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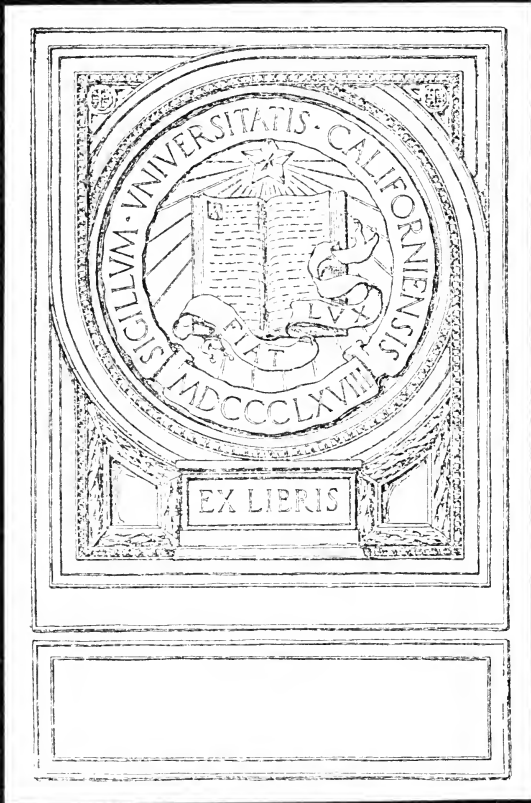
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DISCUSSION OF THE GILBY AND
BROWN-TAIL MONKS AND ITS
VALUE TO BIRDS NOT INCLUDED

By A. A. Sargent

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SUPPRESSION OF THE GIPSY AND
BROWN-TAIL MOTHS AND ITS
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INFESTED

BY

A. F. BURGESS

*In Charge of Gipsy Moth and Brown-Tail Moth Investigations
Bureau of Entomology*

The New England States are carrying the greater part of the burden of gipsy moth and brown-tail moth infestation because from them come mainly the funds for control work and they are suffering from the injury caused by the insects, but the money appropriated by the Federal Government, while assisting these States in some measure, is also providing insurance to the uninfested States, and that at a very low rate.



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By A. F. BURGESS,

In Charge of Gipsy Moth and Brown-tail Moth Investigations, Bureau of Entomology.

MANY years ago a circumstance occurred at Medford, Mass., which was destined to cause enormous expense and trouble in that community and throughout the neighboring States. About 1869, Prof. Leopold Trouvelot, a French naturalist who was a resident of Medford, introduced a few egg clusters of the gipsy moth for the purpose of conducting experiments on silk culture. During the course of the experiments some of the caterpillars escaped. Realizing that the insect was a serious pest in Europe, he made a careful search on the trees and in the woodland nearby for the purpose of destroying any that could be found. He also notified the Department of Agriculture at Washington. None of the insects which had escaped could be found, but as no injury resulted during the next few years, it was thought that the matter was not of great importance.

About 20 years later the neighborhood was invaded by swarms of caterpillars which were supposed by most of the residents to be a native species that had become unusually abundant. A study of the matter developed the fact that the insect which was defoliating the trees was the notorious gipsy moth of Europe and that it had become firmly established in the locality in which it had originally escaped and throughout the immediate surroundings. Its slow increase seemingly was remarkable, but this has been accounted for by the facts that the wood and brush land in the neighborhood was burned over every few years by forest fires, that insectivorous birds and other natural enemies were at that time abundant in the neighborhood, and that the destruction of a few caterpillars when the species was very rare would result in holding down the increase for a number of years.

The city of Medford and the State of Massachusetts soon interested themselves in a campaign to destroy this insect. It had become so abundant in many places during the early nineties that the trees in the residential sections were de-



foliated completely during early summer, and the caterpillars swarmed into houses, making themselves a general nuisance throughout the community. In some sections it was impossible to rent property on account of the abundance of the caterpillars, and real estate values declined rapidly. For 10 years a desperate battle was carried on by the State of Massachusetts to exterminate the insect, and during that period it was found to occur in greater or less numbers throughout 30 towns and cities, principally toward the north and west of Boston. This work reduced the infestations to such an extent that many citizens who, during the first part of the period, had been seriously annoyed by the pest, or had suffered severe loss from it, came to the conclusion that because it was seldom seen the work was unnecessary and no harm would result if measures for its control were discontinued.

In 1897 another foreign pest, namely, the brown-tail moth of Europe, was discovered in Somerville, Mass., and the effort to bring this insect under control added to the State's financial burdens. The caterpillars of this moth are provided with hairs which cause severe itching and urtication when coming in contact with the human skin, producing an eruption which is known by those who have experienced the trouble as the "brown-tail rash." Thus, while the gipsy-moth caterpillars were a nuisance on account of their large size and disagreeable appearance, the presence of caterpillars of the brown-tail moth in large numbers was actually unbearable on account of the poisoning which resulted to the residents.

Enough pressure was brought to bear, however, in the fall of 1899 to cause the discontinuance of State appropriations for the control of these insects. The residents soon found that this policy did not work as anticipated, for both insects increased at an alarming rate, and in the course of three or four years the infestation had become so bad that many citizens were forced to attempt control measures. The work which was done was not carried on in a systematic manner, and while a few exerted every effort to protect their property from the depredations of these insects and to keep their trees free from the caterpillars, many totally neglected to attend to the work, and the result was a general clamor for a systematic and thorough effort to abate the nuisance. During this period many acres of woodland became infested seriously and in the years which followed thousands of acres

were defoliated during the early summer. Matters became so serious in 1905 that work was resumed by the Commonwealth of Massachusetts, but the law was framed in such a way that not only the State but the towns and cities and the owners of property were required to give financial support to the undertaking.

During the period when no work was being carried on by the State of Massachusetts the insects spread to Rhode Island, New Hampshire, and Maine, making the problem far more serious than before. In 1906 funds were appropriated by Congress to prevent the spread of these insects, and since that time Federal work for this purpose has been continued. It is true that both insects have spread over a much larger area since this work began, but that was to be expected, owing to the necessity of properly organizing the work and developing new and better methods for handling the problem on a scale unprecedented for insect control.

The gipsy moth and the brown-tail moth occur in greater or less numbers in all the New England States. The dispersion of the brown-tail moth covers a larger area than that of the gipsy moth, because both sexes of the brown-tail fly freely and, this being the case, it is very difficult to prevent their spread. These white moths are attracted to strong light, particularly electric arc lights, and about the 10th of July of each year they can usually be found in badly infested regions on poles, trees, or buildings near these lights. The extent to which they spread at this time depends largely on the temperature and the direction and velocity of the wind. These moths have been taken on the Nantucket Shoals lightship, which is 42 nautical miles from Nantucket, the nearest land, and as the infestation of that island by this insect is very slight it is probable that the moths came from a much greater distance. Frequent reports have been received from captains of sailing vessels that swarms of these moths have been encountered from 75 to 100 miles out at sea, although there is a possibility that there may have been a mistake in identifying the insect. These facts indicate that the possibility of rapid spread, so far as this insect is concerned, is very great, provided high temperature and favorable winds occur when the moths are flying. Fortunately, the prevailing winds in New England during early July are from a southerly or southwesterly direction, which

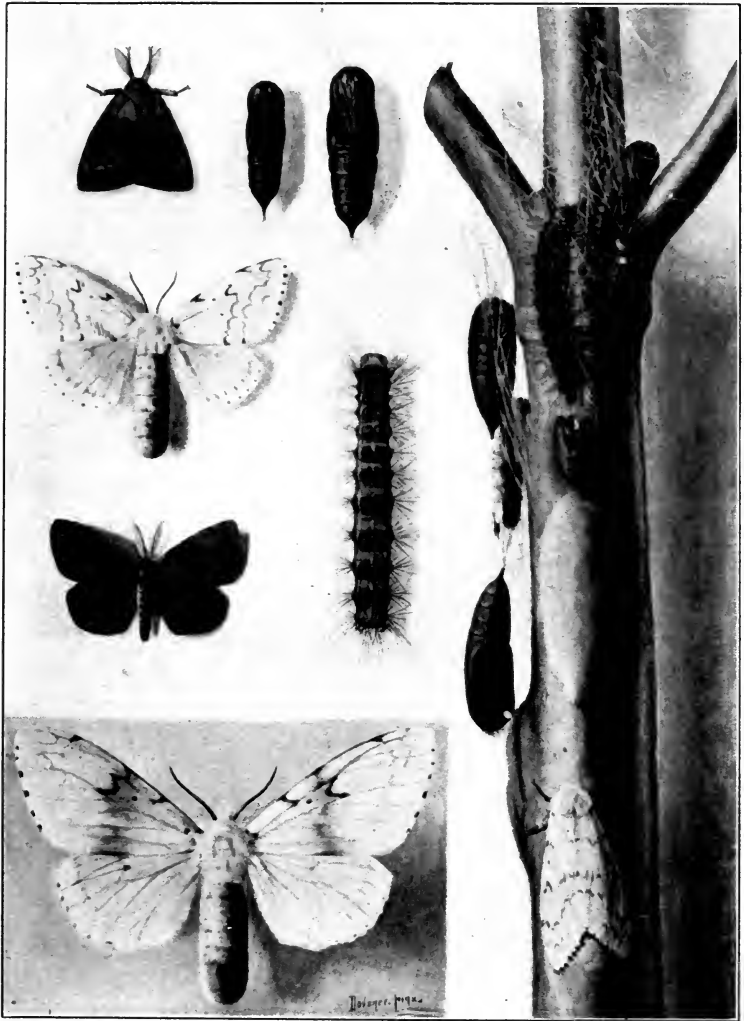
tends to bring about a general spread of the insect toward the seacoast instead of inland.

The female moths deposit egg masses on the underside of the leaves of apple, pear, oak, cherry, rose, and numerous other trees and plants. The caterpillars hatch about the middle of August and feed for about a month. The eggs are usually laid on the leaves on the terminal twigs and the small caterpillars draw a number of these together to form a web, in which they remain during the winter. In the spring, as soon as the buds begin to expand, the caterpillars emerge from the webs and feed on the buds and developing leaves. They become full grown about the middle of June and spin cocoons either singly or in masses, from which the moths emerge during the first part of July.

The large caterpillars, which are provided with many long hairs, are particularly poisonous.

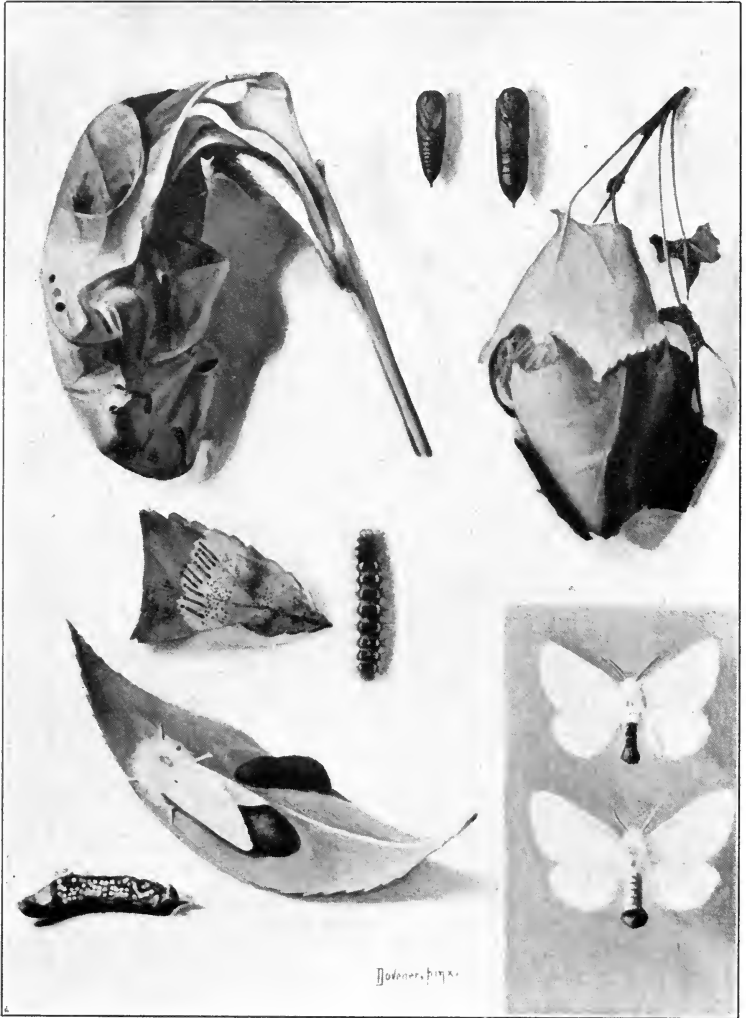
The male and female gipsy moths differ in color, the former being chocolate brown, while the latter is light cream color, having wings marked with black. This insect is in the moth stage during early July, but, fortunately, the female moths are unable to fly on account of the size and weight of their bodies, so that their natural spread is not as rapid as is that of the brown-tail moth. Clusters containing 400 or more eggs are deposited by the females on trees or, in fact, on any material which furnishes a somewhat sheltered location. These clusters are about an inch long, oval in form, and are covered with yellowish hair from the body of the female. As the eggs do not hatch until the following spring, there is ample opportunity for the insect to be spread in the egg stage during the fall and winter if lumber, plant products, or other material upon which they are deposited is shipped to outside points. The caterpillars hatch late in April or early in May, depending on the season, and feed on the leaves which are beginning to expand. They continue to feed and develop until about the first of July, when pupation takes place, the moths emerging a week or more later.

During the first work which was done for the purpose of controlling the gipsy moth, a study was made of the manner in which this insect was spread. It was determined that while the female did not cause spread, since it was impossible for her to fly, egg clusters were frequently transported



THE GIPSY MOTH (PORTHETRIA DISPAR).

Upper left, male moth with wings folded; just below this, female moth with wings spread; just below this, male moth with wings spread; lower left, female moth, enlarged; top center, male pupa at left, female pupa at right; center, larva; on branch, at top, newly formed pupa; on branch, just below this, larva ready to pupate; on branch, left side, pupa; on branch, center, egg cluster; on branch, at bottom, female moth depositing egg cluster. All slightly reduced except figure at lower left. (Howard and Fiske.)



THE BROWN-TAIL MOTH (*EUPROCTIS CHRYSORRHOEA*).

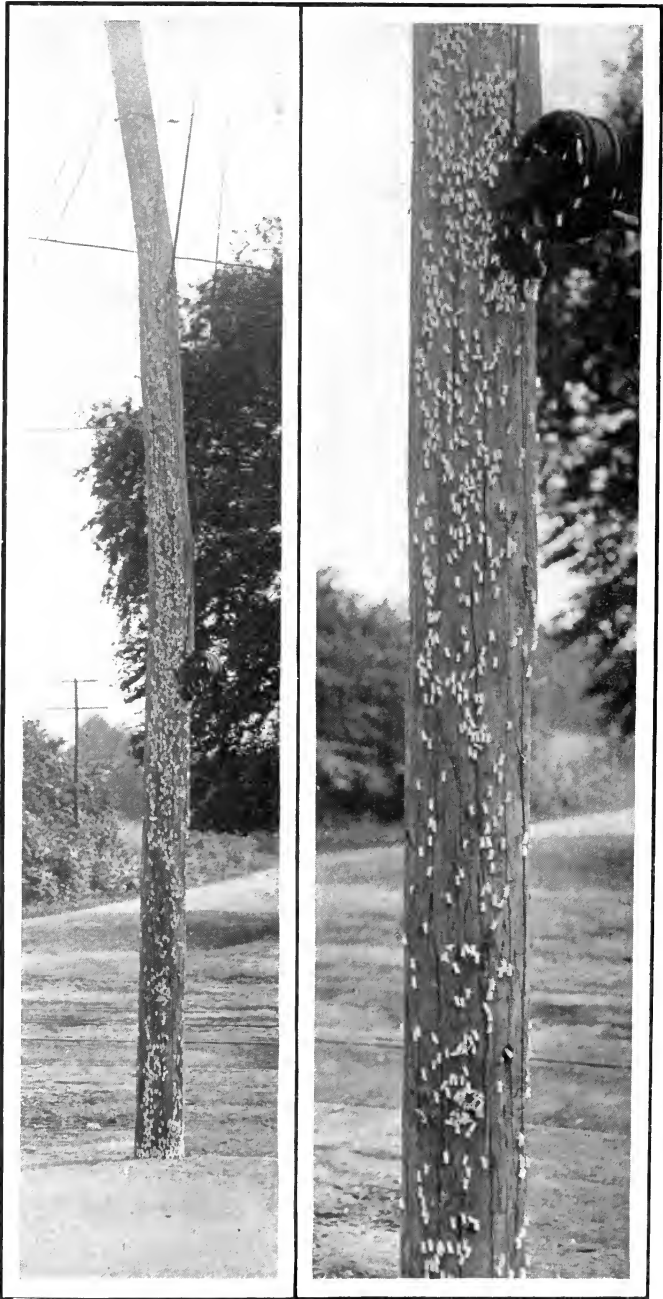
Upper left, hibernating web; just below this, small larvæ feeding at left, larger larva at right; just below this, female moth depositing eggs at left, egg mass at right; lower left, egg mass with eggs exposed; top center, male pupa at left, female pupa at right; upper right, cocoon incased in leaves; lower right, male moth above, female moth below. All slightly reduced. (Howard and Fiske.)



FIG. 1. WOODLAND COMPLETELY DEFOLIATED BY GIPSY-MOTH CATERPILLARS.



FIG. 2. APPLE ORCHARD COMPLETELY DEFOLIATED BY BROWN-TAIL MOTH CATERPILLARS.



BROWN-TAIL MOTHS ON ELECTRIC ARC-LIGHT POLE.



FIG. 1.—MIXED DECIDUOUS AND CONIFEROUS WOODLAND BEFORE THINNING.



FIG. 2.—SAME WOODLAND AFTER FAVORED FOOD PLANTS HAD BEEN REMOVED.



GIPSY-MOTH CATERPILLARS ON TREE TRUNK BENEATH STICKY BAND.



FIG. 1.—MOTER-TRUCK SPRAYER IN OPERATION.



FIG. 2.—PAVING BLOCKS INFESTED WITH GIPSY-MOTH EGG CLUSTERS.

from place to place on shipments of lumber and other material, and that in cases where heavy infestations occurred the caterpillars might be carried a considerable distance on vehicles. It is a common habit of the larvæ, if they are disturbed, to spin silken threads which are attached to the trees and in this way lower themselves to the ground. Since the gipsy-moth campaign first began, an unprecedented development in means of rapid transportation has taken place. At first and for several years motor vehicles were practically unknown, but for the last few years the increase in this mode of transportation has been enormous. It has been found, however, as a result of much work and many experiments, that if the roadways are kept clear from heavy infestation the number of caterpillars distributed by motor vehicles is very small. A number of years ago the results of the scouting work, which consists of examining roadways, orchards, and wooded areas for infestation, indicated that many colonies were present the occurrence of which could not be explained by any known means of spread. Woodland infestations were found in places that were infrequently visited by men or animals. This led to a thorough study and a long series of experiments which proved conclusively that the small caterpillars, immediately after hatching, may be blown long distances by the wind. It has been proved that spread often occurs for a distance of from 12 to 20 miles in this way. These facts would seem to make the prevention of spread of the insect hopeless, if not impossible. But the same factors, namely, temperature and wind direction, which have brought about the greatest drift of infestation by the brown-tail moth toward the seacoast, are equally effective in connection with the spread of small gipsy-moth caterpillars. During the period when these minute larvæ can be blown by the wind it is necessary for the temperature to range from 60° F. upward, the higher temperature increasing the activity of the insect. This comparatively high temperature must be accompanied by strong winds if spread for any great distance is to result, and when the combination of high temperature and strong wind occurs in New England in the month of May the wind usually blows from the south or southwest. Variations in this general rule occur, depending on how far the locality is removed from the sea-

board, and these facts are taken into consideration in carrying on field work against this insect.

The task which has fallen to the Bureau of Entomology in connection with gipsy-moth control has been to use every effort possible to prevent the spread of the insect and to reduce the damage resulting therefrom. It has been necessary to carry through many extensive experiments in order to secure information for use in the field operations, and the experimental work has formed the basis and groundwork for the application of field methods. Prior to 1905 no effort was made to introduce the parasites and natural enemies of the gipsy moth or the brown-tail moth. A popular theory exists that in its native home every insect is held within reasonable bounds by parasites or natural enemies, and that each insect has some one species of parasite or natural enemy which is responsible for its control. When this natural check fails, either on account of attack by its own enemies or for other reasons, the original host will, for a time, become noxious. The problem of utilizing the natural enemies of the gipsy moth and the brown-tail moth appeared somewhat complicated, but the difficulties were not realized until after the work was well under way. It soon became apparent that neither of these pests was controlled by a single species of parasite in its native home. Through the efforts of Dr. L. O. Howard, Chief of the Bureau of Entomology, acting in cooperation with the State of Massachusetts and many foreign entomologists, as well as numerous agents employed by the bureau, a large number, approximately 30 species, of parasites and natural enemies of the gipsy moth and brown-tail moth have been collected and shipped to the Gipsy Moth Laboratory at Melrose Highlands, Mass. Shipments of this sort have been received from most of the countries of Europe and from Japan. The result has been that 7 or 8 species have become established in the infested area and are helping to solve the problem.

It has developed, however, that in Europe, at any rate, the ravages of the gipsy moth are partially controlled by several factors in addition to the work of the parasites. A wilt disease which attacks the caterpillars and causes heavy mortality among them is present not only there but

in this country, and is a powerful agent in curtailing the increase of the species. The character of the food plants is also of great importance. The tree growth of the infested region has been classified according to its adaptability as food for the gipsy moth. It has been found that practically all coniferous growth, if grown in solid stands, fails to support this insect; that ash is not subject to attack, and that maple and hickory are seldom injured to any great extent.

An effort is being made to encourage the growth in woodlands of the tree species just mentioned, and to discourage the growth and planting of oak, willow, and poplar, which are favored foods. Unfortunately the greater part of the infested area abounds in oak growth which, for the most part, is of poor quality and has a very low merchantable value. This fact discourages greatly the elimination of favored food plants in the infested area. Nevertheless some progress has been made in eliminating favored food plants in the heavily infested areas. Thinning work is being carried on by the Bureau of Entomology in the isolated colonies near the borders of infestation also, but in addition it has been necessary to treat the egg clusters found in these areas and to reduce the caterpillars by the application of sticky bands to the trees and by thorough spraying in order promptly to prevent further spread. The importation and colonization of natural enemies has served to reduce the infestation in the many localities in the worst infested sections. These factors are bringing about a gradual reduction in the main supply of the insect which, in case they were not employed, would serve as a stock for further distribution of the pest. Every effort is being made to prevent long-distance spread of both insects by carriage on products shipped to points outside the infested area. The territory infested is under quarantine by the Federal Horticultural Board and all products likely to carry the insect out of the infested area are inspected before they are allowed to be moved. The border territory is thoroughly inspected and the gross infestation in this region is being gradually reduced. It is inevitable that new colonies will be found from time to time outside the region now known to be infested, but substantial progress is being made in preventing any widespread dispersion of the insect.

Each State has its own organization which is attempting to reduce the infestation within its borders, and much effective work has been accomplished as a result. The work of the Bureau of Entomology is so ordered as to avoid duplication and prevent conflict with that carried on by the State authorities, and as these matters have been arranged in advance, little difficulty in this respect has been experienced.

The work which is being carried on in New England to prevent the spread of these insects is of the utmost importance to other States. It has been well said that "an ounce of prevention is worth a pound of cure," and this can be no better demonstrated than in the experience which Massachusetts has had with the gipsy moth. During the time when an attempt was made by the State to exterminate the insects in the nineties, the largest amount of money expended by the State in any one year was \$200,000, and there is good reason to suppose that if this work had been continued the annual expenditure at the present time would have been materially decreased. The year after the work was resumed and thoroughly organized, an expenditure of nearly one-half million dollars was necessary, and the amount expended annually during most of the years since that time has been even greater. This was paid by State appropriation and by contributions required by law from infested towns and cities and from the owners of infested property. While recently the expenditure has been reduced somewhat, over a half million dollars is the yearly expenditure in Massachusetts at the present time, the money being raised by the same method.

The New England States are carrying the greater part of the burden of moth infestation because from them come mainly the funds for control work and they are suffering from the injury caused by the insects, but the money appropriated by the Federal Government, while assisting these States in some measure, is also providing insurance to the uninfested States, and that at a very low rate.

To illustrate the necessary expenditure by towns and cities in the infested area in order properly to control the gipsy moth, a few examples are cited. These are all taken from towns and cities in Massachusetts, where the infestation has been rather heavy during the last few years. The information in regard to population is based on the United

States census of 1910, while that on valuation is the record of the local authorities for the year 1915.

A town having an area of 16 square miles, a population of 559, and an assessed valuation of \$465,513, is badly infested with the gipsy moth. In 1915 the expenditures made by the town, together with those made by property owners, amounted to \$312.84, which was at the rate of 67 cents per \$1,000 valuation, or 52 cents per capita. In addition to this expenditure, State aid to the amount of \$1,322.80 was received.

A town having an area of 19 square miles, a population of 829, a valuation of \$736,945, and about as heavily infested as the preceding, made similar expenditures of \$968.31, which was at the rate of \$1.31 per \$1,000 valuation, or \$1.17 per capita. In addition to this, State aid was received to the amount of \$2,207.90.

In a third town, having an area of 7 square miles, a population of 7,090, and a valuation of \$6,067,430, there was expended \$3,898.83, which amounted to 64 cents per \$1,000 valuation, or 55 cents per capita. In addition to this, \$1,081.32 was received from the State. This town is a manufacturing community, rather thickly settled, with only a small area of woodland, and not as heavily infested as those previously mentioned.

A fourth town, containing 26 square miles, having a population of 6,681 and a valuation of \$9,318,055, expended \$4,447.14 on moth work, which was at the rate of 47 cents per \$1,000 valuation, or 67 cents per capita. In addition to this, \$407.08 was received from the State. This town is residential and has many large estates and some excellent farms, and was generally infested by the gipsy moth.

A city of 32 square miles, having a population of 145,986 and a valuation of \$179,198,586, expended \$17,190.77, which was at the rate of 9 cents per \$1,000 valuation, or 12 cents per capita; \$726.93 was received from the State. This city was not as badly infested by the gipsy moth as the towns which have been mentioned previously, but the brown-tail moth infestation was more severe.

For convenience in making comparisons, a summary of the foregoing information covering four towns and one city is given in the following table:

Expenditures for the control of the gipsy moth and brown-tail moth in certain towns and cities in Massachusetts.

Assessed valuation.	Area in square miles.	Population.	Town and owners' expenditures, 1915.			Additional State aid.
			Amount.	Per \$1,000 valuation.	Per capita.	
\$465,513	16	559	\$312.84	\$0.67	\$0.52	\$1,322.80
736,945	19	829	968.31	1.31	1.17	2,207.90
6,067,430	7	7,090	3,898.83	.64	.55	1,081.32
9,318,055	26	6,681	4,447.14	.47	.67	407.08
179,198,586	32	145,986	17,190.77	.09	.12	726.93

The foregoing figures indicate in a general way the expenditures that are likely to be necessary in towns and cities in uninfested States, in case the gipsy moth becomes established. It shows conclusively the amount of protection which other sections of the country are receiving as a result of the gipsy-moth work which is being done in New England. A large part of the funds expended by towns and cities has been used for the protection of shade and ornamental trees, it having been found impossible to carry on extensive work in woodlands, owing to the extreme cost of these operations.

The beauty and attractiveness of most cities and residential sections depend on the trees. These not only make the region attractive and a desirable place to live, but also add money value to the property. American cities are coming more and more to realize the importance and value of shade trees, and any step that can be taken for their protection or to prevent injury from insects is most desirable.

To prevent the introduction of serious pests into a region where they are unknown is far more important than to expend large sums of money in an attempt to bring about their control after they have been introduced and have successfully established themselves. This is precisely the work which is being attempted in New England on the gipsy-moth problem, and a record of expenditures from a few localities which may be considered as average samples indicates the benefit that other parts of the United States are deriving from this important work.

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