THE INFLUENCE OF MINIMUM TEMPERATURES IN LIMITING THE NORTHERN DISTRIBUTION OF INSECTS[1]

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For the past three winters the mortality of the larvæ of the brown-tail moth (*Euproctis chrysorrhoea*) in their winter nests has been determined by my students at different dates. January 24, 1907, the temperature dropped to —24°F. at Durham, N. H., the lowest tem-

TABLE I.[2]

Locality.	Date counted.	Minimum degrees F.	Per cent. dead.	Number nests.	Average number larvæ per nest.	Remarks.
Durham, N. H..	Jan.-Mar. 1905.........	—17	23	5	271	13 to 39% dead.
Durham, N. H..	Jan.-April 1906	—11	5	53	248	0 to 90% dead.
Durham, N. H..	Dec. 12-Jan. 23, 1907 ..	— 6	6.7	51	374	
Durham, N. H..	After Jan. 24, 1907	—24	100	75	401	Nests from apple, etc.
Durham, N. H..	After Jan. 24, 1907	—24	57	5	922	Nests from tall oaks.
Lewiston, Me...	Mar. 15, 1907...........	—24	72	15	239	
Bath, Me........	Mar. 23, 1907...........	—20	87	15	262	Temperature calculated
Rockland, Me..	Mar. 15, 1907...........	—20	51	15	325	from isotherms of Map 1.
Bar Harbor, Me.	Mar. 15, 1907...........	—19	43	14	282	
Portland, Me...	Mar. 15, 1907...........	—16	98	15	464	
Franklin, N. H..	Feb. 20, 1907..........	—18	54	15	336	
Newton, N. H ..	Feb. 20, 1907...........	—15	27	10	468	
Nashua, N. H ..	Feb. 20, 1907...........	—13	8	15	608	Large nests on elm, oak.
Concord,[3] N. H.	Feb. 20, 1907.....	—12	21	15	342	

[1]A paper read before the section of Economic Zoölogy, of the seventh International Zoölogical Congress, Boston, 1907.

[2]Since the above was written and Map 1 prepared I have received the following data through the kindness of Prof. E. F. Hitchings, State Entomologist of Maine, under whose direction the counts of mortality in the nests were made. (See page 246.)

[3]Nests were also received from Ossipee, N. H., where the temperature must have gone below —20° F. (see Map 1), in which all the larvæ were dead, and no live larvæ were found in nests at Ossipee according to a resident there.

perature recorded there,[1] and absolute minimum temperatures were also recorded at Orono, and other points in Maine. Nests were immediately collected from various localities in New Hampshire and Maine. The mortality record is given in the preceding table.[2]

Locality.	Lowest temperature, degrees F.	Per cent. dead.	Number nests.	Average number larvæ in nest.	Largest number larvæ in nest.
Portland,[3] Me.	—22 (—16)	68	10	389	638
Riggsville, Me	—20	11	10	315	394
Rockland, Me	—28 (*—20)	38	10	399	773
Prospect Harbor	—20	94	10	278	425
Oxford, Me	—20 (*—25)	98	10	282	507
Mechanic Falls	—20 (*—25)	71	10	269	429
Augusta, Me	—42 (—41)	100	10	264	383

These counts show that where average size nests of 300 to 400 larvæ were subjected to —24°F. or lower, that from 72% to 100% were killed, but that in large nests on oak from the same locality only 57% were killed. That the total mortality of the larvæ in the nests from Durham, N. H., after —24°F. on January 24, 1907, was due to the low temperature is demonstrated by there having been but 6.7% dead in 51 nests up to that date, when the mortality at once dropped to 100%. The detailed records of the individual nests show this absolutely.

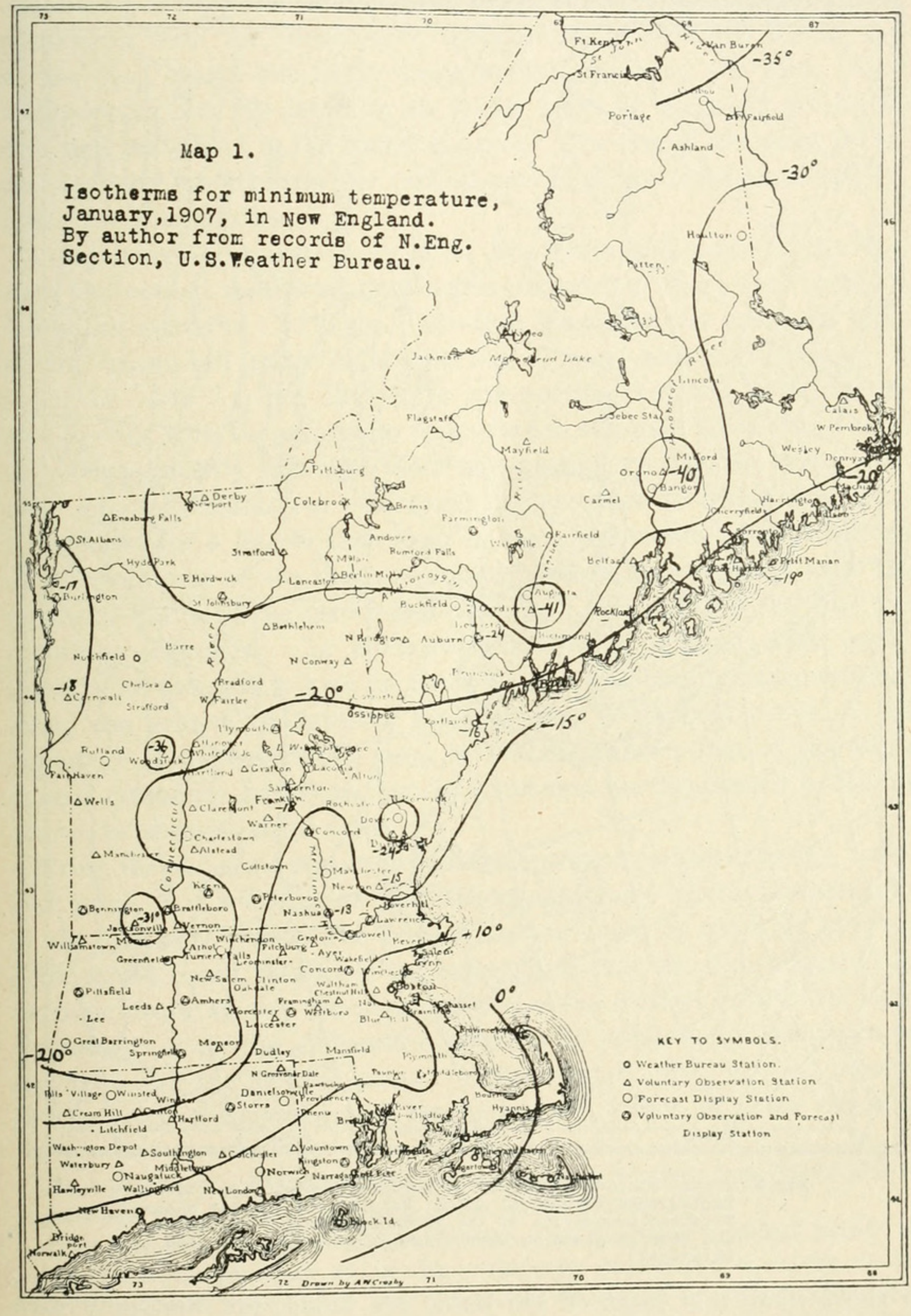
1 —24° F. was the official record of the station thermometer, but several thermometers in the town, whose accuracy need not be doubted, recorded —30° to —35° F.

2 The counts of the nests were made under the immediate supervision of my assistant, Dr. T. J. Headlee, who gave the matter most careful attention and who has prepared the preceding summary, Table I.

3 It is noticeable that the minimum for Portland is 6° below that of the Weather Bureau, as given in Table I, and Augusta is 1° below. There is reason to doubt the accuracy of some of these temperature records made by local and untested thermometers, for Oxford and Mechanic Falls are half-way between Lewiston and North Bridgton, in the same latitude, where weather bureau voluntary observers recorded —24°. Again, it seems remarkable that Rockland should drop to —28° when none of the five other coast points from Portland to Eastport registered below—20°. It would seem probable that Rockland was also about —20° F. I have therefore placed the readings made by weather bureau observers after those of Prof. Hitchings in ( ) and those based on the above remarks in the same way with an *.

The question at once arose whether the northern spread of this pest might not be limited by such minimum temperatures, for over

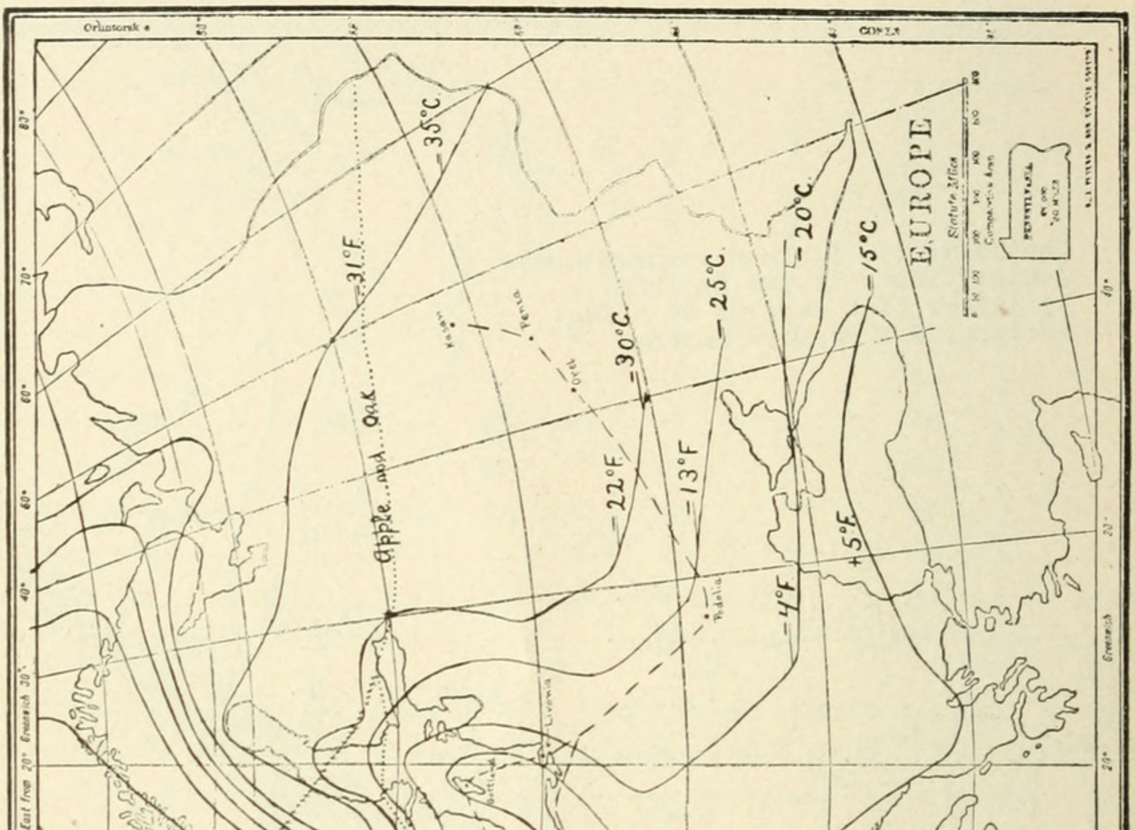
Map 1



most of the area to which the moth spread in Maine during 1906 the temperature dropped to —25° to —30°F.

Grevillius[1] has shown that if nests of the brown-tail moth be placed in a freezing mixture giving a temperature of —30°C. (—22°F.) for

Map 2



Map.2. Annual minimum isotherms of Europe. (Copied from Plate 2, Bartholemew's Physical Atlas, Vol.III, by J.W.Van Bibber.) Northern boundaries of the Brown Tail Moth, Oak, Apple, and Pear as given by Grevillius (l.c. text). Compiled by author.

a short time, that most of the larvæ are killed, but that only with a minimum of —35°C. (—31°F.) were all killed in larger nests of

[1]Grevillius, A. Y., Botanischen Centrallblatt, Band 18, Zw. Abt., Hefte 2 (1905), p. 305-313.

129 to 359 larvæ. The minimum length of time at —35° C. necessary to kill them does not seem to have been determined. It should also be noted that most of the experiments were made with nests containing but few larvæ compared with those of this country, rarely containing over 100, while here the average is over 300 larvæ, and as has been shown the larger nests better withstand the cold. Grevillius notes that the larvæ in the outer parts of the nests are killed first and that those in the center survive. The size of the nest, therefore, greatly complicates the determination of the minimum temperature for this species.

Comparing the northern limit of the brown-tail moth in Europe with the annual minimum temperature occurring there (see map 2), Grevillius remarks (l. c. pg. 314) that Kasan at the northern limit of the brown-tail moth in Russia has a mean annual minimum of —32° or —33°C., and that it is noteworthy that this temperature corresponds with the minimum temperature at which larvæ could exist in his experiments, but that there is a possibility that the larvæ may have adapted themselves to a lower temperature to which they may be exposed for a longer time than in his experiments. The relations of the isotherms of the mean annual minimum temperatures with the northern limits of the brown-tail moth, oak and apple in Europe are certainly suggestive. In northwestern Europe it seems well established that the pest is kept in check by the greater humidity encouraging the growth of fungous disease. The southward curve of the boundary of the brown-tail moth to Podolia follows that of the mean annual minimum isotherms, but its extension northeastward to Kasan cannot be accounted for thus.

From the elaborate researches of Bachmetjew[1] concerning the "critical point,"[2] it would seem that the maintenance of the temperature of the "critical point" for from a few minutes to not over half an hour would result fatally to the insect, and that the time required to produce death at any temperature above the critical point will vary conversely with the difference between it (the body temperature reached) and the critical point. Unfortunately the "critical point" of the body temperature of the brown-tail larvæ in their nests is

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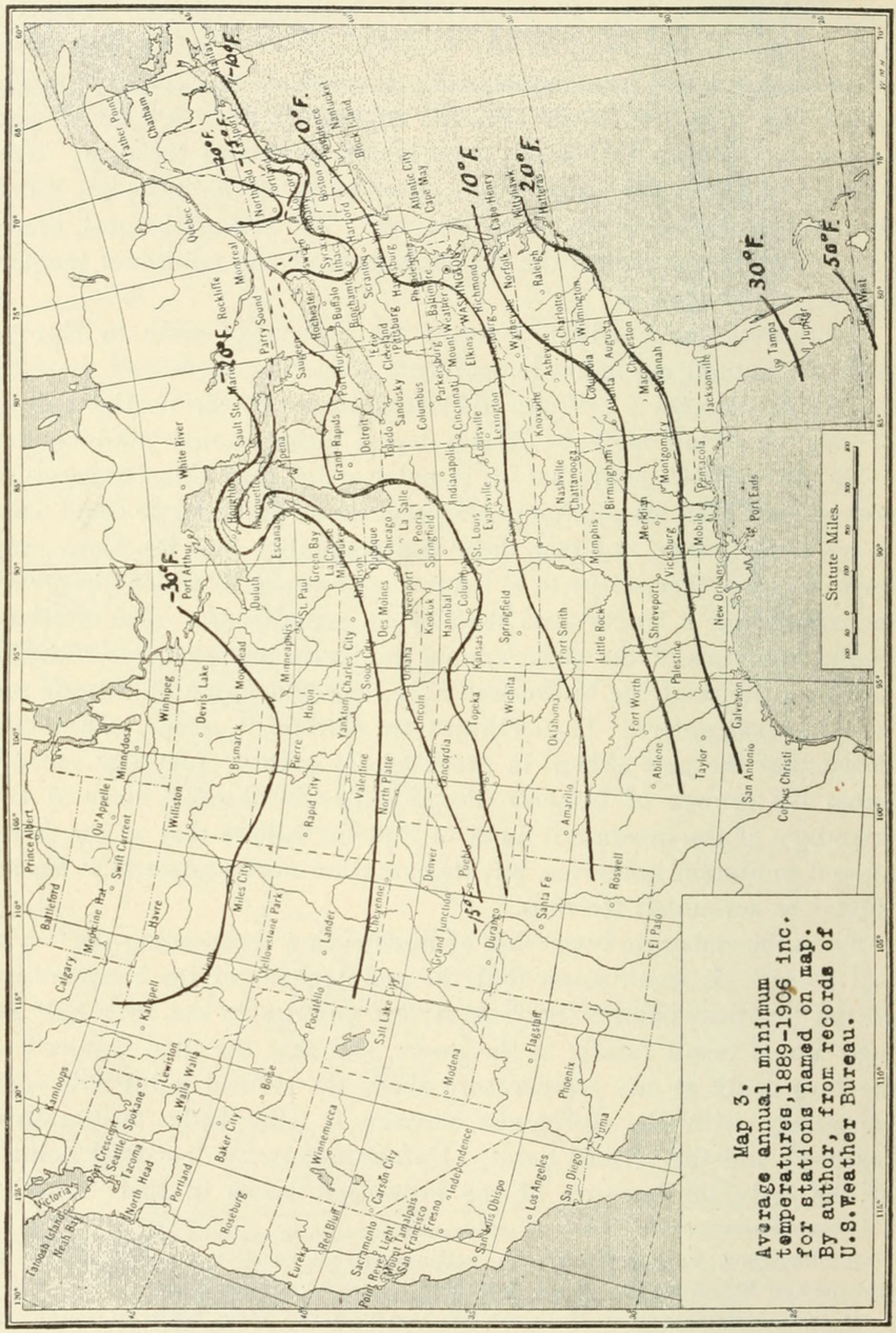
[1]Bachmetjew, P., Experimentalle entomologische Studien vom Physikalisch-chemischen Standpunkt. (Leipzig, 1901) p. 80–90, 132–135.

[2]It is unfortunate that Bachmetjew has used the term "critical point" to define the temperature at which the protoplasm commences to freeze, in an entirely different sense from that previously employed by phenologists who designate the temperature above which positive or effective temperatures must be summed as the "critical temperature," as mentioned on pg. 255 of this paper.

Map 3



Map 3.
Average annual minimum temperatures, 1889-1906 inc. for stations named on map. By author, from records of U.S. Weather Bureau.

not known, but Grevillius' experiments certainly show that it is produced by an outer air temperature of —35°C. (—31°F.) and our records from Durham would show that with nests of similar size an air temperature of —24°F. (—31°C.) is fatal.

It would seem evident, therefore, that the larvæ of the brown-tail moth cannot exist in average size nests where the annual minimum averages —32° to —35°C. or —25° to —31°F.

The effect of minimum temperature on insect life has been frequently recorded, but little study has been given its significance, and only few writers have hazarded the suggestion that the northern distribution of insects might be governed by minimum temperatures.

Dr. L. O. Howard is the first writer, known to me, to definitely formulate this principle in America, though he mentions it as exceptional, and cites only one example. Concerning the American Locust (*Schistocerca americana*)[1] he says, "This species is one of the forms which would seem to indicate that in a few cases, at least, the winter temperature must have some effect in determining distribution. It is exceptional from the fact that it hibernates in the adult condition and we can hardly avoid the conclusion that it is limited in its northern range by circumstances which influence successful hibernation. Nothing is better known than that exceptional freezes may kill off thousands of insects; there must therefore be species whose successful hibernation is limited to certain degrees of cold."

Dr. F. H. Chittenden[2] emphasizes this and states that

". . . . in certain forms of insects the winter temperature must have some effect in determining distribution. While admitting that the past winter was exceptional as regards temperature, the writer feels confident in carrying conclusions still farther in stating that in his opinion, based upon the study of the effect of that winter on injurious northern and southern forms of insects occurring in that portion of the Carolinian or humid life areas of the Austroriparian and Alleghanian zones (a climate like that of the District of Columbia), mean winter temperature has more effect upon determining the rarity or abundance of these species than has the mean summer temperature."

To test this hypothesis, the writer has drawn the average annual-minimum isotherms for the regular stations of the U. S. Weather Bureau (see map 3) together with the maximum annual minimum[3] isotherms (see map 4).

Comparing these with the isotherms of the absolute minima (see map 5), it is seen that the absolute minimum is usually about 10° lower, and the maximum annual-minimum 10° higher than average

[1]"Notes on the Geographical Distribution within the U. S. of Certain Insects Injuring Cultivated Crops," Proceedings Entom. Society, Washington, Vol. 3, p. 225.

[2]Insects and the Weather: Observations During the Season of 1899," Bulletin 22, n. s., Division of Entomology, U. S. Dept. Agr., p. 62.

[3]I. e., the highest annual-minimum recorded.

Map 4

Map 4.
Maximum annual minimum temperatures, 1889-1906 inc. for stations named on map. By author, from records of U.S. Weather Bureau.

annual-minimum, and that the absolute-, average- and maximum-annual-minimum isotherms follow approximately the same paths with the exception of the absolute minimum —20°F. Had the average annual-minimum and maximum annual-minimum isotherms been drawn from records from all the voluntary observers, the dip in southern New York would have extended farther south and many isolated spots in the Alleghanies would stand out with lower temperatures than here indicated.

Upon comparing these isotherms with the boundaries of the life zones (see map 6), charted by Dr. C. Hart Merriam, many similarities become apparent, but also a number of important differences, and upon comparing the distribution of several well known injurious insects with the average annual-minimum isotherms, they were found to define the northern limits in some instances rather better than the life zones of Doctor Merriam.

The basis for the establishment of these zones has been stated by Doctor Merriam as follows:[1]

"Investigations conducted by the Biological Survey have shown that the *northward distribution of terrestrial animals and plants is governed by the sum of the positive* (or 'effective temperatures,' *i. e.*, over 43° F.—E. D. S.) *temperatures for the entire season of growth and reproduction, and that the southward distribution is governed by the mean temperature of a brief period during the hottest part of the year.*"

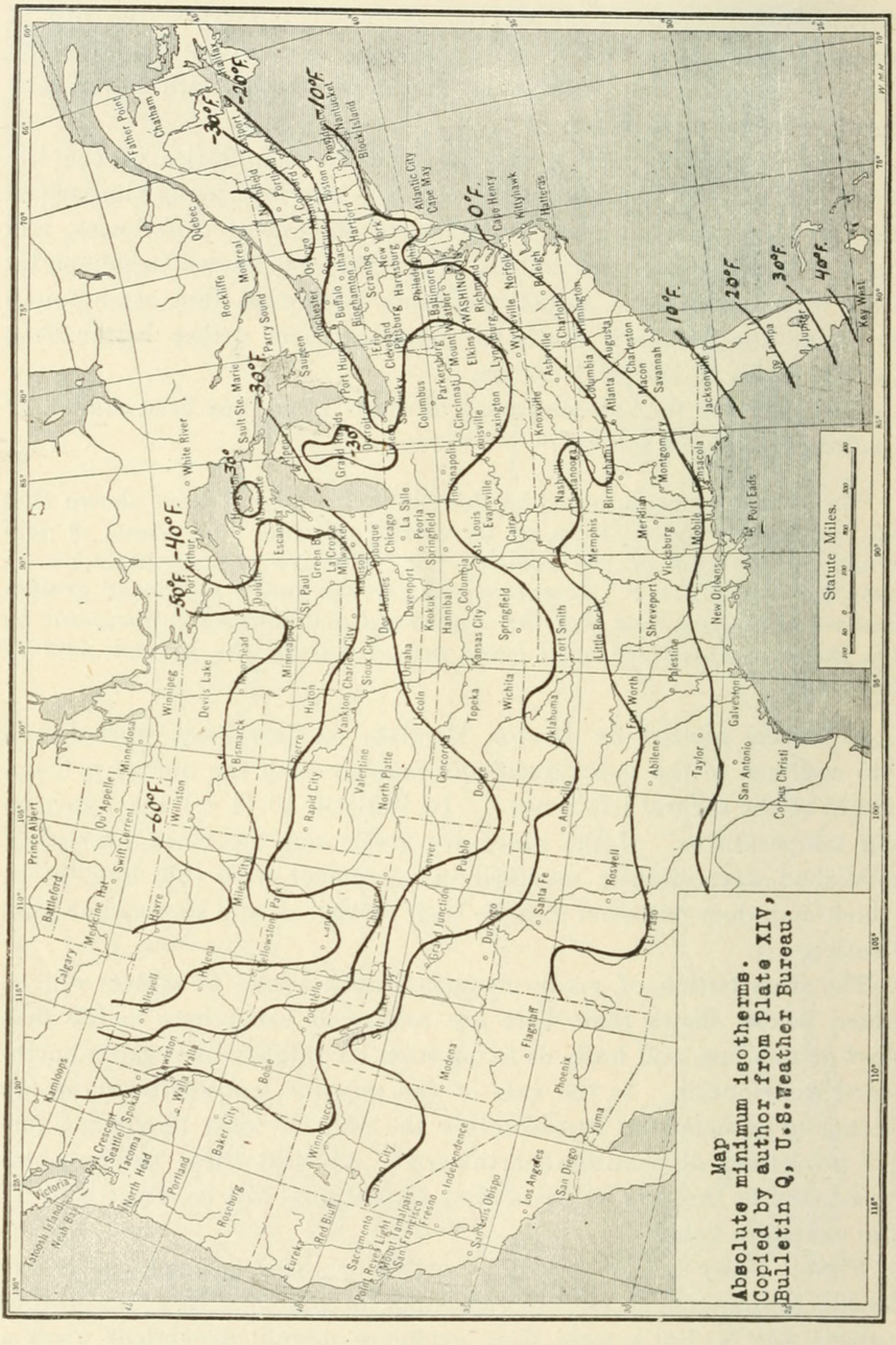
Isotherms plotted by Doctor Merriam on this basis were found "to conform in the most gratifying manner with the northern boundaries of the several life zones." In Bulletin 10 (l. c.) the "governing temperatures" of the zones are given and the maps previously published were slightly modified in agreement with this hypothesis, which map does not seem to have been revised in any subsequent publication.

The distribution of many common insects, some of which will be noted below, shows that there are numerous exceptions to the first part of this law, and leads us to question its validity as regards northward distribution. Is the *sum of the positive temperatures for the season of growth and reproduction* the only or most important factor governing distribution northward? At least three fundamental objections to this law being of first importance will be illustrated by the examples below.

First. Many insects which have two or three generations at 35° to 40° N. Lat. might readily reproduce in southern New Hampshire (about 43° N. Lat.) were their existence merely dependent upon a sufficient summation of temperature over 43°F. (6°C.) which do not

[1]Bulletin 10, Division of Biological Survey, U. S. Dept. Agr. (1898), p. 54.

Map 5



Map
Absolute minimum isotherms.
Copied by author from Plate XIV,
Bulletin Q, U.S. Weather Bureau.

occur north of Long Island, N. Y., southern Connecticut and Rhode Island in appreciable numbers. Other species which might have one generation and exist in abundance if merely so limited occur but sparingly in southern New Hampshire, if at all. That the "sum of effective temperatures" is an important factor is not disputed, but evidence accumulates that the "critical point" (in the sense of phenology) from which the "thermal constant" should be computed varies with groups and species of animals and plants. For example, melons and egg-plants are grown in eastern Massachusetts, but cannot be matured successfully at Durham, N. H. They are planted in Massachusetts about May 20 to 25 and in New Hampshire about June 1, and mature in Massachusetts about September 1. The effective temperature over 43°F. for Boston for the three months is 2343°F. and for Durham, N. H., 2061°F. The effective temperature in May and September is of no value in this connection. That these plants cannot be grown in New Hampshire is due to the fact that there is not sufficient "effective temperature" over 60°F., which is the temperature above which these plants must be grown, or their "critical point." Boston has 801°F. over 60° in summer, while Durham, N. H., has only 525°, or lacks 35% of the requisite effective temperature. Other examples will be given below.

Second. But even if the "effective temperatures" be accumulated above the true "critical points" instead of over 43°F., still there are numerous cases in which there is a sufficient positive temperature for the development of species in southern New Hampshire which are not known to breed there or in eastern Massachusetts commonly. Some other law must therefore determine the limitation of these species to a more southern clime.

Third. It is well known that the main question in the introduction of horticultural varieties northward is one of "hardiness." Many varieties will fruit and mature at latitudes where they cannot grow on account of lack of hardiness. Probably as large a number are disqualified for northern growth on this account as by the shortness of the season.

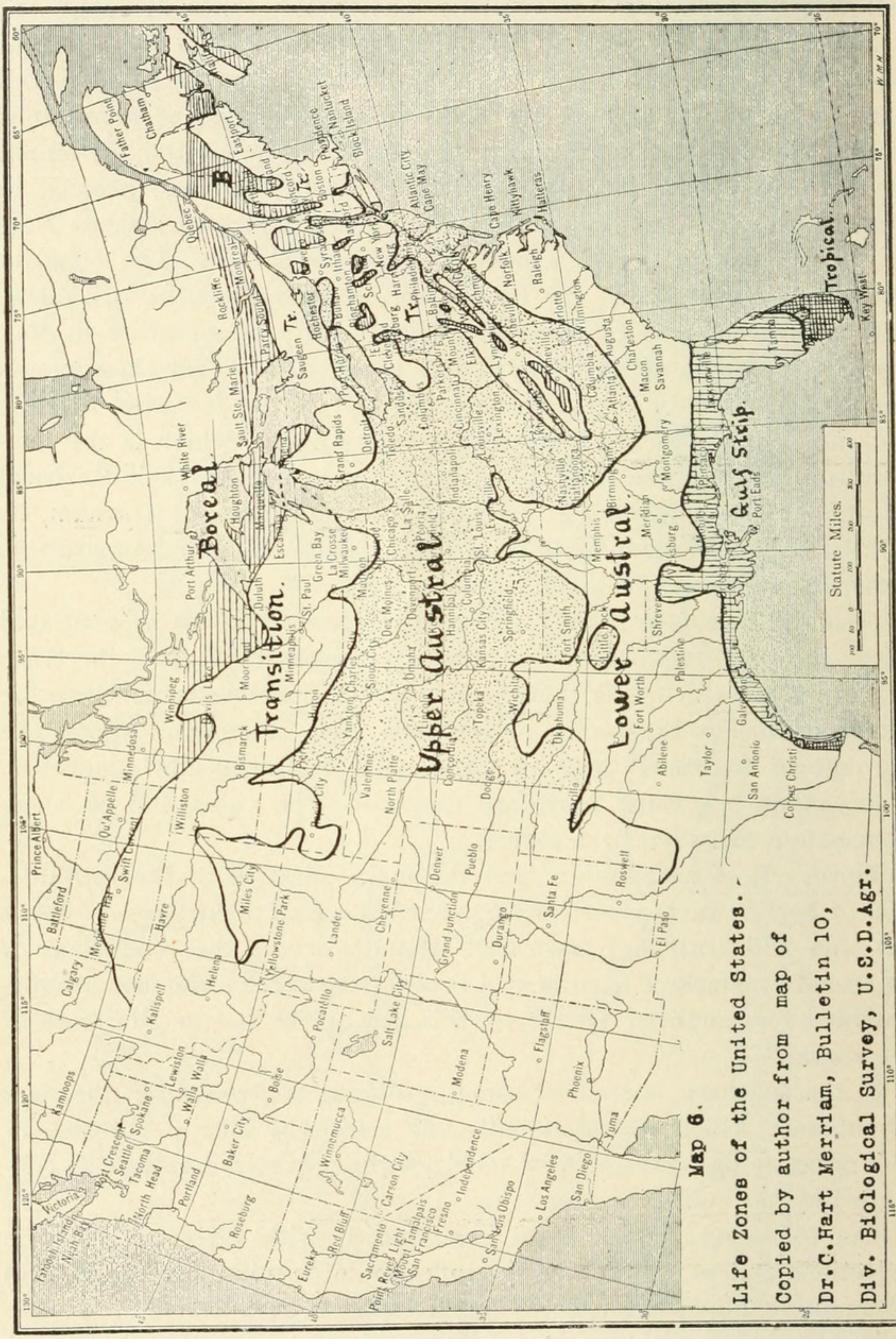
If the southern spread of some species is controlled by the heat of summer, which is undoubtedly the case, why should not the direct opposite be true, and why may not the northward spread be controlled by the cold of winter?

The following species have been studied with reference to these objections and as to whether the influence of minimum temperatures offers any explanation of their northern limits.

The Harlequin Cabbage Bug (*Murgantia histrionica*) has migrated from Mexico around the Atlantic coast to Long Island, N. Y., and up the Mississippi Valley to southern Ohio, where it occurred in five counties bordering the Ohio River in 1895.[1] In 1899 the temper-

[1] Bulletin 68, Ohio Agricultural Experiment Station, p. 36 (1896).

Map 6



Map 6.
Life Zones of the United States.
Copied by author from map of
Dr.C.Hart Merriam, Bulletin 10,
Div. Biological Survey, U.S.D.Agr.

atures at Cincinnati dropped to —17°F. and in these counties to about —20°F. As a result, Prof. F. M. Webster stated that the insect had "certainly sustained a severe repulse by the low temperature of last winter. While observed breeding in Clermont County, southern Ohio, last May, its almost entire absence has been reported in localities where last year it was disastrously abundant."[1] Later Professor Webster stated[2] that it "had spread at one time as far north as Chicago, Ill., and had almost reached the shore of Lake Erie in Ohio. A very severe winter, however, had killed it off in southern Illinois and Ohio, and it has not recovered this lost ground, and might not again in years." It probably still occurs in extreme southern Ohio according to Prof. H. A. Gossard and was noted by Professor Webster in 1901. Doctor Chittenden[3] noted its scarcity in Washington, D. C., in 1899, following a minimum of —15°F., and the writer made the same observation in Delaware. This was the lowest temperature which had been experienced at Washington for over twenty years. As it was accompanied by heavy snow, the harlequin bug was largely protected from the severest cold, otherwise it would doubtless have been exterminated.

The harlequin bug emerges from hibernation at Newark, Del., about May 1, when the temperature is about 55°F. In midsummer, at 74°F., the life cycle there occupies about one month. The life cycle thus consumes 1236°F. over 43°F. At Durham, N. H., there is 2925°F. over 43° from the middle of May to the middle of September, during which time the mean is over 55°F., and according to Merriam's law the species might exist there with two generations. But even if we take 55° as the critical point, there is required but 726° for a life cycle in Delaware and there is available 1119° at Durham, N. H., enough for one brood. But the harlequin bug does not occur north of Long Island, N. Y., and is not spreading there. The northern limit of this species follows the average annual-minimum isotherm of 0°F. (map 2) much more closely than the Upper Austral Zone. It may yet migrate to northern Ohio and Ontario, but further progress seems doubtful.

The Cotton Boll Worm or Corn Ear Worm (*Heliothis obsoleta* Fab.) is injurious throughout the upper and lower Austral zones, but only exceptionally in the transition. It has been injurious at London, Ont., near Boston, Mass., in 1894, and rarely in Michigan. It does not winter in Minnesota and no records of injury occur in Dakota, Montana or Wyoming.[4] Professor Quaintance remarks, "The severe character of the winters of the more northern states coupled with the relatively low sum of effective temperatures, no doubt has

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[1]Bulletin 20, Bureau of Entomology, U. S. Dept. Agr., p. 72 (1899).
[2]Bulletin 60, Bureau of Entomology, U. S. Dept. Agr., p. 130 (1906).
[3]Bulletin 22, n. s., Division of Entomology, U. S. Dept. Agr., p. 55.
[4]Bulletin 50, Bureau of Entomology, U. S. Dept. Agr., p. 26–27.

an important bearing on the comparative immunity of this territory from serious injury." Doctor Chittenden reported the species rare on corn at Washington, D. C., in 1899 following —15°F. in February, where it is usually very abundant.

Eggs of *H. obsoleta* were laid at Newark, Del., about June 12, 1900, and moths from them emerged July 15, at a mean temperature of about 73°F., thus requiring approximately 900° above 43°F. Quaintance (l. c.) found the average effective temperature in Texas to be 1417°F. He also shows (l. c. p. 86) that the sum of the effective temperatures for pupal development are more nearly equal for different temperatures when computed above 58° or 60° than above 43°F. He also shows that at Boston, Mass., there could be two generations with a total effective temperature of 2967°F. over 43°, commencing when the monthly mean has reached 62°F., or May 1. Further, if 58°F. were taken as the critical point, there would have been required in 1900 only 450° at Newark, Del., while there were 801° at Boston and 525° at Durham, N. H. Yet the species breeds only rarely in eastern Massachusetts, according to Dr. H. T. Fernald, and is practically unknown at Durham. The summer temperature evidently does not control the northern limit in this case, though the distribution of the species is practically that of the Austral zones. May not the minimum temperature be the controlling factor?

Prof. F. M. Webster records[1] that the West Indian Peach Scale (*Aulacaspis pentagona* Targ.) withstood —9° during 1897–'98 sufficiently to increase in numbers the next season at Wooster, Ohio, but that in 1899 the temperature fell to —21° one night and to —12° to —18°F. in several successive nights, with the result that all of the scales succumbed.

Mr. C. L. Marlatt[2] calls attention to the influence of the minimum of 1899 (—15°F.) at Washington, D. C., on scale insects, 95 to 100%, of such species as *Diaspis pentagona, D. rosae, Aspidiotus perniciosus,* and others being killed. He points out that such mortality is more likely to occur at Washington where the hibernation of these scales is short and where low temperatures are rarer than further north.[3]

At Nashua and Manchester, N. H., during the past winter something over 60 per cent of the scales were killed by —13°F., but are breeding abundantly now.

The northern limit of the San Jose Scale is shown on map 7. The

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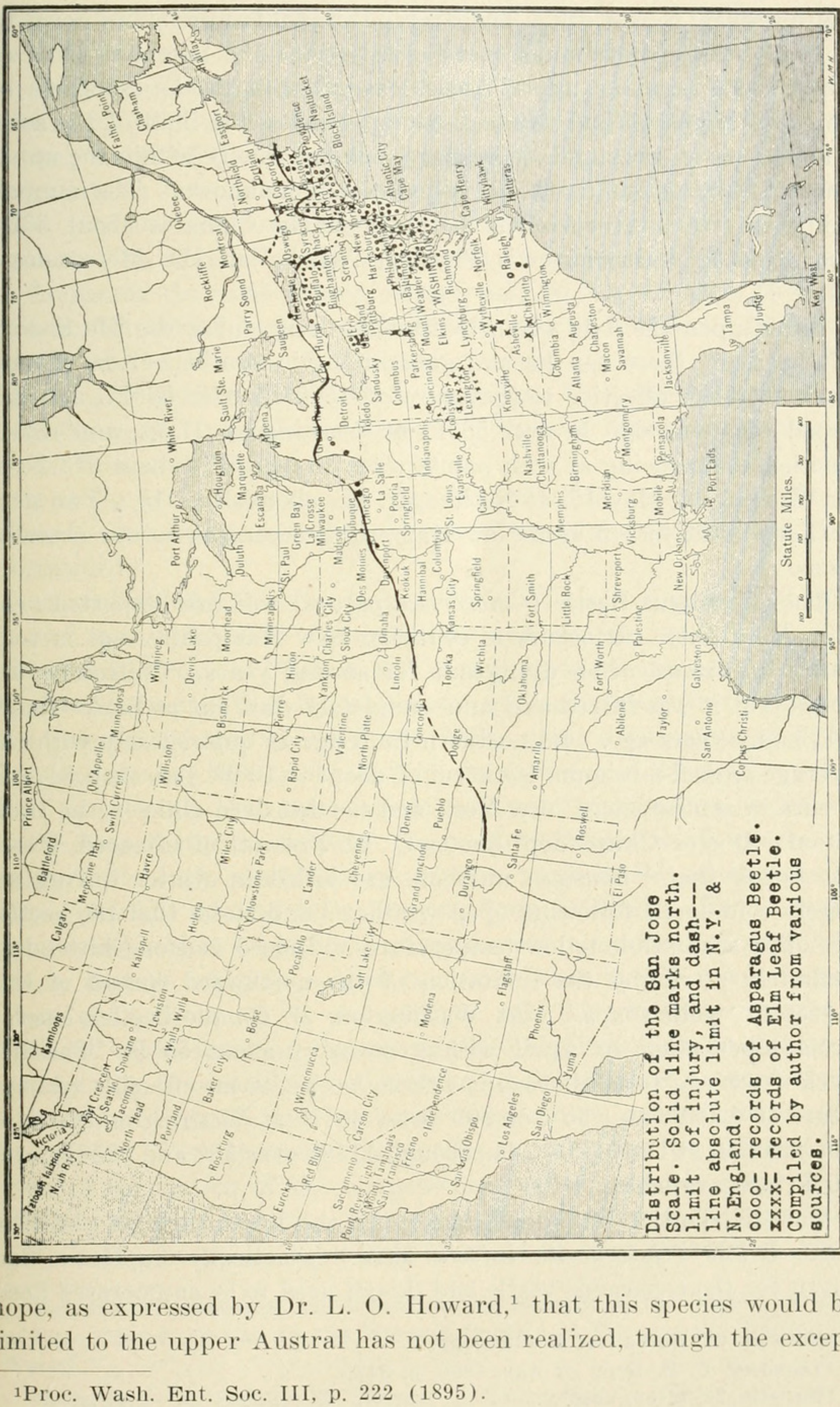
[1]Canadian Entomologist, XXXI, p. 130 (1899).

[2]Bulletin 20, n. s., Division Entomology, U. S. Dept. Agr., p. 76.

[3]See also Voyle, Bulletin 4, old ser., Div. Entomology, U. S. Dept. Agr., p. 70–75, "Low Temperatures vs. Scale Insects."

Map 7



Distribution of the San Jose Scale. Solid line marks north. limit of injury, and dash--- line absolute limit in N.Y. & N.England.
oooo- records of Asparagus Beetle.
xxxx- records of Elm Leaf Beetle.
Compiled by author from various sources.

hope, as expressed by Dr. L. O. Howard,[1] that this species would be limited to the upper Austral has not been realized, though the excep-

[1]Proc. Wash. Ent. Soc. III, p. 222 (1895).

tions occur only in Michigan, Massachusetts, New Hampshire and southwestern New York. The average-annual-minimum isotherm of —15°F. corresponds much more closely with the northern limit of this species than the upper Austral as given, with the exception of northern Michigan and Ontario, but approaches the limit of the scale much better in Iowa and Nebraska, which are wholly within the upper Austral, but where the scale is practically unknown. The annual-minimum temperature of its native home in China is about 5°F., according to Bartholomew's Physical Atlas, Vol. III, Meteorology, Plate II.

Based upon the data given by Marlatt[1] concerning the life history of the scale, there can be two generations in southern New Hampshire, with an effective temperature of 1570°F. over 53°F., a single brood requiring 600°F. over 53°F. at Washington, D. C., and reproduction commencing at both points when the mean is about 63° F.,—at Washington May 15, at Nashua, N. H., about June 15. Two generations occur in southern New Hampshire according to our observations.

The Asparagus Beetle (*Crioceris asparagi*) was first imported near New York City. It occurs in southern New Hampshire, but is very rarely injurious, often dying out for several years. Chittenden records that it was introduced and completely died out at Rock Island, Ill., many years ago. Its northern limit agrees quite closely with the average-annual-minimum isotherm of about —10°F. (see map 3). It occurs in southwestern New York and northeastern Ohio in the transition. Doctor Chittenden[2] quotes C. W. Prescott of Concord, Mass., as stating that "immense numbers are killed in winter during severely cold spells following open weather" and states that the beetles are quite susceptible to low temperatures. Indeed Doctor Chittenden[3] definitely attributes the limitation of the northward spread of this insect to "cold snaps." At Washington, D. C., the beetles emerge from hibernation in April with a mean of about 55°F. The life cycle from egg to adult occupies three weeks, or an effective temperature of 420°F. over 55°, or 300° over 60°F. at Washington, yet it is not common at Durham, N. H., though 1119° over 55° and 525°F. over 60°F. are available.

The distribution and data concerning the life history of the Elm Leaf Beetle (*Galerucella luteola* Müll.) practically duplicate that given for the asparagus beetle and do not need to be enumerated here.

[1]Bulletin 62, Bureau of Entomology.
[2]Yearbook U. S. Dept. of Agr. 1896, p. 347.
[3]Bulletin 22, p. 63, note.

In its northern spread the Cotton Boll Weevil (*Anthonomus grandis* Boh.) had reached the northern boundary of Texas at the end of 1904. In February, 1905, the temperature dropped to 1°F. at Dallas and 14°F. at College Station, Texas. As a result, I am informed by Prof. A. F. Conradi that it seemed to have been killed out entirely north of Dallas and the spread of the previous season was offset, while as far south as College Station so few hibernated successfully that but comparatively little damage was done the following season. The advance of the weevil was also given a decided set-back in Louisiana the same winter, though only in the northern part can this be attributed to low temperature. Again in June, 1906, the agents of the Bureau of Entomology were unable to find weevils which had hibernated successfully in Dallas, Ellis and Navarro counties, Texas, which had been infested for three or four years, following a minimum of 12°F.[1]

It is also interesting to note that from the first, the boll weevil and other southwestern insects have spread much faster eastward than northward.[2]

About 1903 the Morellos Orange Fruit Worm (*Anastrepha ludens* Loew) was introduced from Mexico and became established near Brownsville, Texas. Prof. A. F. Conradi, state entomologist of Texas, advises the writer that it had become quite abundant in this region, but since the freeze of February, 1905, when a minimum of 22°F. occurred, he has been unable to find any evidence of the pest.

It is probable that the absolute minimum temperature is not the controlling factor in limiting the northward spread of insects, for many individuals would always survive in sheltered situations, and these absolute minima occur at very long intervals. But it would seem evident that where the average-annual-minimum temperature is below that at which a species can exist, that it will never become abundant. Inasmuch as the extreme cold of winter is usually in spells of short duration, the average-annual-minimum temperature of any locality is probably a better index of the effect of winter temperature there than the average mean temperature, average daily minimum, etc. Were thermograph records available for the different stations, a summation of the temperatures below a certain point might possibly be more accurate, for it must be remembered that, as Bachmetjew has shown, an insect may be killed by more protracted cold at

[1]For further discussion see a forthcoming bulletin of the Bureau of Entomology, "Some Factors in the Natural Control of the Mexican Cotton Boll Weevil."

[2]Webster, *et al*, Bulletin 60, Bureau of Entomology, p. 130.

a temperature considerably above its "critical point," or absolute minimum.

Snowfall will exercise an important influence in limiting the effect of minimum temperatures. Thus the present season the Rose Chafer (*Macrodactylus subspinosus*), whose larva winters in the soil, has been exceptionally abundant, and the Striped Cucumber Beetle (*Diabrotica vitatta*), which hibernates in the earth, has been as injurious as usual, in spite of the low temperatures of last winter, both having been protected by the deep snow blanket. Species hibernating above ground will therefore be most susceptible to minimum temperatures. Humidity will also materially affect the influence of minimum temperatures.

From the above discussion it seems that the following conclusions may safely be drawn:—First, that the present Upper Austral Zone of Doctor Merriam does not extend far enough to the northeast and extends too far to the northwest. Second, that there is strong evidence against the effective temperature of the growing season being the only or controlling factor in determining the northern limits of life areas. Third, that minimum temperatures often limit northern distribution. Indeed, is it not probable that the laws governing the distribution of life are a complex resulting from many different causes which are of variable importance with each species? Though hypotheses concerning the general principles involved are of the greatest value in forming a basis for further investigation, yet the true life zones can only be ascertained by a patient accumulation of data concerning the actual distribution and spread of life as found, when a comparison with the known physiographical and meteorological conditions will make apparent the laws underlying the distribution of life.

TWO INTERESTING INQUILINES OCCURRING IN THE NESTS OF THE ARGENTINE ANT

Wilmon Newell, *Baton Rouge, La.*

In the February issue of the Journal quite lengthy mention was made of the habits of the Argentine ant, *Iridomyrmex humilis* Mayr, which has become a pest of serious nature in the southern parts of Louisiana and Mississippi.

Although the writer has had this species under constant observation for the past ten months, not a single parasitic or predaceous enemy of it has been discovered. The insects which dwell with this ant, in its colonies, are very scarce and none of the true insects are as yet posi-