarantine and the States, with the cost being shared on an equitable basis. Congress has repeatedly set forth its views as to the equality of interest and responsibility in the various pest problems in which the State and Federal Governments participate. It has been made quite clear that the Federal Government has a responsibility in protecting uninfested States, and for that purpose it is correct to allot and use Federal financial resources.

Under the date of September 4, 1953, the Regional Coordinating Committee on Gypsy Moth Control of the Council of State Governments by resolution approved the plan as outlined above, and recommended that the States urge Congress to appropriate funds necessary to carry out the cooperative program.

SUMMARY

An appraisal of the gypsy moth problem was undertaken in 1952 by the Plant Pest Control Branch, then a part of the Bureau of Entomology and Plant Quarantine, for the purpose of developing a coordinated and detailed plan for the eradication and/or control of this insect in the United States, in cooperation with State governments.

The appraisal was divided into four principal phases: (*a*) A survey to determine the limits of the generally infested area in New England and New York; (*b*) a study to determine the loss caused by gypsy moth defoliation in killing trees, in retarding growth, and in deteriorating forest stands; (*c*) an ecological study to determine the susceptibility of stands in the vast hardwood forests outside the New England-New York area; and (*d*) the formulation of an operational plan of procedure for either the eradication or selective control of the insect.

The survey conducted within the infested territory of New England and data relating to New York revealed that infestation covers an area of approximately 29½ million acres varying from a very light to a very heavy population.

The study of damage included a careful review of previous research and the current examination of 84 susceptible areas within the generally infested territory. It also included interviews with Federal and State personnel responsible for the control programs, as well as with lumbermen and property owners who had suffered severe losses due to defoliation by the gypsy moth. Estimated tangible losses on forest trees in New England for the 1933–52 period are as follows:

	Cords	*Thousand board-feet*	*Value*
Mortality losses	2, 279, 819	128, 951	$4, 223, 556
Growth losses	1, 469, 500	.....	2, 419, 536
Total	3, 749, 319	128, 951	6, 643, 092

In addition to the estimated monetary losses to forest trees, intangible values were affected, such as by damage to site and to the future production of timber and related forest and recreational values. These losses at least equal and probably exceed those from the more tangible forms of damage.

A special survey of forest areas south and west of the infested region showed that about 100 million acres of oak woodlands are highly susceptible to damage should the gypsy moth become established throughout this territory.

With the records of the three studies at hand, a seven-point plan for the prevention of spread and the reduction of damage within the present infested area was formulated. This plan provides for the establishment of a barrier zone along the periphery of the gypsy moth-regulated area, the operation of cooperative surveys and spray programs within and to the east of the barrier zone, cooperative trapping surveys to the west and south of the barrier zone, limited technical assistance to States within the infested area in the development of control techniques, strengthening of quarantine operation, a stepped-up educational program, and further studies on the epidemiology of the insect.

Following approval of the plan on September 4, 1953, by the Regional Coordinating Committee on Gypsy Moth Control of the Council of State Governments, initial steps were taken, within the limits of currently available funds, to put the plan in operation.

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Motion Pictures Available on the Gypsy Moth

GYPSY MOTH. (Color: released 1953. 28 minutes.)

Since 1869, when a few gypsy moths escaped from a Massachusetts scientist who was attempting to breed them with silkworms, this foreign insect has threatened the forested regions of North America. The story told by this film is how Federal-State activity has limited this foliage-feeding pest to New England and eastern New York and is slowly but surely reducing its area of infestation. TV.

GYPSY MOTH. (Black and white; released 1955. 13½ minutes.)

This is a condensed adaptation of the gypsy moth film in color released in 1953 and was prepared for TV projection on 15-minute programs.

For availability information contact U. S. Department of Agriculture, Agriculture Research Service, Plant Pest Control Branch, P. O. Box 72, Greenfield, Mass.

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