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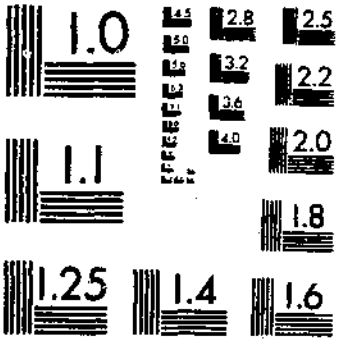
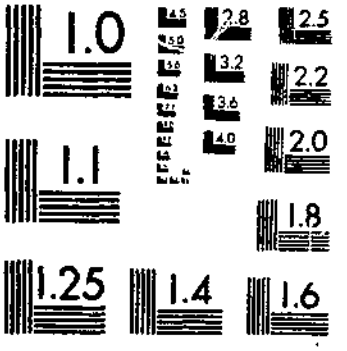


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

PREFACE

Mormon crickets are found only in western North America. They plagued the white man in the West when he grazed his first herds of livestock and cleared small tracts of land to raise his first crops. These insects have continued to affect adversely the economy, development, and agricultural production of the areas they infest.

Mormon crickets are omnivorous feeders. Their damage varies from holes in the leaves to complete destruction of large plants. They eat almost any green vegetation. Although they usually completely destroy succulent gardens and truck crops they invade, these crickets cause the greatest total loss to range plants. One major outbreak in the United States that began in 1931 lasted 17 years. In 1938, at the peak of the infestation nearly 19 million acres in 11 States were known to be infested, with crop losses in these States totaling more than $700,000.

Research on control methods and materials have been abundantly fruitful. For a long period, barriers were relied upon to halt migrating bands of the crickets, but the barriers were expensive to build and maintain and were only partly effective. The development of insecticides made possible the use of baits. They proved so practical, economical, and effective that Mormon cricket control is now mainly directed to destroying small outbreaks before they can expand to economic importance. Another major outbreak of the crickets cannot develop if information now available is consistently put to use to locate and subdue minor outbreaks.

Practical control might be further improved, however, if more could be learned about the causes of generally recognized, but little understood, habits and behavior of Mormon crickets. Definite knowledge of why they exist as harmless solitary individuals for years and then increase in numbers to form vast migratory bands might assist in timing preventive control more exactly and opportunely.

Many publications have been issued dealing with biology, control, and taxonomy of Mormon crickets. This bulletin presents information leading to a general understanding of the Mormon cricket problem, and draws from published and unpublished authentic sources. It names references to sources where more complete information is available. It gives complete information on the distribution of the crickets and evolution of methods for their control; also, the plan of organization for large-scale cooperative control. These facts are presented for the use of control and research workers.

Information on the Mormon cricket in Canada probably is incomplete in some details, but sets forth their distribution and status in the country.

Appreciation to individuals and institutions who furnished or verified information is gratefully acknowledged. The assistance of Miss Lee Southwell in preparing the manuscript is particularly appreciated.

CONTENTS

	Page
Description of species of *Anabrus*	2
Common name	3
Mormon crickets as food	4
Distribution	5
United States	5
Canada	13
Habitat	13
Biology	14
Food plants	17
Nature of injury	18
Amount of damage	20
Outbreaks	25
Duration of infestations	28
Evolution of control methods	30
Natural enemies	41
Development of cooperative control	51
Bibliography	
Literature cited	57
Unpublished reports, insect collections, correspondence, original field notes	70

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MORMON CRICKETS IN NORTH AMERICA

By CLAUDE WAKELAND,[1] entomologist, *Plant Pest Control Division, Agricultural Research Service*

Technically, the common name "Mormon cricket" applies only to the species *Anabrus simplex* Haldeman (*2*).[2] However, two other species of *Anabrus* are also called Mormon crickets—*cerciata* Caudell and *longipes* Caudell. The coulee cricket (*Peranabrus scabricollis* Scudder) is in a distinct but related genus. They all belong to the order Orthoptera, family Tettigoniidae, and subfamily Decticinae. Brief keys for separating the genera and species are given by Gurney (*81*), who has discussed the taxonomic status of these economic species. Members of this subfamily of katydids, or long-horned grasshoppers, are known as shield-backed grasshoppers because of the unusually well-developed pronotum. Locally, however, they often go under the vernacular name "crickets," though they should not be confused with true crickets (Gryllidae). The species named above are incapable of flight, for they have only vestigial wings which extend little beyond the pronotum in males and are mainly concealed by the pronotum in females.

These four species, on numerous occasions, have threatened such destruction to native vegetation and to crops that it was necessary to take control measures against them. They have closely similar life cycles and succumb to the same control means, for which reason they are treated in this bulletin as being in the same general group, "Mormon crickets."

Since the earliest recorded reports in 1848 (*5, 227*), when Mormon crickets damaged the first crops of the pioneers in what is now Salt Lake County, Utah, the insect has periodically caused damage, considerable to crops and severe to range. The numbers of insects in the migrating bands frequently overwhelm individual farmers and communities, who are aroused to protect their crops and prevent unsanitary conditions in their municipalities by any means possible. Control methods have steadily developed until they are now very fast, effective, and economically feasible.

In 1938, at the peak of the last outbreak, nearly 19 million acres were known to be infested in 11 western States: Colorado, Idaho, Montana, Nebraska, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming. Cooperative control was conducted in 65 counties in 1939. During succeeding years, organized control in some areas and unknown factors in others steadily reduced populations until by 1948 (*123**) only approximately 116,000 acres were known to be economically infested in 5 States.

After the subsidence of this last outbreak, interest in and support of organized control became so low in some States that Mormon cricket populations began building up in localized areas.

[1] Retired August 31, 1958.

[2] Italic numbers in parentheses refer to Bibliography, pp. 57 to 77. A number without an asterisk refers to the Literature Cited, pp. 57 to 70; if the number is followed by an asterisk, the reference is to the list of reports, insect collections, correspondence, and original field notes, pp. 70 to 77.

By 1956 (*48**) about 28 counties in 8 States were economically infested.

Control of Mormon crickets, as herein discussed, was not specifically directed toward the control of other species of shield-backed grasshoppers. It was frequently observed, however, that the methods or materials being used where effective against some of the others, especially *Apote notabilis* Scudder.

The habitat of Mormon crickets is from the Coast Range eastward to the north-central part of the Great Plains in the United States and in the southern parts of British Columbia, Alberta, Saskatchewan, and Manitoba in Canada (fig. 1). The earliest record of their occurrence was in 1847 (*5*), but undoubtedly they had repeatedly increased and decreased in abundance and had expanded and retracted in distribution before the written record, as they have continued to do since. Remains of *simplex* from a Nevada hot springs deposit of uncertain age suggest that the species may have existed as long ago as the late Pleistocene period of geological history (*121*).

Mormon crickets were reported from Canada probably as early as 1874 (*204*) and surely in 1897 (*221*). They have occasionally reached threatening numbers there but have generally been of little economic importance.

When infested areas are few and bands of the cricket are small, control may be obtained at little cost. Small areas, left unattended, eventually grow, and separate infested areas coalesce, until another major outbreak develops that is of importance to one or more States or to a region comprised of several States. The heavy cost of controlling a major outbreak can be avoided by constant vigilance to determine where infestations are, followed by timely action to control small bands before they can increase and spread.

DESCRIPTIONS OF SPECIES OF ANABRUS

Howard Stansbury (*186*) in his book on the valley of the Great Salt Lake of Utah, 1852, reported "Many species of insects were procured but unfortunately injured on the return. The few preserved have been ably determined by Professor Haldeman, as will be seen by his report." Haldeman (*82*) reported, "*Anabrus* Hald. This new generic name derived from the Greek *abros*, with the negative prefix *an*, in allusion to the unprepossessing appearance of the insect. *Anabrus simplex* Hald. . . . . Dark shining brown, posterior femora with an external and internal row of small spines beneath upon the posterior extremity; tibiae angular; with a row of spines upon each side above, and two approximate rows beneath the spines alternating. Length fifteen lines, pronotum six, ovipositor twelve, posterior femora and tibiae each eleven, and tarsi three and a half."

Two names, *purpurascens* and *similis*, both of which have long been considered synonyms of *simplex*, were for some years applied to the Mormon cricket. *Anabrus purpurascens* Uhler (*211*) was described in detail from specimens found in "considerable numbers" near the Red River in Minnesota. This name was used

extensively before Caudell's revision of 1907 (*25*), when he placed it in synonymy. *Anabrus similis* Scudder was listed as a species on the basis of specimens occurring on the "banks of the Platte" and described in 1872 (*173*). In 1897 Scudder (*175*) placed *similis* as a synonym of *simplex*.

Several varietal names have been applied to populations of *simplex* that differed in the size or color of individual specimens, usually due to environmental conditions. In 1907 Caudell described the varieties *nigra* and *maculatus*, but both were treated as synonyms of *simplex* by Hebard in 1925 (*87*) and are no longer used. Another name treated as a variety by Caudell is *coloradus*. Originally proposed as *Anabrus coloradus* by Thomas in 1872 (*200*), it was placed as a synonym of *simplex* by Hebard in 1929 (*88*). Frequent references to *coloradus* appeared in literature before 1907.

Several species originally assigned to *Anabrus* are now in the related decticinae genus *Pediodectes*. Among them may be mentioned *stevensonii* Thos. and its synonym *minutus* Thos., both described in 1870 (*199*) from Colorado, and *haldemanii* Girard, described in 1853 from the Red River region either in Texas or Oklahoma.

Anabrus spokan was described from Idaho as a new species by Rehn and Hebard in 1920 (*161*). It is a close relative of *longipes* and may not be entirely distinct (Gurney *81*).

Original descriptions of *cerciata* and *longipes* and a rather detailed redescription of *simplex* were given by Caudell in 1907 (*25*).

COMMON NAME

Bancroft (*5*) wrote, "On July 20, 1847, the Mormon caravan reached the area that is now Salt Lake City and in the vicinity of City Creek, the ground was covered with millions of black crickets which the Indians were harvesting for their winter food." The early pioneers called them simply crickets or big black crickets. In 1876 Thomas (*203*) noted that the insect was called war cricket by the Mormons. Packard called it the western cricket in 1877 (*146*) and again in 1880 (*149*). Bruner called it the western cricket in 1883 (*10*) and the western or buffalo cricket in 1891 (*13*). Riley used western or great plains cricket in 1894 (*164*). Howard in 1895 (*95*) called it the great plains cricket. In 1904 Aldrich (*1*) said it was sometimes called the Idaho cricket, and Gillette (*74*) called it the mountain cricket. That same year Doten (*63*) and Kellogg (*106*) called it the western cricket. In 1905, Englehardt (*66*) called it the Utah cricket, Gillette (*76*) and Johnson (*102*), the western cricket. The name Mormon cricket was then becoming generally accepted, for Johnson (*103*) had changed to it in another publication, and Kellogg (*105*) had adopted it.

Caudell wrote, in 1907 (*25*), "They [*A. simplex*] are known by several common names among which are 'great plains cricket,' 'western cricket,' 'Mormon cricket,' 'Idaho cricket' . . . and 'Idaho devil'."

Names of a people or of a country used as parts of common names of insects seem to cast some stigma rather than explain anything about the insects themselves. Entomologists made repeated efforts to establish an apt common name for *simplex*, but, unfortunately, the common name "Mormon cricket" gradually came into general use. Unfortunate because the insect is not a cricket and because it derives part of its common name simply from the fact that the Mormons encountered it as the greatest hazard to growing the first crops they planted in Utah. This inappropriate common name became so firmly established, that it was finally approved by the American Association of Economic Entomologists in 1927 (*2*).

MORMON CRICKETS AS FOOD

Apparently Mormon crickets made up a large portion of the diet of some Indian tribes before the coming of the white man. Indeed, after organized control was undertaken, Indians who inhabited the infested areas were loath to cooperate for they feared their food supply would be destroyed or poisoned.

Parkman (*153*) said, "The 'Root-Diggers,' a wretched tribe beyond the mountains, turn them to good account by making them into a sort of soup, pronounced by certain unscrupulous trappers to be extremely rich."

When the Mormon caravan approached what is now Salt Lake City on July 20, 1847, Bancroft (*5*) wrote, "the ground was covered with millions of black crickets which the Indians were harvesting for their winter food. An unusual number of natives had assembled for this purpose . . . ."

Glover (*79*), in 1872, said, "These 'crickets' are eaten by the native Indians, generally roasted and pounded into a coarse-grained meal, a sample of which from Camp Harney, Oregon, is on exhibition in the museum of the Department, known as 'pulverized crickets' among which the heads and legs of *Anabrus simplex* are very abundant."

Thomas (*202*) reported in 1875, "This is a species that is eaten by the Indians. Not only do they eat them after roasting, but often without any other preparation than simply pulling off their legs and head."

Doten (*43**) related an experience that he had had in 1890 on the north side of Peavine Mountain, which is located on the California-Nevada line northwest of Reno, Nev. He, a boy of 15, and another boy hunting for caches of pine nuts that the Indians might have made stumbled onto a number of burlap bags filled with dried Mormon crickets. He later saw Indians grind these with dried grass seed in stone grinders and then make a paste which they baked and ate.

In his study of what he designated basin-plateau aboriginals, Steward (*187*) said, "Even insects were of great importance. In some years, grasshoppers and 'Mormon crickets' were extremely abundant and could be taken in quantities that would last for months."

DISTRIBUTION

The known distribution of Mormon crickets is shown on the map (fig. 1). Undoubtedly they have occurred inside the perimeter of the delineated habitat in most of the counties that are blank on the map, especially those surrounded by infested counties, but their presence was not authentically recorded. Records from which this map was prepared are to be found in the following list by years, and by State and County of known occurrence of Mormon crickets. Also given are the sources of information (italicized numbers in parentheses refer to pages 57 to 77).

United States

1846. WYOMING: Albany (*153*)[3]
1847 UTAH: Salt Lake (*5*).
1848 UTAH: Salt Lake (*5*); Weber (*227*).
1849 UTAH: Salt Lake, Weber (*93*).
1850 UTAH: Salt Lake (*93*).
1858 CALIFORNIA: Siskiyou (*229*).
1859 CALIFORNIA: Lassen, Modoc, Shasta (*26*).
1860 UTAH: Davis (*93*). WASHINGTON: Okanogan (*12**).
1864 CALIFORNIA: Lassen (*68*). MINNESOTA: Marshall (*211*).
1865 UTAH: Utah (*149*).
1871 IDAHO: Bannock, Bingham, Bonneville, Cassia, Clark, Franklin, Jefferson, Oneida (*200*). UTAH: Box Elder (*200*); Cache (*201*).
1872 COLORADO: Grand, Park, Summit (*203*).
1873 COLORADO: Park (*203*). OREGON: Wasco (*146*). WASHINGTON: Columbia (*8*); Whitman (*10*). WYOMING: Fremont (*157*).
1874 WYOMING: Big Horn (*127**).
1875 NEVADA: Elko (*147*). NEW MEXICO: Santa Fe (*174*). UTAH: Cache (*197*); Utah (*203*).
1876 UTAH: Utah (*203*). WYOMING: Fremont (*203*).
1877 COLORADO: El Paso (*18**); Park (*91**). NEVADA: Elko, Humboldt (*147*). NORTH DAKOTA: Burleigh (*100**). WASHINGTON: Whitman (*10*).
1878 IDAHO: Ada, Bannock (*148*); Fremont (*149*). NEVADA: Elko, Humboldt (*147*).
1879 COLORADO: Moffat, Routt (*102*). WASHINGTON: Spokane (*12**).
1880 IDAHO: Franklin (*148*).
1882 COLORADO: Moffat, Routt (*102*). NEVADA: Eureka (*172*). WASHINGTON: Kittitas, Klickitat, Spokane, Stevens (*1**).
1883 WASHINGTON: Whitman (*10*). IDAHO: Kootenai (*10*).
1885 KANSAS: Finney (*11*).
1886 NEVADA: Eureka (*172*). WASHINGTON: Douglas (*12**).
1887 WASHINGTON: Douglas (*12**).
1888 WASHINGTON: Douglas (*12**).
1889 CALIFORNIA: Siskiyou (*119*). WASHINGTON: Douglas (*12**).

[3] Parkman (*153*) in 1846 saw insects that almost certainly were Mormon crickets about where the Laramie River flows through the mountains north of the present city of Laramie, Wyo. He said, ". . . the Indians advanced up the side of the stream. Mene-Sella consulted an extraordinary oracle to instruct him where the Buffalo were to be found. When he with the other chiefs sat down on the grass to smoke and converse, the old man picked up one of those enormous black and green crickets which the Dahcotah call by a name that signified, 'They who point to the buffalo'. . ."

1890 CALIFORNIA: Modoc (*56**); Sierra (*43*). NEVADA: Washoe (*43**). WASHINGTON: Douglas, Chelan (*12**).

1891 CALIFORNIA: Siskiyou (*65*). IDAHO: Camas (*12*); Gooding (*100**). MONTANA: Missoula (*100**). NEW MEXICO: Rio Arriba (*100**). UTAH: Tooele (*169*). WASHINGTON: Douglas (*12**).

1892 IDAHO: Camas, Elmore (*14*). WASHINGTON: Chelan (*12**); Grant (*8*).

1893 COLORADO: El Paso (*100**); Moffat (*71*). IDAHO: Blaine (*100**); Camas, Elmore, Lincoln (*164*); Gooding (*160*). WASHINGTON: Chelan (*12**).

1894 IDAHO: Blaine (*135*). WASHINGTON: Chelan (*12**).

1895 COLORADO: Moffat (*76*); Routt (*102*). IDAHO: Franklin (*95*). UTAH: Cache (*95*). WASHINGTON: Chelan (*12**).

1896 WYOMING: Park (*100**).

1897 COLORADO: Routt (*103*). UTAH: Summit (*99*). WASHINGTON: Grant (*12**). WYOMING: Big Horn (*99*).

1898 COLORADO: Clear Creek (*100**); Larimer (*18**); Park, Summit (*176*). UTAH: Summit (*99*). WASHINGTON: Grant (*12**).

1899 COLORADO: Boulder (*100**); Larimer (*18**). WASHINGTON: Grant, Okanogan (*12**). WYOMING: Crook (*100**).

1900 COLORADO: Dolores (*100**); Routt (*102*). IDAHO: Blaine (*100**). NEVADA: Lander (*172*). WASHINGTON: Douglas, Okanogan (*12**); Grant (*8*); King (*103**); Yakima (*1**).

1901 CALIFORNIA: Lassen (*80*). COLORADO: Conejos, El Paso, Park (*24*); Larimer (*100**). IDAHO: Bingham (*1*). NEVADA: Lander (*172*). OREGON: Harney (*96*). WASHINGTON: Chelan, Douglas, Spokane, Whitman (*127**); Grant, Okanogan (*12**).

1902 COLORADO: Moffat (*76*); Routt (100*). NEBRASKA: Cherry (*1**). NEVADA: Elko (*100**); Lander (*172*). OREGON: Harney (*142*). WASHINGTON: Grant, Okanogan (*12**).

1903 COLORADO: El Paso (*88*); Larimer (*100**); Moffat (*76*). IDAHO: Blaine (*1*). NEBRASKA: Sioux (*1**). NEVADA: Elko (*100**); Lander (*172*). UTAH: Uintah (*57**). WASHINGTON: Douglas (*8*); Grant, Okanogan (*12**); Pierce (*1**).

1904 COLORADO: El Paso (*159*); Moffat, Routt (*76*). IDAHO: Blaine (*1*); Washington (*106*). MONTANA: Gallatin (*1**). NEVADA: Elko (*99**); Lander (*172*). UTAH: Beaver, Iron, Washington (*66*); Tooele (*4*). WASHINGTON: Chelan, Grant, Okanogan (*12**); Douglas (*8*). WYOMING: Yellowstone National Park (*159*).

1905 COLORADO: Moffat, Routt (*102*). IDAHO: Fremont, Madison (*61**). WASHINGTON: Chelan, Grant, Okanogan (*12**); Douglas (*181*); Pierce (*91**).

1906 COLORADO: El Paso (*159*); Larimer (*88*). UTAH: Beaver (*158*). WYOMING: Yellowstone National Park (*159*).

1907 COLORADO: Boulder, Huerfano (*88*). NORTH DAKOTA: Burleigh (*92*). WASHINGTON: Whitman (*1**).

1909 IDAHO: Kootenai (*100**). MONTANA: Park (*1**). UTAH: Salt Lake (*100**).

1910 WASHINGTON: Pierce (*1**).

1911 IDAHO: Kootenai (*127**).

1912 NEBRASKA: Thomas (*1**).

1913 NEBRASKA: Sioux (*55**). OREGON: Gilliam (*1**). WASHINGTON: Chelan, Grant (*12**).

1914 COLORADO: Mineral (*88*). IDAHO: Fremont (*11**). OREGON: Klamath (*75**). WASHINGTON: Douglas (*23*); Grant, Okanogan (*12**).

1915 COLORADO: El Paso (*88*). IDAHO: Fremont (*61**); Latah (*1**). MONTANA: Flathead, Lake (*31*); Missoula (*1**); Sanders (*32*). WASHINGTON: Grant (*100**); Okanogan (*12**).

1916 IDAHO: Fremont (*61**); Latah (*100**). MONTANA: Lake (*31*); Mineral (*127**). WASHINGTON: Douglas, Grant (*127**); Okanogan (*12**).

1917 COLORADO: Lincoln (*100**). IDAHO: Fremont (*100**). MONTANA: Broadwater (*1**); Glacier, Lake (*100**); Sanders (*32*). UTAH: Washington (*1**). WASHINGTON: Chelan, Grant (*12**); Douglas (*8*).

1918 COLORADO: Moffat (*41*). IDAHO: Gem, Shoshone (*100**); Valley (*86**). MONTANA: Gallatin, Lake (*33*). WASHINGTON: Douglas (*128*); Grant (*12**); Okanogan (*86**).

1919 COLORADO: Moffat (*41*). MONTANA: Phillips (*1**). WASHINGTON: Grant (*19*); Okanogan (*13**).

1920 COLORADO: Moffat (*41*). IDAHO: Franklin, Idaho, Jefferson, Lemhi, Madison, Valley (*105**). MINNESOTA: Kittson (*97*). MONTANA: Beaverhead, Gallatin (*100**). NORTH DAKOTA: Bottineau (*100**); Ransom (*74**).

1921 COLORADO: Conejos, San Miguel (*1**); Moffat (*41*); Routt (*77*). MONTANA: Teton (*1**); Toole (*98**). NORTH DAKOTA: Nelson, Pierce, Ramsey (*97*). UTAH: Box Elder (*57**); Cache (*16**); Iron, Juab (*1**). WASHINGTON: Pierce (*131*).

1922 COLORADO: Moffat, Rio Blanco (*78*); Routt (*98**). IDAHO: Camas, Caribou, Franklin, Oneida, Washington (*128**). MONTANA: Beaverhead, Flathead (*1**); Fergus, Gallatin, Hill, Judith Basin, Sweet Grass (*73**); Teton, Toole (*34*). NEVADA: Elko (*1**). NORTH DAKOTA: Bottineau (*1**); Cass, Nelson (*92*); Cavalier (*74**); Ramsey (*97*). UTAH: Cache (*16**); Unitah (*98**). WYOMING: Johnson (*7**); Laramie, Lincoln, Yellowstone National Park (*1**).

1923 COLORADO: Moffat (*41*). IDAHO: Camas (*129**); Franklin (*98**). NORTH DAKOTA: Cass (*74**). UTAH: Cache (*98**); Uintah (*66**). WYOMING: Big Horn, Johnson, Lincoln, Natrona, Park, Sheridan, Washakie (*66**); Fremont, Hot Springs (*8**).

1924 COLORADO: Moffat (*41*). IDAHO: Franklin (*85*). MONTANA: Lake, Sanders (*38**). NEVADA: Lander (*172*). UTAH: Cache, Uintah (*67**). WYOMING: Fremont, Hot Springs (*9**).

1925 COLORADO: Moffat (*41*); Rio Blanco (*98**). IDAHO: Franklin (*130**). MONTANA: Lake (*29**); Sanders (*38**). UTAH: Cache, Uintah (*86*). WYOMING: Fremont, Washakie (*98**); Hot Springs (*10**); Yellowstone National Park (*1**).

1926 CALIFORNIA: Modoc (*98**). COLORADO: Moffat, Rio Blanco, Routt (*41*). MONTANA: Lake (*30**); Missoula (*35*); Sanders (*43*). UTAH: Duchesne (*197*); Uintah (*11**). WYOMING: Big Horn (*123*); Lincoln (*1**).

1927 CALIFORNIA: Lassen (*80*). COLORADO: Moffat (*41*); Park (*88*). MONTANA: Flathead (*68**); Lake (*36*); Madison (*73**); Sanders (*31**).

1928 CALIFORNIA: Lassen, Modoc (*100**). COLORADO: Chaffee (*1**); Moffat (*48*); Rio Blanco, Routt (*98**). IDAHO: Blaine, Custer (*1**). MONTANA: Lake (*151*), Sanders (*39*). WASHINGTON: Stevens (*1**).

1929 COLORADO: Gunnison (*1**); Moffat (*32**); Routt (*51*). IDAHO: Bonneville (*100**). MONTANA: Lake, Sanders (*39*).

1930 COLORADO: Moffat (*32**). IDAHO: Bannock (*220*); Bingham (*106**); Idaho (*100**); Latah (*1**). MONTANA: Big Horn, Lake (*39*); Glacier (*100**); Sanders (*98**). UTAH: Davis (*98**); Millard, Tooele (*184*).

1931 CALIFORNIA: Tuolumne (*16**). COLORADO: Moffat (*49*). IDAHO: Bannock (*220*); Bingham, Bonneville (*106**); Gooding (*100**); Valley (*86**). MINNESOTA: Kittson (*90*). MONTANA: Big Horn (*73**); Missoula (*1**). OREGON: Wallowa (*75**). SOUTH DAKOTA: Haakon, Hyde, Jones (*179*). UTAH: Millard, Tooele (*184*). WASHINGTON: Franklin (*85**).

1932 COLORADO: Moffat (*77**). IDAHO: Bannock (*76**); Bear Lake, Bingham, Blaine, Boise, Bonneville, Elmore, Fremont, Jefferson, Madison, Oneida, Power (*106**); Franklin (*57**); Latah (*102**). MONTANA: Big Horn, Chouteau (*189*); Carbon (*98**); Gallatin (*76**). NEVADA: Elko, Eureka (*172*). NORTH DAKOTA: Cass (*100**); Grand Forks, Steele (*98**); Ramsey (*1**). OREGON: Douglas (*75**). SOUTH DAKOTA: Hand, Jones (*178*); Hyde (*179*). UTAH: Millard, Tooele (*184*); Uintah (*93**). WASHINGTON: Franklin, Okanogan (*100**).

1933 IDAHO: Ada, Bear Lake, Blaine, Caribou, Elmore, Franklin, Fremont, Madison (*107**); Bannock, Bingham, Bonneville (*77**). MONTANA: Big Horn, Blaine, Lake, Phillips, Sanders (*190*); Carbon, Chouteau (*83**); Glacier, Pondera (*83**); Yellowstone (*77**). NEVADA: Elko, Eureka, Lander (*172*). NORTH DAKOTA: Burke (*98**); Cass (*1**). OREGON: Baker (*86**). UTAH: Iron (*77**); Millard, Tooele, Uintah (*184*); Rich (*110*). WASHINGTON: Franklin (*86**). WYOMING: Converse, Crook, Sheridan (*23**); Johnson (*98**); Lincoln (*77**).

1934 CALIFORNIA: Tuolumne (*67*). COLORADO: Moffat (*78**). IDAHO: Ada, Teton (*108**); Bannock, Bear Lake, Bingham, Blaine, Boise, Bonneville, Camas, Caribou, Elmore, Franklin, Fremont, Oneida, Power (*78**); Latah (*102**). MONTANA: Beaverhead, Blaine, Phillips, Sanders (*98**); Big Horn, Carbon, Chouteau, Fergus, Glacier, Judith Basin, Lake, Pondera, Yellowstone (*191*); Daniels (*83**); Toole (*38**). NEVADA: Elko, Eureka, Lander (*172*). NEW MEXICO: San Miguel (*91*); Santa Fe (*1**). NORTH DAKOTA: Burke, Cass (*92*); Ransom (*74**). OREGON: Baker (*69**); Gilliam (*86**); Lake (*58**). UTAH: Cache, Sevier (*104**); Iron (*78**); Millard (*79**); Tooele (*57**); Uintah (*184*). WASHINGTON: Chelan (*127**); Franklin (*78**). WYOMING: Albany, Johnson (*78**); Converse, Carbon, Crook, Fremont, Lincoln, Park, Platte, Sheridan, Teton (*24**).

1935 ARIZONA: Coconino (*101**). COLORADO: Archuleta, Eagle, Garfield, Larimer, Mesa, Montrose, Routt (*40**); Moffat (*122*). IDAHO: Ada, Adams, Bannock, Bingham, Bonneville, Butte, Clark, Elmore, Jefferson, Madison, Owyhee, Payette, Power, Teton, Washington (*40**); Bear Lake, Blaine, Boise, Camas, Caribou, Franklin, Fremont, Gem, Idaho, Oneida (*220*); Lincoln, Minidoka (*109**); Valley (*86**). MINNESOTA: Polk (*1**). MONTANA: Big Horn, Carbon, Cascade, Lake, Rosebud, Stillwater, Sweet Grass, Treasure, Yellowstone (*40**); Chouteau, Fergus, Glacier, Judith Basin, Pondera (*191*). NEVADA: Elko (*1**); Eureka (*172*); Humboldt, Lander, Pershing (*40**). NORTH DAKOTA: Mountrail (*92*). OREGON: Baker (*98**); Malheur (*62**); Umatilla (*143*); Wallowa (*6**). UTAH: Box Elder, Cache (*94**); Iron, Juab, Tooele (*40**); Millard, Sanpete (*184*); Uintah (*101**). WASHINGTON: Benton, Chelan, Franklin, Garfield (*3**). WYOMING: Albany, Johnson, Lincoln, Washakie (*26**); Big Horn, Converse, Carbon, Crook, Fremont, Park, Platte, Sheridan (*25**); Hot Springs, Teton (*98**).

1936 ARIZONA: Coconino (*1**). CALIFORNIA: Modoc (*34**). COLORADO: Moffat (*34**). IDAHO: Ada, Adams, Bannock, Bear Lake, Blaine, Boise, Fremont, Gem, Idaho, Lewis, Nez Perce, Oneida, Power (*34**); Bingham, Bonneville, Butte, Camas, Caribou, Cassia, Clark, Elmore, Franklin, Jefferson, Owyhee, Payette, Teton, Washington (*110**); Latah (*1**). MINNESOTA: Polk (*1**), MONTANA: Beaverhead (*100**); Big Horn, Carbon, Cascade, Chouteau, Gallatin, Judith Basin, Park, Pondera, Powder River, Rosebud, Stillwater, Sweet Grass, Treasure, Wheatland, Yellowstone (*192*); Blaine, Glacier, Lake, Madison, Phillips, Sanders, Toole (*34**); Fergus (*78**). NEVADA: Elko, Pershing, White Pine (*171*); Eureka (*6*); Humboldt, Lander (*34**). NORTH DAKOTA: Burleigh, Divide, Emmons, Pembina, Pierce, Stark, Ward

(*98**). OREGON: Baker, Klamath, Wallowa (*34**); Lake (*86**); Malheur (*62**). SOUTH DAKOTA: Brule (*179*). UTAH: Box Elder, Cache, Daggett, Juab, Millard, Rich, Sanpete, Uintah (*34**); Iron, Sevier, Tooele (*95**). WASHINGTON: Asotin, Grant (*127**); Chelan, Franklin, Garfield (*4**). WYOMING: Albany, Johnson, Lincoln, Teton (*34**); Big Horn, Campbell, Converse, Crook, Fremont, Natrona, Niobrara, Park, Platte, Sheridan, Washakie (*27**); Hot Springs (*28**).

1937 COLORADO: Lincoln (*98**); Moffat (*35**). IDAHO: Ada, Bannock, Blaine, Boise, Butte, Clark, Clear Water, Custer, Elmore, Fremont, Gem, Idaho, Jefferson, Owyhee, Payette, Washington (*111**); Adams (*35**); Nez Perce (*1**). MINNESOTA: Polk (*103**). MONTANA: Beaverhead, Custer, Musselshell (*35**); Big Horn, Carbon, Cascade, Chouteau, Golden Valley, Judith Basin, Lake, Lewis and Clark, Meagher, Park, Sanders, Yellowstone (*136*); Blaine, Broadwater, Carter, Fergus, Gallatin, Glacier, Hill, Jefferson, Liberty, Madison, Phillips, Pondera, Powder River, Prairie, Rosebud, Stillwater, Sweet Grass, Teton, Toole, Treasure, Valley, Wheatland (*71**). NEBRASKA: Cheyenne, Hayes (*55**); Grant (*98**). NEVADA: Elko, Eureka, Humboldt, Lander, Pershing, White Pine (*172*); Washoe (*136*). NORTH DAKOTA: Adams (*144*); Burleigh (*98**); Emmons, McKenzie (*20*); Ward (*74**). OREGON: Baker, Klamath, Lake, Wallowa (*35**); Sherman (*132**). SOUTH DAKOTA: Brule, Buffalo, Hand, Jones, Lawrence, Mellette (*127**); Butte (*98**); Lyman, Pennington, Spink, Walworth (*179*); Potter (*112**). UTAH: Box Elder, Sevier (*95**); Cache, Davis, Salt Lake, Weber (*60**); Iron, Juab, Millard, Rich, Sanpete, Tooele, Uintah (*35**). WASHINGTON: Asotin, Chelan, Franklin, Garfield (*35**); Douglas (*127**). WYOMING: Albany (*112**); Big Horn, Campbell, Crook, Fremont, Goshen, Hot Springs, Johnson, Lincoln, Natrona, Niobrara, Park, Sheridan, Washakie, Weston (*35**); Converse, Teton (*43*).

An extension of Mormon crickets eastward was noted in 1937; so an extensive survey was made in 1938 to ascertain whether control might be necessary in areas where it had been no problem before.

1938 COLORADO: Moffat, Rio Blanco (*112**). IDAHO: Ada, Adams, Bannock, Blaine, Boise, Butte, Camas, Clark, Custer, Elmore, Fremont, Gem, Jefferson, Lincoln, Madison, Oneida, Owyhee, Payette, Twin Falls, Washington (*112**); Idaho, Shoshone (*100**); Lemhi (*49**). MINNESOTA: Kittson, Marshall, Polk (*103**). MONTANA: Beaverhead, Blaine, Carbon, Carter, Chouteau, Custer, Fergus, Gallatin, Golden Valley, Hill, Judith Basin, Lake, Lewis and Clark, Madison, Meagher, Musselshell, Park, Phillips, Pondera, Powder River, Rosebud, Sanders, Stillwater, Sweet Grass, Toole, Treasure, Wheatland, Yellowstone (*112**); Big Horn (*73**); Broadwater, Jefferson (*81**); Cascade (*41**). NEBRASKA: Banner, Box Butte, Cheyenne, Lincoln, Morrill, Sioux (*112**); Blaine (*195*); Garden, Scotts Bluff (*55**). NEVADA: Elko (*41**); Eureka, Humboldt, Lander, Pershing, Washoe, White Pine (*112**). NORTH DAKOTA: Adams, Barnes, Bowman, Dickey, Eddy, Hettinger, Ransom, Sargent, Slope, Stuttsman (*112**); Benson, Billings, Bottineau, Burke, Divide, Dunn, Foster, Golden Valley, Grand Forks, Grant, McLean, Mercer, Morton, Mountrail, McHenry, Oliver, Pierce, Ramsey, Renville, Rollette, Sheridan, Sioux, Stark, Steele, Towner, Ward, Wells, Williams (*14**); Burleigh, Cass, Emmons, Griggs, La Moure, Logan, McKenzie (*15**); Cavalier, Pembina, Walsh (*92**); McIntosh (*168*); Nelson (*73**). OREGON: Baker, Gilliam (*100**); Klamath (*89**); Lake, Morrow, Umatilla, Wallowa, Wasco (*112**). SOUTH DAKOTA: Aurora, Beadle, Bennett, Buffalo, Butte, Campbell, Corson, Edmunds, Faulk, Haakon, Hughes, Hyde, Jackson, Jerauld, Jones, McPherson, Meade, Mellette, Pennington, Potter, Spink, Stanley, Sully, Walworth (*112**); Brule, Hand, Lyman (*179*). UTAH: Box Elder, Iron,

Juab, Kane, Sanpete, Tooele, Utah (*112**); Millard (*95**). WASHINGTON: Asotin, Chelan, Franklin, Klickitat, Okanogan, Yakima (*112**). WYOMING: Albany, Converse, Platte (*28**); Big Horn, Campbell, Crook, Fremont, Goshen, Hot Springs, Johnson, Laramie, Natrona, Niobrara, Park, Washakie, Weston (*112**); Sheridan (*104**).

1939 CALIFORNIA: Lassen (*17**); Plumas (*80*). COLORADO: Adams, Arapahoe, Kit Carson, Lincoln, Washington (*113**). IDAHO: Ada, Adams, Bingham, Blaine, Clark, Custer, Elmore, Fremont, Gem, Jefferson, Madison, Owyee, Payette, Twin Falls, Washington (*113**). MINNESOTA: Kittson, Marshall, Pennington, Polk (*103**); Red Lake (*70**). MONTANA: Beaverhead, Big Horn, Blaine, Carbon, Carter, Cascade, Chouteau, Custer, Fergus, Golden Valley, Hill, Judith Basin, Lake, Meagher, Musselshell, Park, Phillips, Powder River, Rosebud, Sanders, Stillwater, Sweet Grass, Treasure, Yellowstone (*113**); Gallatin (*137*). NEBRASKA: Banner, Cheyenne, Morrill, Scotts Bluff (*113**); Lincoln (*98**). NEVADA: Churchill, Elko, Eureka, Humboldt, Lander, Pershing, Washoe, White Pine (*113**). NORTH DAKOTA: Adams, Barnes, Bowman, Burleigh, Cass, Dickey, Emmons, Hettinger, La Moure, Logan, McIntosh, Sargent (*113**). OREGON: Baker, Gilliam, Jefferson, Klamath, Malheur, Morrow, Sherman, Umatilla, Union, Wallowa, Wasco, Wheeler (*113**); Harney (*88**). SOUTH DAKOTA: Beadle, Bennett, Brule, Buffalo, Butte, Campbell, Corson, Custer, Edmunds, Faulk, Hand, Hyde, Jackson, Jerauld, Jones, Lyman, Lawrence, McPherson, Meade, Mellette, Pennington, Potter, Spink, Stanley, Todd, Tripp, Walworth (*113**); Haakon (*96**). UTAH: Iron, Juab, Millard, San Juan, Tooele, Utah (*113**); Sanpete (*182*). WASHINGTON: Ferry, Franklin, Kittitas, Okanogan, Yakima (*113**); Klickitat (*98**). WYOMING: Big Horn, Campbell, Converse, Crook, Fremont, Goshen, Hot Springs, Johnson, Natrona, Park, Platte, Sheridan, Washakie, Weston (*113**).

1940 CALIFORNIA: Mono (*17**). IDAHO: Ada, Adams, Bannock, Bingham, Blaine, Bonneville, Clark, Elmore, Fremont, Gem, Jefferson, Madison, Owyhee, Payette, Teton, Twin Falls, Washington (*114**). MONTANA: Beaverhead, Big Horn, Carbon, Chouteau, Judith Basin, Meagher, Sanders, Yellowstone (*114**). NEBRASKA: Banner, Box Butte, Cheyenne, Deule, Garden, Kimball, Morrill, Scotts Bluff, Sioux (*114**). NEVADA: Churchill, Elko, Eureka, Humboldt, Lander, Pershing, Washoe, White Pine (*114**). NORTH DAKOTA: Nelson (*145*). OREGON: Baker, Gilliam, Jefferson, Malheur, Sherman, Umatilla, Wasco (*114**); Harney (*89**). SOUTH DAKOTA: Bennett, Faulk, Hand, Jones, Lyman, Mellette, Spink, Stanley, Todd (*114**). UTAH: Cache (*104**); Iron, Juab, San Juan, Tooele, Utah (*114**). WASHINGTON: Franklin, Klickitat, Okanogan, Yakima (*114**). WYOMING: Big Horn, Campbell, Crook, Fremont, Goshen, Hot Springs, Johnson, Natrona, Park, Sheridan, Washaki, Weston (*114**).

1941 CALIFORNIA: Lassen (*17**); Plumas (*98**). IDAHO: Ada, Adams, Bannock, Bingham, Blaine, Bonneville, Clark, Elmore, Fremont, Gem, Jefferson, Madison, Owyhee, Payette, Twin Falls, Washington (*115**). MONTANA: Beaverhead, Big Horn, Sanders (*94*); Cascade, Meagher (*138*); Chouteau, Yellowstone (*115**). NEBRASKA: Scotts Bluff (*198*). NEVADA: Elko, Eureka, Humboldt, Lander, Pershing, White Pine (*115**). OREGON: Baker, Gilliam, Jefferson, Malheur, Morrow, Sherman, Umatilla, Wasco (*115**). SOUTH DAKOTA: Aurora, Beadle, Bennett, Brule, Buffalo, Campbell, Faulk, Hand, Hughes, Hyde, Jackson, Jerauld, Jones, Lyman, Mellette, Potter, Spink, Stanley, Todd, Tripp, Walworth (*115**). UTAH: Iron, Juab, Millard, Tooele, Utah (*115**); San Juan (*104**). WASHINGTON: Franklin, Klickitat, Yakima (*115**). WYOMING: Big Horn (*180*); Campbell,

Crook, Fremont, Goshen, Hot Springs, Johnson, Sheridan, Washakie, Weston (*115**).

1942 CALIFORNIA: Lassen (*116**); Plumas (*80*). IDAHO: Bannock, Bingham, Caribou, Clark, Fremont, Jefferson, Madison, Owyhee (*116**). MONTANA: Beaverhead (*140*); Big Horn, Yellowstone (*116**). NEBRASKA: Cherry (*98**). NEVADA: Churchill, Elko, Eureka, Humboldt, Lander, Pershing, Washoe, White Pine (*116**). OREGON: Gilliam, Jefferson, Malheur, Sherman, Wasco (*116**). SOUTH DAKOTA: Bennett, Lyman, Mellette, Walworth (*116**). UTAH: Iron, Juab, Millard, Tooele, Utah (*116**). WASHINGTON: Franklin, Klickitat, Yakima (*116**). WYOMING: Fremont, Hot Springs, Johnson, Natrona, Sheridan, Washakie (*116**).

1943 CALIFORNIA: Lassen (*117**); Plumas (*17**). COLORADO: Moffat, Rio Blanco (*117**). IDAHO: Bannock, Bingham, Clark, Fremont, Jefferson, Madison (*117**). MONTANA: Beaverhead, Big Horn, Yellowstone (*117**). NEVADA: Churchill, Elko, Eureka, Humboldt, Lander, Pershing, Washoe, White Pine (*117**). OREGON: Gilliam, Malheur, Sherman, Wasco (*117**); Morrow (*19**). SOUTH DAKOTA: Lyman (*117**). WASHINGTON: Franklin, Klickitat, Walla Walla, Yakima (*117**). WYOMING: Fremont, Hot Springs, Washakie (*117**).

1944 CALIFORNIA: Lassen, Plumas (*119**). COLORADO: Moffat (*119**). IDAHO: Bingham, Clark, Fremont, Jefferson, Madison (*119**). MONTANA: Beaverhead, Carbon, Yellowstone (*119**); Big Horn (*140*). NEVADA: Elko, Eureka, Humboldt, Lander, Pershing, Washoe (*119**). OREGON: Baker (*20**); Gilliam, Malheur, Morrow, Sherman, Umatilla (*119**); Wasco (*63**). WASHINGTON: Franklin, Grant, Klickitat, Okanogan, Yakima (*119**). WYOMING: Crook, Fremont, Hot Springs, Natrona, Washakie (*119**).

1945 IDAHO: Bingham, Clark, Fremont, Jefferson (*120**). MONTANA: Big Horn, Yellowstone (*120**). NEVADA: Elko, Eureka, Humboldt, Lander, Pershing (*120**). OREGON: Gilliam, Morrow, Sherman, Umatilla (*120**); Wasco (*64**). WASHINGTON: Franklin, Grant, Klickitat, Okanogan, Walla Walla, Yakima (*120**). WYOMING: Big Horn, Crook, Fremont, Hot Springs, Park, Sheridan, Washakie (*120**).

1946 IDAHO: Bear Lake, Bingham, Blaine, Bonneville, Clark, Elmore, Fremont, Gem, Jefferson, Washington (*121**). MONTANA: Big Horn, Carbon, Cascade, Chouteau, Custer, Fergus, Judith Basin, Lake, Rosebud, Sanders, Yellowstone (*141*). NEVADA: Elko, Eureka, Humboldt, Lander, Pershing (*121**). OREGON: Gilliam, Jefferson, Klamath, Morrow, Sherman, Umatilla, Wasco (*121**). WASHINGTON: Franklin, Grant, Klickitat, Okanogan, Walla Walla, Yakima (*121**). WYOMING: Big Horn, Crook, Fremont, Hot Springs, Park, Sheridan, Washakie (*121**).

1947 IDAHO: Blaine, Clark, Elmore, Jefferson, Washington (*122**). NEVADA: Elko, Humboldt, Lander, Pershing (*122**). NORTH DAKOTA: Ward (*74**). OREGON: Baker (*21**); Gilliam, Jefferson, Morrow, Sherman, Umatilla (*122**). WASHINGTON: Benton, Franklin, Grant, Klickitat, Okanogan, Whitman (*122**); Yakima (*1**). WYOMING: Big Horn, Converse, Crook, Goshen, Niobrara, Platte (*122**); Fremont, Hot Springs, Park, Sheridan, Washakie (*52**).

1948 IDAHO: Elmore, Washington (*123**). NEVADA: Elko, Humboldt, Lander, Pershing, Washoe (*123**). OREGON: Baker (*22**); Gilliam, Morrow, Sherman, Umatilla (*123**). WASHINGTON: Franklin, Grant, Okanogan (*123**). WYOMING: Campell, Crook, Johnson, Park, Sheridan, Washakie (*53**); Hot Springs (*5**).

1949 COLORADO: Moffat (*124**). IDAHO: Kootenai (*100**); Washington (*124**). NEBRASKA: Hayes (*55**). OREGON: Baker (*123**); Gilliam, Morrow, Sherman, Umatilla (*124**).

WASHINGTON: Adams, Franklin, Grant (*124**). WYOMING: Campbell (*124**); Hot Springs, Johnson (*53**); Park (*54**).

1950 COLORADO: Moffat (*125**). MONTANA: Big Horn, Cascade (*155*); Chouteau (*125**). NEVADA: Washoe (*125**). OREGON: Gilliam, Morrow, Umatilla (*125**); Wallowa (*100**). UTAH: Daggett (*206*); Garfield (*100**); Tooele, Uintah (*125**). WASHINGTON: Franklin (*125**). WYOMING: Campbell, Crook, Hot Springs, Sheridan (*53**); Park (*54**).

1951 COLORADO: Moffat (*126**). IDAHO: Clark (*126**). MONTANA: Chouteau (*126**). NEVADA: Churchill, Elko, Eureka, Humboldt, Lander, Pershing, Washoe (*126**). OREGON: Gilliam (*59**); Morrow, Umatilla (*126**); Sherman (*97**). UTAH: Daggett, Tooele, Uintah (*126**). WYOMING: Big Horn, Park (*54**); Crook, Sweetwater, Sublett (*126**).

1952 CALIFORNIA: Lassen, Sierra (*17**); Plumas (*124*). COLORADO: Moffat (*44**). IDAHO: Ada, Adams, Blaine, Boise, Bonneville, Boundary, Cassia, Clark, Fremont, Gem, Idaho, Kootenai, Lemhi, Lewis, Oneida, Owyhee, Valley, Washington (*44**); Camas (*84**); Elmore (*126*). MONTANA: Beaverhead, Big Horn, Powell (*44**); Carbon (*44*); Chouteau (*98**). NEVADA: Churchill, Elko, Eureka, Humboldt, Lander, Pershing, Washoe, White Pine (*44**). NEW MEXICO: Rio Arriba (*44**). OREGON: Gilliam, Morrow, Wallowa (*44**). UTAH: Box Elder, Cache, Daggett, Garfield, Grand, Millard, San Juan, Sanpete, Tooele, Uintah (*44**); Iron (*208*). WYOMING: Crook, Lincoln, Park, Sweetwater, Sublett, Teton, Yellowstone National Park (*44**).

1953 CALIFORNIA: Lassen (*64*); Mono (*45**). COLORADO: Archuleta, Delta, Dolores, Eagle, Garfield, Huerfano, Las Animas, Moffat, Montrose, Pueblo (*45**). IDAHO: Ada, Adams, Blaine, Camas, Cassia, Clark, Custer, Elmore, Fremont, Idaho, Lemhi, Oneida, Payette, Valley, Washington (*45**). MONTANA: Big Horn, Judith Basin, Meagher, Powell (*45**); Carbon (*45*). NEVADA: Elko, Eureka, Humboldt, Lander, Pershing, Washoe, White Pine (*45**). NEW MEXICO: Rio Arriba (*61*). OREGON: Baker, Gilliam, Morrow, Wallowa (*45**). UTAH: Box Elder, Beaver, Garfield, Grand, Iron, Juab, Millard, Piute, San Juan, Sanpete, Summit, Tooele, Uintah, Washington (*45**); Wayne (*222*). WYOMING: Big Horn, Crook, Johnson, Lincoln, Park, Sheridan, Teton, Washakie (*45**).

1954 COLORADO: Moffat (*46**). IDAHO: Ada, Blaine, Boise, Camas, Cassia, Clark, Elmore, Fremont, Idaho, Payette, Washington (*46**); Cascade, Custer (*49**). MONTANA: Big Horn, Carbon, Chouteau, Judith Basin, Meagher, Park, Powell, Stillwater, Sweet Grass (*46**). NEVADA: Elko, Eureka, Pershing (*46**). OREGON: Baker, Gilliam, Wallowa (*46**). UTAH: Daggett, Grand, San Juan, Uintah (*46**); Juab, Millard, Piute, Sanpete, Tooele (*207*). WASHINGTON: Klickitat, Okanogan (*46**). WYOMING: Big Horn, Crook, Johnson, Park, Yellowstone National Park (*46**).

1955 COLORADO: Huerfano, Moffat, Mineral, Pueblo, Rio Blanco (*47**); Rio Grande (*134*). IDAHO: Fremont, Lemhi, Valley (*47**). MONTANA: Beaverhead, Big Horn, Missoula, Park, Powell, Sanders (*47**). NEVADA: Churchill, Elko, Eureka, Humboldt, Lander, Pershing, Washoe (*47**). OREGON: Wallowa (*47**). UTAH: Daggett, Juab, Piute, San Juan, Uintah (*47**). WYOMING: Big Horn, Crook, Fremont, Hot Springs, Johnson, Lincoln, Park, Sheridan, Sweetwater, Washakie, Weston (*47**).

1956 COLORADO: Moffat (*48**). IDAHO: Caribou, Fremont (*48**); Lemhi (*49**). MONTANA: Big Horn, Golden Valley, Judith Basin, Meagher, Park, Rosebud, Sweet Grass, Yellowstone (*48**); Silver Bow (*83**). NEVADA: Elko, Humboldt, Lander, Pershing, White Pine (*48**); Eureka (*60*). OREGON: Harney, Wallowa (*48**). SOUTH DAKOTA: Custer (*7*).

UTAH: Daggett, Uintah (*48**). WASHINGTON: Asotin (*48**). WYOMING: Big Horn, Campbell, Converse, Crook, Hot Springs, Johnson, Natrona, Park, Sheridan, Yellowstone National Park (*48**); Fremont (*185*).

Canada

1874 MANITOBA: Locality unrecorded (*204*).
1878 MANITOBA: Locality unrecorded (*221*).
1887 ALBERTA: Assiniboia (*27*). MANITOBA: Souris (*27*). SASKATCHEWAN: Wood Mountain (*27*).
1903 MANITOBA: Brandon (*221*).
1904 MANITOBA: Brandon (*221*).
1906 BRITISH COLUMBIA: East Kootenay (*72*).
1907 SASKATCHEWAN: North Battleford (*221*); Fort Walsh (*221, 50**).
1909 MANITOBA: MacDonald (*160*).
1911 BRITISH COLUMBIA: Yale (*209*).
1919 BRITISH COLUMBIA: Yale (*15*).
1920 ALBERTA: Locality unrecorded (*226*). BRITISH COLUMBIA: Cariboo (*15*).
1921 BRITISH COLUMBIA: Cariboo (*15*).
1922 BRITISH COLUMBIA: Yale (*209*). MANITOBA: Souris (*72**).
1923 BRITISH COLUMBIA: Yale (*21*); [Similkameen].
1925 BRITISH COLUMBIA: Yale (*212, 17*); Kamloops (*51**); East Kootenay (*57*).
1926 BRITISH COLUMBIA: Yale (*213*).
1927 BRITISH COLUMBIA: Yale (*166*).
1928 SASKATCHEWAN: Qu' Appele (*107*).
1932 MANITOBA: Lisgar (*58*).
1933 SASKATCHEWAN: Qu' Appele (*188*).
1935 ALBERTA: Lethbridge (*223*); MacLeod (*224*). SASKATCHEWAN: Rosthern (*108*).
1936 ALBERTA: MacLeod (*225*).
1937 ALBERTA: Bow River (*165*); Lethbridge, MacLeod (*177*). MANITOBA: Souris (*83*).
1938 SASKATCHEWAN: Humboldt, Melville, Rosthern, South Battleford (*210*); North Battleford, Qu' Appele (*109*).
1939 ALBERTA: Lethbridge (*100*); locality unrecorded (*154*). SASKATCHEWAN: Moosejaw (*228*).
1942 MANITOBA: Lisgar (*72**).
1946 MANITOBA: Winnipeg (*72**).
1947 BRITISH COLUMBIA: Yale (*18*).
1950 MANITOBA: Locality unrecorded (*9*).
1951 ALBERTA: Lethbridge (*69*).

HABITAT

Mormon crickets are found only in North America. They occur from the Coast Range eastward to the north-central Great Plains and in southern British Columbia, Alberta, Saskatchewan, and Manitoba in Canada. Although *simplex* is found throughout this general region, its principal habitat, as determined from a study of the distribution, pages 5 to 13, is east of the Coast Range in Washington, Oregon, and California, northern Nevada, southern Idaho, Utah, the western two-thirds of Montana, Wyoming, and western Colorado. (See map, fig. 1.) The outline of habitat area has been prepared only from definite records of specific locations. A few records that appear in earlier publications are not included in the distribution list or in the map,

because they could not be confirmed or were found to be wrong. The habitat probably is somewhat larger than shown, for frequently statements occur such as "east of the Rocky Mountains" or "throughout the southern part of the Province." When populations increase in the principal habitat, increase takes place throughout the general habitat. The species then may, but rarely does, become injurious in areas where it usually is of no importance.

A. cerciata is known to occur only in north-central Oregon and southern Washington (*81*), where it often is intermingled with *simplex*. Control of both species is equally important. *A. longipes* occurs in northern Idaho, western Montana, eastern and north-central Washington, and in British Columbia (*81, 16*). It may also be intermingled with *simplex*, but it may be the chief or sole species in a locality. The coulee cricket occurs in northern Oregon (*218*); in central and northern Washington (*181*); in central and northern Idaho (*49*, 127*); in southern British Columbia (*209*); and in southern Alberta (*226*).

Any of the four species discussed may, for years, exist in a solitary form practically unnoticed because they are then no immediate threat to range plants or crops. Given a period of favorable years, they begin to increase, very slowly at first and progressively more rapidly with successive years until they become gregarious and form bands that begin to migrate. Outbreaks occur when attention is not given to controlling small bands before they reach a size that is unmanageable at reasonable expense.

BIOLOGY

These four species have similar life histories and habits, variations occurring as the result of many factors such as climate, weather, elevation, latitude, and environment. Only a summary sufficient to understand control aims and accomplishments that are discussed later is given here. Detailed accounts will be found in publications cited as follows: *48, 54, 56, 76, 93, 132, 139, 163, 220*.

Mormon crickets usually complete one generation each year. Cowan and Shipman (*42**) determined that in the high elevation of the Big Horn Mountains in Wyoming eggs of *simplex* are capable of surviving for an entire year after being deposited. In that area, at least, the life cycle of *simplex* is 2 years. The typical life cycle is as follows: Eggs are deposited in the summer and hatch the following spring; nymphs are present in the spring and early summer; adults appear in the summer; mating and egg-laying take place in late summer and early fall.

Eggs

Eggs are laid singly in soil, but many eggs may be deposited in one place without the female completely withdrawing her ovipositor from the soil. They are laid just below the surface, in soil of almost every type and under many conditions of soil covering. They may even be found closely pressed into soil-filled rock

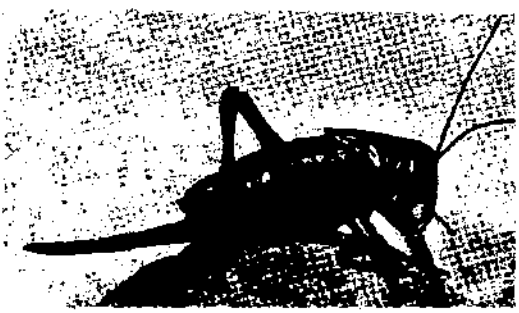
crevices (*108**) or above the soil surface in crowns of bunchgrass in hot, sandy soil (*55*). The average number of eggs laid per female is probably about 150. They are dark brown when first laid but later become dull gray, at which time they resemble kernels of rye. Embryos begin to develop within the eggs before the onslaught of cold weather, but eggs do not hatch until after the ground becomes warm the following spring. The date of hatching varies with changes in seasonal weather conditions and with such factors as slope of exposure and elevation. Normally, hatching starts about April 1. However, in Nevada in 1938 (*112**) eggs began hatching in mid-January, and in Idaho in 1944, not until April 21 (*118**).

Nymphs

When eggs hatch, the nymphs wriggle upward through the soil to the surface. Newly emerged nymphs are only about ¼ inch long. They are light tan at first but soon change to nearly black with white markings on the edge of the pronotum. Except for size and color, they closely resemble their parents. They pass through seven stages of growth, separated by molts. When about a third grown they are various shades of green, tan, or black. After about 60 days they become adults that are reddish brown at first but change gradually to dark olive green and finally to nearly black. Most of the feeding and migrating occurs in the nymphal stage.

Adults

Females are readily distinguished by their ovipositors, which are nearly as long as their bodies (fig. 2). Adult males make



BN—7406

FIGURE 2.—Adult female of *Anabrus simplex*. Natural size.

a chirping or singing sound with their vestigial wings. Most adults die soon after mating and egg-laying has ceased, but some stragglers may remain alive in higher elevations until after the first freezes. Females, after mating, carry conspicuous white sperm sacs about for a time, apparently until the contents are

extracted to fertilize the ova. This phenomenon was reported by John Feilner in 1864 (*26*). It was described for the Mormon cricket by Gillette in 1904 (*75*) and for the coulee cricket by Snodgrass in 1905 (*26*).

Because there are such broad variations in color, size, and habit at different elevations and in different environments, specimens of *simplex* have been described as several species or varieties. Most of them have been discredited until the only economic species currently recognized are those named in the introduction. Between outbreaks, solitary individuals exist in especially favorable habitats. Solitary forms of *simplex* may be more purplish than those that form bands and are much more shy and inactive. They were formerly given the species name *purpurascens*.

Habits

Migration is a pronounced habit of Mormon crickets throughout their active lives. The movements take place on clear or partially cloudy days with air temperature of 65° to 95° F., and soil-surface temperatures of 75° to 125°, when the wind velocity is less than 20 to 25 miles per hour.

The nymphs form small groups in sheltered places, and later these groups merge into moving bands. By the time the crickets have molted four or five times, the migrations have become general and the bands may cover hundreds of acres. Migrations continue until egg-laying starts.

A cricket band performs as a unit. All crickets within the band move in the same direction unless the band is disturbed or split. Even so, they reassemble after a disturbance or after an obstacle has been passed.

It is not known why a band moves in a definite direction. The direction is not known to be governed by wind, sun, or other climatological factors, nor do the bands always move toward better crops or food.

Crickets can travel from ½ to 1 mile a day. On the basis of 50 favorable days from the time migration starts until egg-laying begins, a band may travel from 25 to 50 miles in a single season.

Other Mormon cricket activities—feeding, shelter seeking, clustering on warm bare ground and roosting on brush, grass or weeds during the heat of the day—are governed by temperature.

A marked characteristic of Mormon crickets is that the stronger individuals attack the weaker or injured ones and devour them. Cowan (*48*) aptly describes this propensity, which all who have studied Mormon crickets have repeatedly observed. "Great numbers are crushed when crossing highways where vehicles are passing. The more fortunate fellows immediately gather to the feast, until the passage of a car or wagon through a band can be traced by the two black lines of crickets gathered to eat those that have been injured . . . The insects may keep accumulating in the wheel tracks, to be run over by oncoming cars until their crushed bodies form a slippery mass not unlike soft mud" (figs. 3 and 4).

BN 7328

FIGURE 3. Migrating Mormon crickets gathered to feed upon members of the band that have been injured by passing automobiles. (Photo by Nevada State Department of Agriculture.)

Cowan (*58*) also fittingly described a characteristic reaction when he said, "The Mormon crickets are, as a rule, inclined to be timid. On approaching a 'bunch' of them gathered together on a bare spot surrounded by heavy vegetation, one has to be cautious in order to get very close. As soon as the presence of an intruder is noticed, they all immediately scamper for shelter and soon lose themselves in the vegetation.

"It is interesting to observe the effect of a sudden motion on a migrating band. Those nearest the source jump away from it, thus exciting others nearby, and the motion travels and spreads out in waves resembling those produced by casting a stone into a quiet pool of water. These waves gradually subside as the distance from the source is increased, until they die out entirely."

This reaction was also described by Gillette in 1905 (*76*). Similar reactions are created by sound vibrations, particularly those of shorter wave length.

FOOD PLANTS

Mormon crickets are omnivorous feeders (*112**, *132*). They show definite preference for certain food plants on their range, but in scarcity or absence of these they devour almost any kind of

FIGURE 4.—Road sign erected by the Nevada Highway Commission to warn automobile travelers. Several serious accidents and injuries have resulted from travelers speeding along open highways, driving unsuspectingly onto "cricket-greasy" highways. (Photo by Nevada State Department of Agriculture.)

green vegetation (*48, 220*). Probably the only reason that the list of plants they are known to attack is not longer is that observers were not present in more places at the right times to record their findings.

Mills (*146*) reports a study of food plants during a year when moisture conditions favored the growth of succulent plants; so grasses sustained less injury than they would have in a dry year. Of 203 range plants observed, 55 were fed upon by Mormon crickets. He divided them into two groups—those that showed the greatest injury to leaves and those, the greatest injury to flowers and seeds. In each group, he listed, in order of the amount of damage, the 10 species of plants found to be most readily eaten.

Swain (*194*) observed Mormon crickets feeding on 27 kinds of cultivated crops, besides garden vegetables and truck crops. He listed 401 species of range plants fed upon to a greater or lesser extent. These he divided into four groups, and in each group listed the plants in descending order according to the insect's preference, as follows: Grasses, 74 species; grasslike plants, 10 species; weeds, 262 species; browse plants and trees, 55 species.

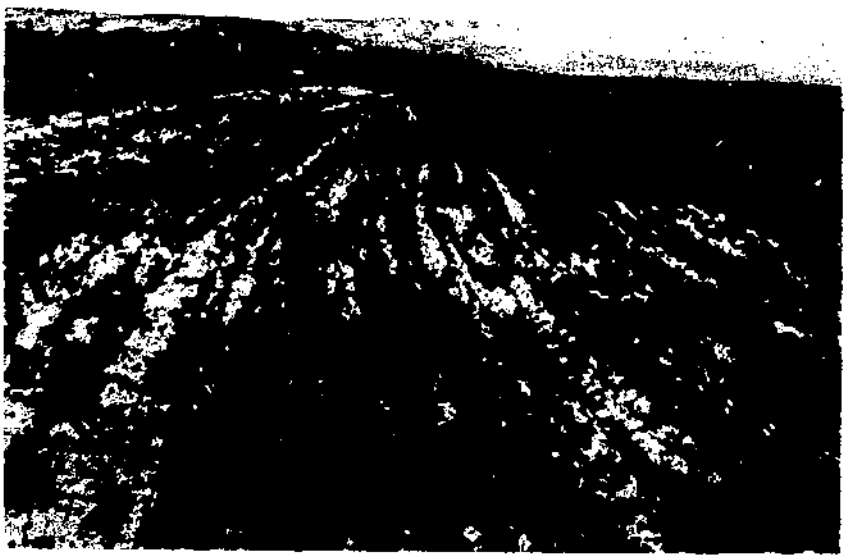
NATURE OF INJURY

The kinds of damage done to plants by Mormon crickets vary from scalloping leaf margins, shredding leaves, or eating holes in

the leaves of grasses and succulent plants, to complete destruction of large plants.

Mormon crickets favor plants with fleshy, succulent leaves, such as balsam root, the mustards, bitterroot, and Russian thistle (*55*). In drought areas they destroy large plants probably as much for their water content as for their food. There are recorded instances where they have concentrated on plants of mullen (*Verbascum* sp.) 4 or 5 feet high with stalks as much as 2 inches in diameter, first defoliating them, then gnawing the tough stalks to the ground and below soil surface as far as they could reach (*109**).

They may injure small plants of grasses or grains to a less or greater degree, or may completely devour them (fig. 5). Or they



BN—7422

FIGURE 5.—Field of young wheat showing marginal damage caused by Mormon crickets migrating into it from rangeland.

may allow grasses and grains to grow to maturity only to destroy their seeds in the field or even in the shock (fig. 6). They attack young grain crops on dry land greedily and eat them to the ground. The crickets begin feeding on the leaves of plants in later stages of growth, then gnaw the stems, weakening them so that the heads hang downward or drop. They are likely to concentrate on single plants of alfalfa and later congregate on terminals to cause general injury throughout the field, especially when alfalfa is being grown for seed (fig. 7).

FIGURE 6.—Mature wheat showing Mormon cricket damage to plants and to grain heads. (Photo by the University of Idaho.)

Small-fruit bushes and browse plants may be killed by Mormon crickets defoliating them and then eating the bark until stems are girdled (fig. 8).

They may injure or destroy garden crops or, by contamination, leave them unfit for human consumption. They have invaded numerous farm yards and small towns, often defoliating everything green. Their dead bodies contaminate water supplies of many ranches and small towns, rendering the water unfit for human use. In several instances towns have erected barrier fences entirely around their boundaries to protect water supplies and to barricade themselves against the obnoxious nuisance (fig. 9).

AMOUNT OF DAMAGE

For an insect so voracious, so large, and so formidable in appearance, either as individuals or in bands, crop losses caused by Mormon crickets in the infested area as a whole have been slight. In localized areas, however, devastation of crops has frequently

BN—7420

FIGURE 7.—Alfalfa plant defoliated by Mormon crickets.

varied from severe to complete, and crop loss ruinous. Whitney (*227*) wrote, "The opening of spring in 1848 in Great Salt Lake City saw nearly seventeen hundred souls dwelling in four hundred log and adobe huts inside the 'Old Fort'. Over five thousand acres of land had been brought under cultivation, nearly nine hundred of which had been sown to winter wheat; the tender blades of which were now beginning to sprout. A few months more and the settlers whose breadstuffs and provisions of all kinds were getting quite low, and would just about last, with due economy, until harvest time, would be rejoicing . . . in the reaping and partaking of their first harvest in the Rocky Mountains.

"But now came a visitation as terrible as it was totally unexpected. It was the cricket plague. In May and June of that year, an army of famine and despair rolled in black legions down the mountainsides and attacked the fields of growing grain. The tender crops fell an easy prey to their fierce voracity. They literally swept everything before them. Starvation with all its terrors seemed staring the poor settlers in the face."

Cannon (*22*) said, "The pioneers had already planted a few seeds and made some attempt at irrigation; . . . . After our grain had been sown [1848] and our fields looked promising, black crickets came down by the millions and destroyed our crops. I have seen fields of wheat look as promising as they could in the morning and by evening they would be as bare as a man's hand devoured by these crickets."

Between 1848 and 1922, many records describe the damage caused by Mormon crickets but do not estimate the monetary losses from such damage. Cowan and McCampbell (*51*) estimated that in 1922 Mormon crickets destroyed crops in western

Colorado worth between $15,000 and $20,000. They assumed that the decrease in the number of occupied farms from 429 in 1922 to 258 in 1927 was caused principally by fear of depredations by the

BN 7419

FIGURE 8.—Mormon crickets feeding upon sagebrush in Nevada, 1938.

Mormon crickets and the prospect of having to work to control them.

Cooley (*36*) reported, "The mormon cricket has been steadily

BN - 7418

FIGURE 9.- Mormon crickets invading the town of Jarbridge, Nev., 1937. (Photo by Nevada State Department of Agriculture.)

becoming more abundant and injurious in western Montana for some years and the situation became alarming in 1926. Some farmers have left the country on account of it and a large acreage in the Camas Prairie region which normally would have been planted to wheat in the fall of 1926 was not planted at all." He calculated that crop damage by Mormon crickets amounted to $120,000 that year in Lake and Sanders Counties.

Strand (*192*) noted that in 1936 damage from Mormon crickets to cultivated crops in Montana was in excess of $340,000.

At the height of organized control operations in 1937–39, State and Federal cooperators estimated total crop losses in all infested States to be $765,823 in 1937 (*50*); 12,935 acres of crops totally destroyed in 1938 (*112**) and 6,445 acres in 1939 (*113**). An estimated 673,749 crop-acres were damaged by Mormon crickets from 1937 through 1949 (*90**). The pioneers had no knowledge of effective control procedures. Researchers had developed partially effective control by 1928. By 1939, operations were better organized and methods still further improved. It should be borne in mind that while crop losses seem trivial for the acreage infested in the later years, they all occurred while extensive, organized control was being carried on. One can only speculate what they

would have been had there not been conducted well planned, organized control that prevented most bands of migrating Mormon crickets from reaching crops.

Whether Mormon crickets will cause serious damage to crops when they invade them cannot be foretold. A band may march through one field without causing appreciable injury to the crop, but may destroy the next crop it comes to. Gardens, when invaded, are usually seriously damaged or completely destroyed, a fact that is very important to families living on isolated farms.

The Mormon cricket problem in Canada is of small economic importance. On one occasion, Ruhmann (*166*) reported that *longipes* had caused more than 50-percent loss to crops in a truck-crop section near Vernon, British Columbia, and that some fields had been completely destroyed.

Mormon crickets are very destructive to range plants, because they devour young annuals and perennials, feed on the flowering parts and seeds of annual and perennial grasses, and defoliate larger browse plants and shrubs. Reduction of feed available for grazing livestock takes place every year in areas where Mormon crickets are present, both from the actual feed consumed and from the destruction of floral parts and seeds necessary for sustaining or renewing a stand. When vast hordes overrun an extensive area, they denude the range of practically all grazing plants. Then the insects concentrate along streams and gulches where the last green plants remain and proceed to defoliate them.

Although all who have studied Mormon crickets acknowledge that they cause the greatest damage to range plants, none has studied the precise amount of damage or the total estimated loss in any year in the infested area as a whole. Cowan and Shipman (*53*) concluded from feeding studies on northern Nevada range that on the basis of Mormon crickets covering a section of land at a density of 10 per square yard they would, from hatching until 20 days after becoming adult, consume 120 tons of forage (dry weight), the quantity estimated to be required for adequate pasturage of 44 head of cattle for 9 months. They concluded also that only 0.3 adult cricket per square yard over a section of range would eat as much as 10 head of mature cattle and that 25 adults per square yard would ruin 1 ton of alfalfa hay in 32 days.

Little information is available for the Mormon cricket habitat as a whole. Studies of damage require so much time that they cannot be made in many areas in the same year by one man. Results differ from year to year according to the density of Mormon cricket infestations and the density of vegetation. Injury varies from region to region according to vegetation types and climate. Swain (*194*) established 27 observational plots in Nevada, Oregon, and Idaho and made random observations in a few other States. He also arrived at a method of estimating damage to forage (*193*). He determined, in 1938 and 1939, that maximum loss due to Mormon cricket feeding reached 100 percent in Nevada and Oregon. A heavily damaged area in Humboldt County, Nev., lost 45 percent of its total weight of herbage in 1939.

This amounted to 280 pounds (dry weight) per acre of forage and nonforage plants. He calculated that the seasonal forage losses for the same area were 74 percent for cattle and 98 percent for sheep. He pointed out that these areas were small and limited in number.

Swain concluded that Mormon crickets show a definite preference for the inflorescence of plants, that moderate damage to a cereal crop on a percentage-volume basis may result in almost complete destruction of all grain, and that range plants may be exterminated locally. He concluded, also, that similar amounts of Mormon cricket feeding cause much less injury where the weight of herbage per unit area in the mixed prairie vegetation is great, as in eastern Montana, South Dakota, eastern Wyoming, and Nebraska, compared with the desert shrub vegetation, as in southern Oregon, Nevada, southern Idaho, and Utah.

OUTBREAKS

When Mormon crickets form migrating bands and control is necessary to protect crops or range, in the economic sense, they are said to be in an outbreak stage. Small outbreaks, such as those that threatened the first crops in Utah, are of little importance in relation to the habitat area as a whole, though vitally important to the communities concerned. On the other hand, outbreaks may occur over wide areas simultaneously, as they did in the 1930's and 1940's. Then, faced with the possibility of crop ruin, farmers and ranchers roused themselves to take control measures against the insect in broad areas, including many counties of several adjoining States. Between these two extremes have occurred many outbreaks in varying degrees of intensity and importance.

The distribution list, page 5, gives a fairly accurate picture of when and where outbreaks of more than local concern occurred. In the earlier years, when there were few settlers, most outbreaks that caused severe damage, whether or not control was done, were recorded in some manner—by personal letter as much as by scientific reports. In later years when there were heavier human populations, more interest, and more observers, the data are much more complete.

After the first report in 1848, no intercounty or interstate infestation developed until 1871, when Thomas (*200*) reported large numbers of Mormon crickets in an area which today is comprised of nine contiguous counties in Utah and Idaho. He said, "In the north part of the Cache Valley I frequently noticed ditches and little streams covered with these insects, which having fallen in, were floating down on the surface of the water, and, though watching them for hours, they would flow on in an undiminished stream."

The outbreak that seemed to be developing in 1871 subsided before it became a major interstate outbreak. Since then, several other threatened outbreaks did not develop. Only one that encompassed many contiguous counties in several adjacent States

has developed since the western United States was settled by ranchers and farmers. That was the one that started in 1930, increasing each successive year until it began to diminish in 1940. Although it continued to subside until about 1949, the low point reached that year was still much higher than the low points following previous recessions. In 1950 Mormon crickets again began to increase and spread, and a second major outbreak would probably have developed had not organized work been done almost every year to find forming bands and control them before they could invade crops or spread over extensive range areas. Populations in 1958 remain large enough to create another major outbreak if not carefully watched and controlled.

Local outbreaks in the United States that are known to have caused damage or required some form of control occurred as follows:

1848 Salt Lake and Weber Counties, Utah (*5*, *227*).

1849 Salt Lake and Weber Counties (*93*).

1950 Salt Lake County (*93*).

1865 Utah County, Utah. Col. E. L. Berthoud wrote Packard (*149*) that ". . . in 1865, . . . large crickets made their appearance [in the Spring Lake area] . . . and helped . . . destroy the crops."

1873 Wasco County, Oregon. Henry Edwards wrote to Packard (*146*) that [about 1873] "The large brown cricket (*Anabrus simplex*) is a great trouble to this region (The Dalles) and this year has been unusually common. It appears that they march to attack the cornfields in columns."

Columbia County, Washington (*8*). "In 1873 an outbreak of crickets . . . occurred near Dayton."

Whitman County, Washington. W. T. Bowen (*10*) said, "Crickets are frequently seen throughout eastern Washington Territory and at times have done considerable damage to crops, vegetables and grasses." He described control measures.

1876 Elko County, Nevada. Packard (*147*) reported that "Mr. Wheeler also said that the cricket (*Anabrus*) was very destructive in northern Nevada. He observed them August 16 and 17 laying their eggs in the sand on the road between Cornucopia and Winnemucca. In 1876 they devoured about three thousand dollars' worth of grain and wheat . . ."

1878 Elko and Humboldt Counties, Nevada. Packard (*149*) reported that in 1878 crickets were very thick between Elko and Humboldt, filling the wells and spoiling the water so that the people had to use brook water.

1882 Eureka County, Nevada. Severe invasion in the Pine Valley area. Not only were crops damaged, but it was reported that trains were unable to make headway on the main line through Palisade, because the rails were so heavily greased with the bodies of crushed crickets (*172*).

1889 Siskiyou County, California. Koebele (*119*) said that in late July, on account of the unusually dry season, crickets, and grasshoppers, the crop had been an entire failure in the Montague area. He identified *simplex* as being in the population.

1891 Camas and Elmore Counties, Idaho. Bruner (*14*) noted that *simplex* reappeared in great swarms. Early in July a swarm, forming between Mountain Home and Camas Prairie, migrated northward. It was said to be about 3 miles wide and 9 miles long.

1893 Blaine, Camas, Elmore, and Gooding Counties, Idaho. Riley (*164*) wrote that ". . . . *A. simplex* . . . has caused a great deal of consternation on a large area of the middle portion of the Great Snake River plains in Idaho and the mountain region to the north, chiefly the Wood River and its tributary valleys. In

that particular locality the crickets have been known to hatch in limited quantities annually. They have not become so numerous, however, as to cause serious damage until the present year. . . . . Some little damage was caused by many thousands being carried down the Boise River and finding their way into the irrigating canals, thus being carried out into cultivated fields."

1894 Blaine County, Idaho. Milliken (*135*) said, "On a visit to Wood River . . . I saw from the foot of the mountains to Hailey swarms of them, containing untold millions destroying every green thing in their track . . ."

1895 Franklin County, Idaho, and Cache County, Utah. Howard (*95*) reported observations of William H. Crane, who wrote "that he had seen an insect which he calls the army cricket marching in innumerable numbers destroying everything green in their path. A swarm was seen on the Bear River on the boundary of Utah and Idaho. It was 10 miles in length and a quarter of a mile in width. In front of this army the landscape was green, behind a brown waste."

1900 Grant County, Washington. A serious epidemic of coulee crickets occurred (*8*).

1901 Harney County, Oregon. Howard (*96*) reported "July 30, 1901, Mr. R. J. Hollis sent specimens of one of the so-called western crickets (*Anabrus purpurascens* Uhl.) from Andrews, Harney County, Ore. . . . . In places there were millions of them, and they ate everything from garden truck to leather and canvas. . . ."

1902 Harney County, Oregon. Morris (*142*) stated that swarms of *A. purpurascens* Uhl. observed at two places on Steen's Mountains were defoliating everything in their path, even "salt bushes."

1903 Elko County, Nevada. Heavy infestations occurred in the Starr Valley (*63*).

Douglas County, Washington. Benson (*8*) said, "In 1903 the most disastrous cricket [*P. scabricollis*] devastation the State has ever known began when the cricket armies swept up from Moses Coulee and devastated many sections of wheat on the south side of Badger Mountain." Snodgrass (*181*) reported, "Over thousands of square feet the [coulee] crickets were simply massed together, there being on much of this crowded area a cricket to every square inch of surface."

1904 Routt County, Colorado. Gillette (*76*) noted that *simplex* for the first time in Colorado, attracted attention as an injurious insect.

Elko County, Nevada (*63*).

Beaver, Iron, and Washington Counties, Utah. Englehardt (*66*) said, ". . . . in certain localities the surface of the ground was overrun by vast multitudes of the so-called 'Utah cricket', *Anabrus simplex*. . . . In the morning the crickets forsook their places of concealment among the sage brush . . . and attacked the alfalfa, returning in the evening in such numbers that it was impossible to avoid trampling upon them. The cultivation of fields infested by them had frequently to be abandoned, the farmers making no effort to destroy them."

Douglas County, Washington. ". . . . armies of coulee crickets had increased to such an extent that they overran many hundred square miles of that part [Badger Mountains] of Douglas County (*8*)."

1905 Madison and Fremont Counties, Idaho. Mormon crickets reported doing serious injury to alfalfa and all kinds of field crops (*87**, *2**).

1916 Grant County, Washington. Benson reported that the development of coulee crickets was so great as to become a menace to the entire district and possibly to all of eastern Washington (*8*).

1917 Lake and Sanders Counties, Montana. *P. scabricollis* was found doing damage near Ronan (*32*).

1922 Moffat and Rio Blanco Counties, Colorado. Destructive in these two counties (*78*). Control begun (*51*).
Toole and Teton Counties, Montana. First mention of *simplex* in State Entomologist's Report (*34*).

1926 Moffat and Routt Counties, Colorado. Infestation of 1922 had spread eastward to include western Routt County (*51*).
Lake and Sanders Counties, Montana. Cooley said, "The Mormon cricket has been steadily becoming more abundant and injurious for some years and the situation became alarming in 1926." (*36*)

1927 Lake and Sanders Counties, Montana. Peak of infestation, control work undertaken (*38*).

1928 Moffat and Routt Counties, Colorado. The Mormon cricket infestation had increased and spread still farther, and organized control was started (*51*).
Lake and Sanders Counties, Montana. The infestation was greatly diminished over that of 1927 (*38*).

1930 Local outbreaks began to increase and spread in the United States. This time the infestation did not recede as infestations had done previously but continued to grow into the major outbreak that reached its climax in 1939.

Mormon crickets were first found in Canada in 1874, when Cyrus Thomas (*204*) received specimens of *simplex* variety *coloradus* from Manitoba. He noted that they have never been of more than small, local importance. *A. longipes* was first reported by Fletcher and Gibson (*72*) in 1906 from Nelson, British Columbia; *scabricollis*, by Whitehouse (*226*) in 1920 from Alberta and by Trehern and Buckell (*209*) in 1922 from British Columbia.

Outbreaks or near outbreaks have occurred in Canada but a few times. *A. longipes* in outbreak form was noted by Treherne and Buckell (*209*) in 1911 on the range land west of Vernon in north Okanogan Valley, British Columbia; by Buckell (*17*) in 1925 from Kelona to Vernon as threatening destruction of the onion crop; and by Ruhmann (*166*) in 1926 as causing severe damage locally to truck crops near Vernon. Ruhmann (*167*) implied that there had also been an outbreak of *simplex* in British Columbia in 1926, and that there was the possibility of a serious outbreak over the same areas in 1927, but that the expected outbreak did not develop.

Twinn (*210*) reported that *simplex*, which had not been of economic importance, became sufficiently abundant in 1938 to cause apprehension in Saskatchewan.

DURATION OF INFESTATIONS

Mormon crickets have endured for many consecutive years, as shown in table 1. Control was not practiced in any of the counties every year that the population persisted, but the potentiality of an outbreak existed in many of them. Sometimes more than one period occurred in several counties. For example, a period of 21 years, 1918–38, and another of 8 years, 1949–56, occurred in Moffat County, Colorado; and one of 17 years, 1932–48, and another of 5 years, 1951–55, in Elko County, Nev. Almost certainly, in any year between known periods, Mormon crickets

could have been found in many of the counties listed had diligent search been made to seek out solitary crickets. They are not readily found by survey procedure designed to ascertain the areas where control may be needed.

TABLE 1.—*Counties in which Mormon crickets are known to have endured for five or more consecutive years, in order of duration*

County	State	Duration of population	
		Period	*Years*
Moffat	Colorado	1918–38	21
Franklin	Washington	1931–50	20
Big Horn	Montana	1930–46	17
Gilliam	Oregon	1938–54	
Elko	Nevada	1932–48	
Lander	do	1933–48	16
Hot Springs	Wyoming	1935–50	16
Fremont	Idaho	1932–46	15
Eureka	Nevada	1932–46	15
Bannock	Idaho	1930–43	14
Yellowstone	Montana	1933–46	
Humboldt	Nevada	1935–48	
Pershing	do	1935–48	
Fremont	Wyoming	1934–47	
Washakie	do	1935–48	
Clark	Idaho	1935–48	
Jefferson	do	1935–47	
Tooele	Utah	1930–42	13
Crook	Wyoming	1944–56	
Park	do	1945–56	12
Morrow	Oregon	1943–53	11
Sherman	do	1939–49	11
Blaine	Idaho	1932–41	10
Elmore	do	1932–41	
Iron	Utah	1933–42	
Millard	do	1930–39	
Klickitat	Washington	1938–47	
Yakima	do	1938–47	
Johnson	Wyoming	1933–42	
Sheridan	do	1933–42	
Ada	Idaho	1933–41	
Beaverhead	Montana	1936–44	
Carbon	do	1932–40	
Baker	Oregon	1933–41	9
Wasco	do	1938–46	
Grant	do	1897–1905	
Crook	Wyoming	1933–41	
Moffat	Colorado	1949–56	
Bingham	Idaho	1930–46	
Owyhee	do	1935–42	
Chouteau	Montana	1934–41	8
White Pine	Nevada	1936–43	
Umatilla	Oregon	1944–51	
Juab	Utah	1935–42	
Adams	Idaho	1935–41	7
Bingham	do	1930–36	
Gem	do	1935–41	
Madison	do	1938–44	
Payette	do	1935–41	
Washington	do	1935–41	
Judith Basin	Montana	1934–40	

TABLE 1.—*Counties in which Mormon crickets are known to have endured for five or more consecutive years, in order of duration* —Continued

County	State	Duration of population	
		Period	*Years*
Lake	Montana	1933–39	
Sanders	do	1924–30	
Lyman	do	1937–43	
Uintah	Utah	1932–38	
Uintah	do	1950–56	7
Grant	Washington	1913–19	
Big Horn	Wyoming	1935–41	
Converse	do	1933–39	
Park	do	1934–40	
Bonneville	Idaho	1931–36	
Fergus	Montana	1934–39	
Sanders	do	1936–41	
Pershing	Nevada	1951–56	
Malheur	Oregon	1939–44	6
Mellette	South Dakota	1937–42	
Douglas	Washington	1886–91	
Grant	do	1944–49	
Okanogan	do	1900–1905	
Campbell	Wyoming	1936–41	
Bear Lake	Idaho	1932–36	
Boise	do	1934–38	
Franklin	do	1932–36	
Polk	Minnesota	1935–39	
Cascade	Montana	1935–39	
Lake	do	1924–28	
Meagher	do	1937–41	
Pondera	do	1934–38	
Rosebud	do	1935–39	
Sweet Grass	do	1935–39	
Elko	Nevada	1951–55	
Eureka	do	1951–55	
Lander	do	1900–1904	
Wallowa	Washington	1935–39	5
Bennett	South Dakota	1938–42	
Hand	do	1937–41	
Jones	do	1937–41	
Spink	do	1937–41	
Cache	Utah	1921–25	
Sanpete	do	1935–39	
Uintah	do	1922–26	
Utah	do	1938–42	
Chelan	Washington	1934–38	
Okanogan	do	1944–48	
Albany	Wyoming	1934–38	
Lincoln	do	1933–37	
Goshen	do	1937–41	

EVOLUTION OF CONTROL METHODS

When Mormon crickets unexpectedly threatened to destroy the crops of the pioneers, no effective method of control was known. Many accounts have been written of how the pioneers in Utah strove to save their first crops. Two such accounts serve to describe what they did in the extremity facing them. Whitney (*227*) said that "With the energy of desperation, the community,

men, women and children, thoroughly alarmed, marshalled themselves to fight and if possible repel the rapacious foe. While some went through the fields killing the crickets and at the same time . . . crushing much of the tender grain, others dug ditches around the farms, turned water into the trenches, and drove and drowned therein myriads of the black devourers. Others beat them back with clubs and brooms, or burned them in fires set in the fields. . . . . Too much headway had been gained by the crickets before the gravity of the situation was discovered, and in spite of all that the settlers could do, their hopes of a harvest were fast vanishing, and with those hopes, the very hope of life."

Archibald Gardner (*98*) wrote, "The darkest of these days came in the summer of '48 when the black crickets swarmed down from the mountains and began to devour their crops. Myriads of them completely covered the ground and fields. . . . . The people working with fire and water could do nothing to stop their onslaught. As fast as their front ranks were killed millions took their places. They devoured the beautiful fields of grain leaving the ground dry and dusty and we were a thousand miles from succor."

Delila Gardner Hughes (*98*) noted her aunt remembered as a girl in 1848 going out with other youngsters on several occasions and driving sheep across fields to kill Mormon crickets.

More than 20 years later, the Utah pioneers were still seeking a way to cope with this pest. The Deseret News of May 21, 1870, described one method recommended for controlling Mormon crickets in crops: "Bishop A. Gardner of West Jordan called in this morning and gave us his plan for killing grasshoppers. It consists of driving a flock of sheep hurriedly over the field. He considers it more effectual than any other he has tried. It is necessary to keep the sheep in a compact herd, and when driven early in the morning on a cool day, when the pests are sluggish and inclined to lie still, one or at most two drivings over, will completely clear the field of live grasshoppers. . . . . Brother Gardner thinks that with a flock of sixteen hundred sheep they killed ten acres of grasshoppers in about two hours." It will be noticed that the terms grasshoppers and Mormon crickets were, in the early days, often indiscriminately used synonymously for the Mormon cricket. The grasshoppers referred to in this article were p r o b a b l y Mormon crickets.

Packard (*148*) also suggested that since young crickets will eat tender grass and young grain, the best way to destroy them was to herd sheep in the grain, keeping them compactly herded for sheep "do little harm to grain when young and they trample the crickets to death."

It was not only in Utah that Mormon crickets were playing havoc with the efforts of pioneers to eke a living from virgin land and the people were trying every device they could think of to combat the pest. Henry M. Edwards (*146*), in an account of control efforts in Oregon in 1873, makes probably the first mention of the use of trench and kerosene barriers: "When fields of grain are invaded or in danger of being invaded by crickets, ditching,

dry and wet with the liberal use of coal oil is the easiest, most thorough, and practical remedy . . . . Where irrigation is practiced it would be easy to protect fields of grain to allow coal oil to drop from a pail on the surface of water running in the ditches. . . . . If a film of oil covers these holes [trachae], the insect . . . becomes suffocated and speedily dies. Hence the use of coal oil or any greasy matter is sure death, provided the oily substance comes in contact with the body. . . ."

In 1880 Packard (*149*), writing of the general area of Utah, Nevada, and Idaho, also recommended a film of "coal oil" on water. In 1905, the method was mentioned by Gillette (*76*), and by Melander in 1914 (*129*) and again in 1916 (*130*).

Although oil on water had frequently been mentioned as a means for keeping migrating Mormon crickets out of irrigated crops, Corkins (*27**) seems to have been the first to employ this method when he used oil in field control in Wyoming in 1936. Application of oil on irrigation ditches and streams is one of the cheapest and most effective methods known. It has been used extensively and it still is practical for keeping migrating Mormon crickets out of irrigated lands (figs. 10 and 11).

Ditching was being recommended by most observers. Bruner (*10*), in 1883, quoted from a correspondent in Washington Territory, who stated that Mormon crickets "are very easily checked in

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FIGURE 10.—Irrigation canal oiled to form a barrier. Two barrels of oil are in position. When one barrel is emptied by the steady release of a small stream of oil, the second is ready for immediate use.

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FIGURE 11.—Oil barrier control, 1938. Mormon crickets killed attempting to cross an oil-treated irrigation ditch. Dead and dying removed from behind a baffle placed in the canal.

their march by ditches, and can be readily destroyed. If a ditch two feet wide and two and a half feet deep be dug across their line of march they will fall into it and cannot get out. By putting in larger pits at intervals they are double 'corralled' and soon begin destroying one another, as they are great cannibals."

Ditching was recommended and used over a span of more than a half century: Aldrich (*1*) mentioned its being in use in Idaho in 1904; that year Piper (*156*) reported that farmers in Washington resorted to ditching with "perfect success"; Benson (*8*) reported that the first organized control in Washington, in 1904, was the construction of approximately 50 miles of trenches and fences in a desperate effort to keep coulee crickets in Douglas County from "sweeping the entire country."

The following year, 1905, Gillette (*76*), writing on the life history and habits of the cricket in the west, reported the use of, in addition to ditching, a variety of ways for their control: herding, fencing, kerosene on water, poisoning with arsenic, plowing up the eggs, burning where brush or vegetation is dry enough, crushing with rollers or sheep. Melander (*129*), in 1914, added his recommendation to that of others of the use of trenches in coulee cricket control, and in 1916 (*130*) suggested additional methods—spraying with kerosene, burning with a blast torch, scattering straw and burning them, poisoning with arsenic, and keeping migrating bunches out of crops by fencing. Grant County, Wash., for instance, had constructed about 35 miles of trenches and fences. In 1917, he reported (*132*) that some experimental work had been done by the counties and farmers and much control had resulted.

Burning with a blast torch and scattering straw and burning them had been recommended by Melander (*130*) in 1916. Benson (*8*), in 1917, reported that that year gasoline torches were used to destroy heavy concentrations of the insect.

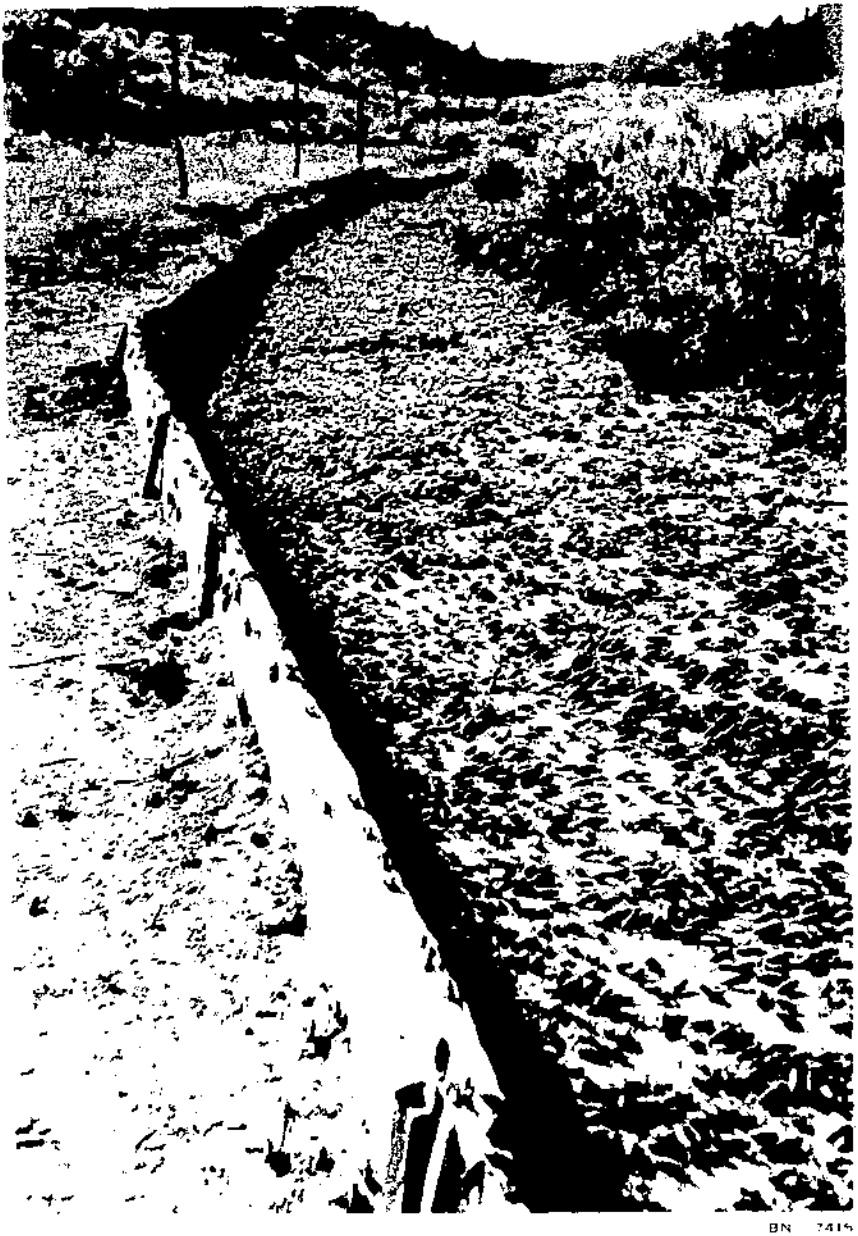

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FIGURE 12.—Board fence with a metal strip on top, showing its effectiveness in stopping the march of a migrating band of Mormon crickets.

In British Columbia, Ruhmann (*166*) reported that in 1926, efforts were made to organize growers to institute control measures against *longipes* that was damaging truck crops near Vernon. Trenching below the main irrigation ditch was first attempted, but owing to the gravelly nature of the soil the results were not satisfactory. As an area extending for 5 miles along the main ditch was affected, water was turned into the ditches for a period of 6 days to check the advance of the crickets until more satisfactory measures could be applied. Growers were advised to erect a fence of 12-inch boards flashed with a 3-inch strip of tin. Cooperation of the growers was not satisfactory; some followed the advice, but others ignored it until they realized that "their time-honored method of beating tin cans proved unavailing." After their crops had suffered severely, growers went to the other extreme and constructed a fence of tin 18 inches high. In one instance to protect a field of cabbage, a trench was dug, then the upper part was completely lined with sashlights. In describing this, Ruhmann said, "The protection was perfect but at a cost probably exceeding the value of the crop."

Fences to stop migrating bands and to prevent the invasion of Mormon crickets into fields were being used as early as 1894, in many instances in conjunction with ditches. Milliken (*135*) describes fencing as seen in use in Idaho that year: "The best preventive measure I have seen applied is to fence them out. This is easily done. A board fence 6 inches or more in width placed on edge and provided with a strip of tin bent to an angle, and projecting outward from the top of the board, will effectually exclude the insects from the field if they are not allowed to find holes under, or defects in the construction, by which they can find passages through the fence . . . . They may crawl up the side of the board until they come to the overhanging tin caps, when they fall to the ground, but cannot cross. Often they will accumulate in such heaps as to form bridges higher than the fence. . . . This has been tried with very satisfactory results by the Orchard Farmers Company at Bisuka and by the farmers near Bellview and at other places" (fig. 12).

Later, in 1908, Snodgrass (*181*) agreed to the efficacy of fencing: "A force of men at work in front of them [coulee crickets migrating across the Badger Mountains, Douglas County, Wash.] constructing a low fence to prevent their further advance toward the wheat fields . . . . Near the fence, which was placed across the predicted line of march the scene was something marvelous. Over thousands of square feet the crickets were simply massed together, there being on this crowded area actually a cricket to every square inch of surface. . . . The fence consisted merely of six-inch boards set on edge banked by earth on the side away from the crickets, and topped with a strip of tin projecting about an inch toward them and bent slightly downward. Many miles of this had been constructed . . . and it effectively kept the crickets back from the wheat fields in the valley below. By means of ditches and holes dug along the inner side of the fence enormous numbers of the insects were captured and killed. The moving

horde simply flowed over the edges of these holes like some viscid liquid poured out upon the ground. Those on the rim of the hole were helplessly shoved over and in by the crowd behind, and in turn were followed by those that pushed them in. Thus they piled up until wagon-loads of them accumulated. Each hole soon contained a wriggling, squirming, angry mass of life that extinguished itself through the fierce fighting and mutual smothering thus heaped upon one another."

Doten (*63*) in 1904 added to the growing list of methods the idea of burlap fences, faced with oil cloth.

Fence barriers created the problem of economically disposing of the enormous numbers of Mormon crickets that such barriers deflected from their course of march to a course parallel to the barrier (fig. 13). Pen traps constructed at intervals along a

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FIGURE 13.—A migrating band of Mormon crickets stopped by metal barrier, Nevada, 1938.

barrier fence so that the crickets crawling along the fence would enter a pen but not escape, alleviated the problem (*52*, *54*, *129*). At first these pens were too small in diameter, which made it necessary for the crickets to be constantly shoveled into the center, else they would pile up next to the wall enabling others to crawl over them and escape (fig. 14).

Many different pen designs were used in different States, but the general tendency was to make them large so the captured crickets would not crowd the pens so closely and would have vegetation to cluster on. Large pens functioned properly with a minimum of labor. The numbers of Mormon crickets captured in pits and pen traps seemed fantastic. Operators in Nevada

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FIGURE 14.—Mormon crickets captured in a pen trap in 1936. Note entrance in foreground, constructed in such a manner that insects freely crawl into the trap but cannot escape. (Photo by Nevada State Department of Agriculture.)

estimated in 1936 that 120,463 bushels of crickets were caught in 2,500 pit and pen traps (*131**).

Galvanized iron barriers 8 to 10 inches high proved more effective than others (fig. 15). While their cost was high, they

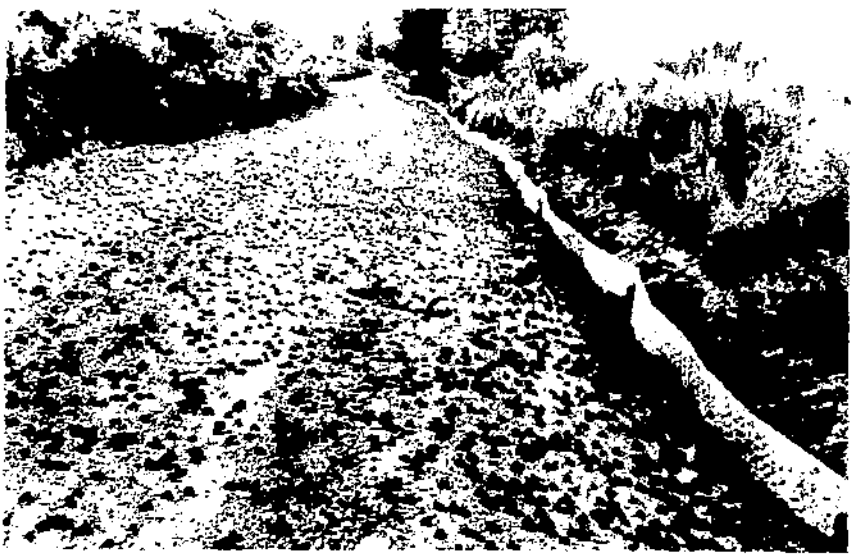

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FIGURE 15.—Galvanized iron barrier holding migrating Mormon crickets on a road where they were killed by sodium arsenite dust, 1938. (Photo by Nevada State Department of Agriculture.)

could be used year after year, so that these barriers proved to be cheapest in the long run. Thereafter, as long as fence barriers were employed, they were made almost exclusively of galvanized iron.

Many weird devices for killing Mormon crickets were originated by people in invaded communities, such as a set of rollers motivated by a water wheel, set across the entire width of a canal and adjusted so that the surface area of the water passed between the rollers for the purpose of crushing crickets floating in the canal. The device was used near St. Anthony, Idaho, in 1905 but accomplished little in the reduction of cricket numbers. Another device that functioned well in the Fort Hall, Idaho, outbreak in 1932 (*220*) consisted of a plank floated diagonally across the main canal. Crickets floating down the canal, offered something to cling to, climbed out on the plank and up an incline to drop into a pit. So many crickets were caught that the incline had to be extended to another pit.

From time to time the possibility of poisoning the crickets was mentioned. Out of this idea was to grow large-scale, successful Mormon cricket control. Norman Criddle (*56*) tried combining horse manure and arsenic, which came to be known as the Criddle mixture. Aldrich (*1*) in 1904 thought the Criddle mixture was a promising remedy but did not say specifically that it had been used. Doten (*63*) indicated that, judging from experiments he had made, he did not consider poisoning successful enough to justify its recommendation. In fact, he concluded that the number of Mormon crickets in a single swarm was so vast, and they came with so little warning, it was usually impossible to check them with means available at that time.

Benson (*8*), too, reported that in 1917 large amounts of poison were applied. He noted that Alfred C. Burrill was temporarily assigned to the State of Washington by the U.S. Bureau of Entomology; however, that under his direction "all available help in the community was employed chiefly in building fences and using torches." Burrill (*12**) reviewed and evaluated the different methods used and the cost and relative efficiency of each.

Also in 1917 Yothers (*132*) indicated that the coulee cricket could be killed in the laboratory with a mixture of horse manure and paris green or sodium arsenite but did not state whether the bait had been tried in field control. However, Cooley (*32*) noted, the same year, that the coulee cricket did not take poisoned bran mash as readily as did grasshoppers in the genus *Melanoplus*.

In 1922 Corkins (*40*) reported that in an experiment a bait composed of bran and white arsenic had killed from 90 to 98 percent of the Mormon crickets, and in 1924 (*42*) that bait that had been allowed to ferment gave excellent results.

In 1923 came Malley's report (*125*) from South Africa that he had found sodium arsenite used as a dry-powder contact poison to be very effective in killing grasshoppers.

Following Malley's announcement, Cowan and his coworkers (*47*) tested the effectiveness of sodium arsenite dust against Mormon crickets in 1926 and 1927. They found that a mixture of sodium arsenite and dehydrated lime mixed in proper proportions

and applied at a given amount per acre produced a very high kill of Mormon crickets and that calcium arsenite, which was in plentiful supply, could be satisfactorily substituted for the more scarce sodium arsenite. The discovery that such a dust mixture was effective in killing Mormon crickets in all stages of growth was the greatest contribution to practical control up to that time and marked the turning point in the fight against large infestations (fig. 16). The mixture was used in field operations to control the outbreak in Lake and Sanders Counties, Montana, in 1927 (*48*).

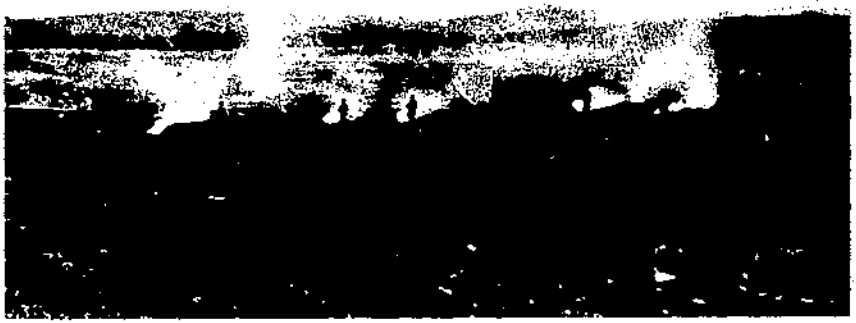

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FIGURE 16.—Applying sodium arsenite dust with hand dusters.

Of this campaign Cooley (*37*) reported that control work progressed rapidly, that hardly any crop damage occurred, and that the Mormon cricket infestation was materially reduced. He said that the amount of sodium arsenite available was insufficient to meet the demand, but that a mixture of calcium arsenite and dehydrated lime gave good results. Later, experiments were conducted to ascertain whether the composition and effectiveness of the mixed dust might be improved (*84*). The question arose whether feed so treated would be hazardous to livestock. Conclusions of investigators (*62*) were that there appeared to be no such hazard, providing the dusting was done in strict accordance with recommended practices.

The calcium arsenite-dehydrated lime mixture was used effectively in a campaign in 1928–29 (*51*) to control Mormon crickets in northwestern Colorado. Within the next few years, diatomaceous earth replaced dehydrated lime in the dust mixture.

At first, application of sodium arsenite dust mixtures was made

with hand dust guns, but power dusters began to be used in 1937 (*35**) and except for small infestations, hand dust guns rapidly went out of use. Experiments in applying sodium arsenite dust from an airplane were made in Nevada in 1936 (*171*).

Cowan made extensive bait tests with many combinations and concluded (*47, 48, 80**) that the arsenic baits being successfully used in grasshopper control gave erratic results when used against Mormon crickets. He found, in 1928 and 1929, that an arsenic bait was not reliable, because though good results were sometimes obtained against young Mormon crickets, larger insects would not eat the bait at all. His experiments showed that a bait containing arsenic was repellent to Mormon crickets.

Sodium arsenite dust, metal barriers, and pen traps made of metal barrier were used extensively in Mormon cricket control in all infested States until 1938. Thereafter, they were rapidly replaced by baiting, for Cowan and Shipman (*52*), after 4 years of testing nonarsenicals in baits, had determined that wet baits containing sodium fluosilicate as the insecticide were readily eaten by Mormon crickets and were quite lethal to them (*36**, *37**, *39**, *52*, *80**). The cost of sodium fluosilicate bait was so much less and it was so much more effective, that as soon as adjustments in planned control programs could be made, all other methods, except oil-on-water barriers, were discarded.

It had been the practice to mix the ingredients for bait with water. By substituting for the heavy weight of water a small amount of oil that served to make the flakes more pliable and cause the sodium fluosilicate to adhere better to the bran, bait distribution was made more practical. This change produced the so-called dry bait that feeds readily from ground and airplane spreaders and nearly doubled the acreage that could be spread with one load of bait. Bait mixed with oil is more costly and somewhat less effective than wet bait, a disadvantage that is offset by a reduction in manpower and airplane requirements to cover a greater acreage (*36**, *133*, *214*).

A serious fault of arsenite dusts had been their danger to humans, livestock, and green vegetation. The discovery of the effectiveness of sodium fluosilicate revolutionized Mormon cricket control by the fact that a safe, economical bait effectively controlled the insects. Feeding experiments conducted by veterinarians showed that the amount of sodium fluosilicate in an effective bait was only approximately one-eighth as toxic to sheep as the amount of sodium arsenite in an equivalent quantity of grasshopper bait; that sodium fluosilicate bait was not readily eaten by chickens, ducks, quail or pheasants; and that it was extremely distasteful to sheep, horses, cows, and rabbits (*152*).

Dinitro-ortho-cresol was tested by Decker and Drake (*59*), who found it to be effective in killing young Mormon crickets. It did not come into field use, because of its high cost as well as some undesirable qualities inherent in the material and because sodium fluosilicate bait was generally so much more satisfactory to use.

Sodium fluosilicate bait was applied by power bait spreaders at first, but airplane spreading, begun in 1940 (*114**), now is used to control most large infestations (*133*, *214*) (fig. 17).

FIGURE 17.—Bait being applied by airplane for Mormon cricket control.

Research has shown that for Mormon cricket control insecticides applied in sprays have been less effective and more costly than those in baits. Instances have occurred in several States, however, where Mormon crickets intermingled with grasshoppers have been controlled satisfactorily with spray used primarily against several species of rangeland grasshoppers.

When organic insecticides became available, experiments were made with some of the newer ones in place of sodium fluosilicate (*39**). Results were outstanding; they remained effective for a long period of time and stored well. The chemicals tested were toxaphene, chlordane, and aldrin, named in the order in which they came into field use.

As the poison carrier in Mormon cricket bait, steam-rolled wheat was found to be more desirable than bran, because its particles are so large that a single one contains enough poison for a lethal dose. The particles, also, are so heavy that they will fall to earth from an airplane from a greater height and in more turbulent air. An airplane distributing rolled-wheat bait can work longer periods on many more days than when distributing a bran bait. The daily flying time of an airplane is thus increased when rolled wheat is dispensed and the time required for baiting a certain area is shortened. The so-called dry bait containing aldrin is now used almost exclusively to control Mormon crickets (*150*).

NATURAL ENEMIES

Mormon crickets are destroyed by a great number of predators and parasites. When large bands of crickets cover extensive areas, natural enemies have little noticeable effect in reducing the enormous populations. However, when populations are small, or when severe infestations have been reduced by applied control or weather, effects of the attacks of natural enemies become extremely important.

The first record of the benefit from natural enemies is the notable experience of the pioneers in Utah. Mormon crickets invaded the small amount of land that they had been able to get broken and seeded in the Salt Lake Valley in 1848. All their efforts at control were proving insufficient, when flocks of seagulls flew in to gorge themselves on the insects. The pioneers credited the intervention of the gulls as being almost the sole means of saving their first crops, of which they were in dire need (*93*). The experience is vividly described in the words of a few writers and historians.

"They were saved, they believed," wrote Whitney (*227*), "by a miracle . . . Just in the midst of the work of destruction, great flocks of gulls appeared, filling the air with their white wings and plaintive cries, and settled down on the half-ruined fields. At first it seemed as if they came but to destroy what the crickets had left. But their real purpose was soon apparent. They came to prey upon the destroyers. All day long they gorged themselves, and when full, disgorged and feasted again . . . until the pests were vanquished and the people were saved. The heaven-sent birds then returned to the lake islands whence they came, leaving the grateful people to shed tears of joy at the wonderful and timely deliverance wrought out for them."

"I went to Salt Lake City and returned on horseback," said Gardner (*98*). "I heard the sound of flying fowl behind me and looking up I saw seagulls in such a cloud as to darken the sky. What new calamity was upon us? I put my horse through after them. I was only four miles behind them but when I got to our patch in the Big Field, the ground was covered with birds. In two days the black plague was destroyed. But all over the earth, near streams where the gulls had drunk after glutting themselves, were little piles of dead crickets about the size of a goose egg that had been swallowed and then disgorged."

Cannon (*22*) wrote, "To us who lived in Utah . . . it seemed there was a visitation of Providence to save us. Seagulls came by hundreds and by thousands, and before the crops were entirely destroyed these gulls devoured the insects, so that our fields were entirely freed from them. . . . . I have gone along ditches in the morning and have seen lumps of these crickets, vomited up by the gulls, so they could begin again killing them."

Benjamin G. Ferris (*70*), who was serving as Secretary of the Territory of Utah in the winter of 1852–53, described the coming of the gulls and then added, "It is no matter for wonder that the leaders should place this [gull] in the list of miraculous interpositions in their favor, nor that the mass of Saints should implicitly believe that the gulls were hatched into sudden maturity for the occasion; but it is a little strange that one of the intelligence of Colonel Kane [assistant postmaster of Salt Lake City] should speak of these fowl as 'before strangers to the valley.' The crickets and the gulls have been annual visitors since, as they were before, the bane and the antidote come together. . . ."

Since organized control began, gulls have repeatedly been observed feeding on Mormon crickets and have often cleaned up

FIGURE 18.—California gulls feeding upon Mormon crickets.

infestations that were easily accessible to them on ground without much cover, in young grain fields or damaged fields where the vegetation was sparse (fig. 18). They rarely feed extensively in heavy crops or on rangeland with heavy vegetative cover. The invasion of 1848 was a small one, compared with later enormous infestations, and was concentrated on only a few thousand acres of partly destroyed crops. Undoubtedly gulls destroy many Mormon crickets (*111, 112*), but experience has shown that they cannot be depended upon solely for control. Were this not so, poisoning the insects would not have had to be resorted to repeatedly in areas frequented by gulls.

Thomas (*200*) said in 1872 that he "noticed in the road, where one of the armies was crossing, a number of large hawks feasting themselves upon the helpless victims." Fisher (*71*) relates that a correspondent, in 1889, described seeing bunches of large hawks circling and perched on the ground. The flock contained at least 500 birds which were feeding upon Mormon crickets.

It is common knowledge that a congregation of hawks in an infested area is a sure indication that a band of Mormon crickets is close by. They may soar over a band, or, if a fence is near, perch on every post. Supervisors commonly follow an unusual assemblage of hawks to guide them to infestations.

Cowan (*48*) noted that 19 species of birds and several species of rodents are fond of Mormon crickets, and that coyotes, skunks, and badgers undoubtedly eat great numbers of the insects. He gave a rather detailed account of the egg parasite *Sparasion pilosum* Ash. and of the predator *Chlorion lacriventris* Cress.

Before regional organized control of Mormon crickets began in 1937, records of natural enemies were rather sparse. They were more numerous thereafter but, on the whole, are quantitative rather than qualitative, for few studies have been made to determine the benefits from specific enemies.

In 1878 Riley (*162*) reported that a nematode, *Gordius robustus* Leidy, was taken from *Anabrus purpurascens*. Cockerell (*30*), in 1890, noted that the sparrow hawk does excellent service in keeping down Orthoptera and that he found the remains of *Anabrus* in its stomach. Piper (*156*) wrote that unsuccessful attempts were made in 1902 and 1903 to inoculate coulee crickets with the South African mucor disease. Melander and Yothers (*132*) found eggs of the coulee cricket parasitized by *Sparasion pilosum* and observed two predaceous insects feeding upon coulee crickets—*Calosoma luxatum zimmermanni* Lec., a ground beetle, and *Cyrtopogon maculosis* Coq., a robber fly.

Kalmbach (*104*) reported that stomachs of six crows collected at Okanogan Landing, British Columbia, contained Mormon crickets in considerable numbers, in several cases to the extent of nine-tenths of the contents.

A program planned for control of the coulee cricket in Washington, in 1919, was abandoned, according to Burrill (*19*), because western meadowlarks that appeared in great numbers were almost entirely responsible for the cleanup of the infested area. Sage grouse were observed by Boyd (*9**) to be feeding on Mormon crickets in 1924. Early in the morning, he said, a bunch of grouse could be found in almost every large band.

Cooley (*38*) reported that *Chlorion laeviventris* (as *Palmodes l.*), discovered in western Montana in 1926, became very abundant in 1927 and mentioned that the egg parasite *Sparasion pilosum* occurred there also.

Christie (*29*) told of the nematode *Agmospriura anabri* having been taken from the bodies of *simplex* collected from Bush Creek, Mont., in 1926.

Parker and Mabee (*151*) described in detail the habits and activities of *C. laeviventris* and how abundant they were in the fall of 1927. They also briefly described the egg parasite *S. pilosum*, its life history and habits. Bailey and Sperry (*3*) in 1929 noted that the summer food of grasshopper mice is almost exclusively animal matter, the highest percentage of insects being eaten during late summer and fall, when both insects and seeds are most abundant and a free choice is available. In captivity, they eat Mormon crickets eagerly.

Gordius sp. was found infesting Mormon crickets in the vicinity of Arrowrock Dam, Idaho, in 1934 (fig. 19) and much more abundantly in 1935 (*215*). A detailed description of the life history and habits of *G. robustus* was published by Thorne (*205*). From field observations he determined that in areas favorable to the survival of *Gordius*, parasitization ranged from 25 to 99 percent, but concluded that favorable areas were so few and small that the percentage parasitized during Mormon cricket outbreaks was too little to be of economic importance.

FIGURE 19.—A mass of mature [illegible] that was observed in 1934. They were found [illegible] Ammon, Bonneville County, Idaho, and had emerged from [illegible] (Photo by [illegible], University of Idaho.)

In 1936 Wakeland (1[illegible]) reported that *Ichneumon laetatis* was widely distributed in Idaho and believes (1[illegible]) that the species was attacking Mormon crickets in eastern Nevada.

In 1939 Cowan and Shipman (1[illegible]) examined 37,911 *simplex* eggs collected in 10 States to determine the percentage that were parasitized by *Systasius pallipes* [illegible]. A brief summary of their results follows:

State	Number of egg pods examined	Percentage parasitized	
		Highest	Average
[illegible]	[illegible]	[illegible]	2.0
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1.8
[illegible]	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	1.8
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	3.1
[illegible]	[illegible]	[illegible]	2.8
[illegible]	[illegible]	[illegible]	1.7
[illegible]	[illegible]	[illegible]	2.1

The natural enemies of Mormon crickets are discussed in four State publications; namely, Colorado (*51*), Idaho (*220*), Montana (*139*), and Nevada (*172*).

Supervisors working on control in a 10-State regional area in 1938 listed all the animals they observed attacking or feeding upon any stage of Mormon crickets (*112**). Any recorded natural enemies may have been widely distributed in the State or restricted to a single area. The order of importance of the natural enemies of Mormon crickets is roughly indicated in the following tabulation by the number of States in which they were found:

Enemy	*States in which found Number*	*Enemy*	*States in which found Number*
Crows	9	*Aphodius denticulata*	1
Hawks	9	Badgers	1
Meadowlarks	8	Bee martins	1
Blackbirds	7	Buzzards	1
Small field birds (unidentified)	7	Chipmunks	1
Chlorion laeviventris	6	Cowbirds	1
Turkeys	6	Curlew	1
Ground squirrels	5	Hogs	1
Magpies	5	Horned toads	1
Poultry	5	House wrens	1
Chinese pheasants	4	Hungarian partridges	1
Horned larks	4	Lark buntings	1
Black widow spiders	3	Mourning doves	1
Pinon jays	3	Osprey	1
Robins	3	Prairie-dog owls	1
Sage grouse	3	Quails	1
Sparasion pilosum	3	Ravens	1
Bluebirds	2	Rock lizards	1
Coyotes	2	Sagebrush swifts	1
Dogs	2	*Sarcophaga* sp.	1
Gordius sp.	2	Scorpions	1
Grouse	2	Sharp tailed grouse	1
Gulls	2	Sparrows	1
Kangaroo rats	2	Spiders sp.	1
Mice, 5 species	2	Toads	1
		Vesper sparrows	1

The main publications since 1937 dealing with natural enemies of Mormon crickets are briefly reviewed in the next three paragraphs.

Sorenson and Jeppson (*183*) listed 29 species of animals that attacked Mormon crickets in Utah—12 species of birds, 7 of Arachnida, 4 of lizards and horned toads, 4 of mammals, and 2 of insects. Mills (*187*) reported that *Sparasion pilosum* was parasitizing Mormon cricket eggs in most parts of Montana and that predators were numerous, including *Chlorion laeviventris*, hawks, crows, magpies, sage grouse, Brewer's blackbird, meadowlarks, horned larks, lark buntings, coyotes, skunks, and field mice that in one case he credited with digging up 43 percent of the Mormon cricket eggs. Evidences of digging by rats and mice for Mormon cricket eggs are shown in figure 20. Knowlton and Thornley (*118*) found that sage grouse consumed many Mormon cricket eggs. Gahan (*73*) described and named *Oencyrtus ani-*

Figure 20. Cavities in the soil showing where kangaroo rats and mice have dug up Mormon cricket eggs, 1938.

bricorus which was reared from Mormon cricket eggs collected in the Big Horn Mountains of Wyoming.

Knowlton (*113*) found that sagebrush swifts and horned toads fed on Mormon cricket nymphs. Knowlton and Harmston (*116*) listed sage grouse as eating Mormon cricket eggs, the California gull and American raven as feeding upon nymphs and adults. La Rivers (*120*) concluded from a study of *Chlorion laeviventris* in a 1/2-square-mile area in Nevada that approximately 30,000 *Chlorion* destroyed about 500,000 Mormon crickets in 6 days. He found also insect enemies of *Chlorion*.

Knowlton, Maddock, and Wood (*117*) made a 16-year study of the sagebrush swift in Utah, during which, in the examination of 2,191 stomachs, they found 21 contained Mormon cricket adults and 24 contained nymphs. Knowlton (*115*) found that the stomachs of 9 species of birds and 3 species of lizards contained Mormon cricket nymphs or adults, and that one raven (*114*) had eaten 3 adults and 285 eggs.

Little definite knowledge has been gained concerning the effects of weather on Mormon crickets, but there is no doubt that at times it has wiped out widespread infestations or prevented small ones from developing into outbreaks. During stormy or cold weather Mormon crickets seek protection in soil cracks, and under rocks and debris, becoming active again with the return of more

favorable weather. Packard (*149*) reported that in 1878 Col. E. L. Berthoud observed them at Targhee Pass, Idaho, at an elevation of 6,970 feet and that "they seemed, in spite of the cold and snow, to scarcely be hindered by a temperature of 7° above zero." Many observers have since reported that with the passing of unfavorable weather, Mormon crickets have soon reappeared in seemingly unreduced numbers and with undiminished activity. Such observations have led to an assumption by some that they are almost immune to the effects of weather extremes.

On numerous occasions several inches of snow have fallen on infested areas, or cold, wet weather has persisted for long periods. At such times control work has had to be discontinued, because the insects were in protected places and were not feeding, to be renewed with greater vigor after the return of favorable weather. Doubtless, many Mormon cricket nymphs were killed at such times, especially first-instar nymphs, but the remaining population was so large as to still require control and the dead ones were not readily missed.

Many extensive, heavy infestations have diminished or disappeared without any work having been done to control them. Predators or parasites have not been found to any extent in such cases, so it is assumed that weather has been one of the factors that reduced the populations.

Parker (*82**) reported a study of weather patterns in several areas in Montana and Idaho by Cowan and Shipman, who said:

> Observations have indicated . . . that the critical conditions probably occur most frequently during the hatching and nymphal period. Other factors such as control operations, parasites, and predators must also be considered, but with the possible exception of control operations applied when the cricket bands start to spread from outbreak centers, weather still is the prime factor in cricket outbreaks.
>
> In the typical outbreak center where crickets can survive over a period of years, the hatch is normally retarded until a more stabilized condition of warm weather prevails. In the typical outbreak areas, the hatch comes early during a period of 'unseasonably warm weather,' only to be wiped out later by a prolonged period of cold and snow.
>
> Conditions favorable to cricket increase do occur in these outbreak areas, and a succession of years of such conditions naturally results in a wide spread cricket problem. . . .
>
> Once a cricket infestation has spread beyond the outbreak center it becomes differentially vulnerable to weather conditions. An example of this may be cited in Clark and Fremont Counties in Idaho in 1942. The infestation had spread in 1941 until cricket bands were common throughout the higher and lower foothills, and desert country to the south. The hatch apparently was normal over the whole area. In the early part of May 1942, a two weeks period of cool, wet weather settled over the region. In the higher foot-hills, the storm was apparently severe enough to practically eradicate the crickets. In the lower foothills where the storm was less severe, several bands of crickets were observed about June 1 to be unusually small or stunted. The crickets in the large desert were to all appearances affected very little if any.
>
> Similarly the storm may be severe enough to wipe out an infestation even in the lower areas. Such a storm occurred at about the same time in the vicinity of Sheridan, Wyo. The crickets were observed to be 50 to 60 percent hatched by April 18, 1942. Then on April 23, with the hatch practically complete, a 13-day period of cold, wet weather began. During this period 2.06 inches of precipitation fell in 9 days. The maximum temperature was 59° F. and the minimum 32° F. The

newly hatched crickets probably did very little feeding in this 13-day cold spell and while it is unlikely that many were killed, most of them were undoubtedly seriously weakened.

The week of May 5 to 12 was warmer with temperatures rising to a maximum of 71° F., but the rain continued to interfere with feeding activities and probably didn't allow for a proper recuperative period from the earlier cold spell. Then on May 12, the weather again turned cold and in some areas as much as 7 inches of heavy wet snow fell between May 12 and 16. During the continuing cold weather the snow was removed very slowly and some bands were buried as long as 10 days. At any rate, the weather between April 23 and May 19 as described above, either killed outright or weakened the crickets to a point where they couldn't recover, and what had been a threatening outbreak was almost entirely wiped out.

Another instance of conditions unfavorable to crickets in outbreak stage, occurred in the vicinity of Benteen, Mont., in 1939. In the period of approximately one month between May 20 and June 18, the rainfall totaled 7.32 inches. . . . . It rained measurable amounts for 14 days which were quite evenly distributed through the 30-day period. On many days when no rain actually fell, the weather remained cool and cloudy, and the soil and vegetation being thoroughly saturated presented very unfavorable conditions for feeding or other activity. Of course there were some bright sunny days during this period when feeding did take place and the crickets did continue to develop slowly. On May 20 the crickets were noted to be in the 4th to 7th instars and on June 20th they were mostly adults. . . . The development, however, was retarded considerably due to the frequent interruptions caused by the unusual amount of rain.

The adult crickets that developed in this area were abnormally small. Later observations showed further that they died earlier than usual and laid considerably fewer eggs than their numbers indicated. At any rate the cricket infestation which had been flourishing for 2 or 3 years in the Benteen area was practically non-existent the next year.

. . . . . .

It is quite likely that there are still other weather conditions which have an adverse effect on crickets. . .

Abnormal weather in Idaho in 1953 was primarily responsible for a population reduction of Mormon crickets and a subsequent reduction of the planned control program. Trained supervisors were working in the infested area from the time the eggs hatched until the end of the control season. They knew that nymphs had hatched as expected, that they had disappeared in May, and that the weather had been unusually wet and cold. They all concluded that the abnormal weather had killed the nymphs and found no other cause.

A fall survey in 1952 had indicated that infestations then present would require control operations on 32,000 acres of rangeland in Ada County and 28,000 acres in Washington County in 1953, and plans were made accordingly. In the spring of 1953, emergence of nymphs was well under way in both counties on April 20. Frequent observations of populations were made thereafter. Population reductions began to be apparent by May 4 and continued until precontrol surveys were made on June 2. Weather for that time of the year was the coldest and wettest ever experienced by the oldest inhabitants or recorded by the U.S. Weather Bureau. When the population decreases became evident, revisions in control estimates were made, and eventually only 4,645 acres in Ada County and 11,000 acres in Washington County required control, reductions of 85.5 and 60.7 percent, respectively.

Records of the U.S. Weather Bureau at Arrowrock, Boise, and Cambridge, Idaho, in or near the infested area showed the following average percentages of normal monthly precipitation and of normal mean monthly temperature for the period February through September, 1953:

Month	Precipitation	Temperature
	Percent	*Percent*
February	114	105
March	123	100
April	107	95
May	227	96
June	151	91
July	0	99
August	69	101
September	5	100

Average of daily minimum temperatures at Arrowrock, Boise, and Cambridge, Idaho, were as follows:

Day of month	April	May	June	Day of month	April	May	June
	°*F.*	°*F.*	°*F.*		°*F.*	°*F.*	°*F.*
1	22.0	27.3	44.7	16	35.0	42.7	47.3
2	22.0	30.7	46.3	17	40.0	41.7	49.0
3	27.3	33.3	39.7	18	32.0	42.7	48.0
4	27.7	36.7	42.3	19	37.0	44.0	44.7
5	29.7	37.0	43.7	20	39.0	37.3	39.0
6	28.3	44.3	47.7	21	41.0	40.7	43.0
7	27.3	40.3	43.7	22	43.3	34.7	46.3
8	24.0	37.7	37.0	23	43.3	40.7	48.0
9	30.3	34.7	43.7	24	36.3	36.3	36.3
10	28.3	31.0	44.0	25	39.3	34.3	42.0
11	22.7	34.0	47.0	26	46.7	40.0	46.0
12	20.0	39.0	47.0	27	43.7	34.3	47.7
13	31.0	39.0	40.7	28	38.3	40.0	50.0
14	28.3	42.0	46.3	29	29.0	42.3	46.7
15	27.7	46.3	45.7	30	35.7	46.3	45.3
				31		48.0	

After nearly all the eggs had hatched, the weather was abnormally wet and cold from the latter part of April through the first part of June. Measurable precipitation was recorded in April for 12 days at Arrowrock, 11 days at Boise, and 7 days at Cambridge; in May, for 16 days at Arrowrock, 12 days at Boise, and 10 days at Cambridge; and in the first half of June for 9 days at Arrowrock, for 7 days at Boise, and 5 days at Cambridge. On several other days traces of precipitation were recorded at each station.

The combined effect of abnormally cold and wet weather during the critical nymphal stage kept the nymphs inactive for such prolonged periods that they undoubtedly died from exposure and starvation. Indeed, supervisors had great difficulty in traversing the infested area in 4-wheel drive jeeps during May and early June.

DEVELOPMENT OF COOPERATIVE CONTROL

The first 80 years that Mormon cricket outbreaks were known in the United States, the people were unprepared to cope with them. Outbreaks came without warning, usually at a time when farmers were busy in the fields. At different times and in many States, money had been belatedly raised for fighting specific outbreaks and the people in the infested communities volunteered their services, but no definite plans for financing a control program or no concerted effort had been made.

After the major outbreak began developing in 1930, several States used every means of control they could muster, but it soon became apparent they were not enough to reduce the infestation.

To help in fighting Mormon crickets in Moffat County, Colo., in 1929, the United States Government appropriated $8,000 to cooperate with the State and the county and provided additional assistance in 1930 and 1931. When the outbreak occurred at Fort Hall, Idaho, in 1932, it was part of the regional outbreak that was to involve 11 States before it subsided. The State had no funds for Mormon cricket control. The following request for help is quoted from the Congressional Record, June 11, 1932, page 12709, because it pictures a situation that was illustrative of the helplessness of other States then or in the years following, a helplessness that proved to be the challenge that b r o u g h t about organized control:

> Mr. Smith of Idaho: Mr. Speaker, for the first time we have found it necessary to come to the Federal Government for aid to help eradicate grasshoppers in Idaho. When the invasion of these pests was brought to our attention about 10 days ago, we took the matter up with the Commissioner of Indian Affairs because of the fact that they appeared first on the Fort Hall Indian Reservation. He telegraphed the superintendent for a report, and I wish to read the superintendent's reply to the commissioner's inquiry, showing the immediate need of additional help to eradicate these grasshoppers or crickets as they are known in Idaho.
>
> Pocatello, Idaho
> June 2, 1932
>
> C. J. Rhodes
> Commissioner of Indian Affairs
> Washington, D. C.
>
> Retel second, grasshopper situation reaching enormous proportions. Hundreds of men working day and night without compensation. Volunteers help cannot hold out much longer. Funds allotted being used for food supplies and other materials. Additional funds necessary if effective results had. Old crickets originated on reservation. Millions have drifted down main canal onto white lands off reservation. Some crickets crossing canal onto farming lands of reservation. Campaign must be carried on strenuously for indefinite time. Most urgent wire additional funds.
>
> s/ Gross
>
> The Commissioner of Indian Affairs at once authorized an expenditure of $500.00 for cooperative work and duplicated that amount the next day because of the urgency of the situation.

Representative Smith then read another telegram stating that a citizens' committee had been formed. This committee informed him that all local agencies were cooperating but that volunteer labor could not be depended upon exclusively, and recommended

that funds be hastened to employ workers for which it estimated that $300 per day for 30 days would be needed.

The final cash outlay in the Fort Hall outbreak of 1932 was only $2,500, of which $500 was provided by the county, $500 by the State, and $1,500 by the Bureau of Indian Affairs (*106**). An abundance of volunteer workers compensated somewhat for the meager funds available. With each succeeding year, workers volunteered their services less and less to meet a problem that was growing larger and larger in many States.

Various Federal relief agencies were functioning by that time and several States obtained allotments to aid in employing labor and purchasing control materials. Some of them obtained small State-appropriated funds.

Compilation of incomplete records, as shown in table 2, gives an idea of the large amount of Mormon cricket control work done before a regional project was established.

TABLE 2.—*Money expended by various agencies*[1] *in five Western States for control of the Mormon cricket, 1935–36*

Year and State	Area dusted	Expenditures[2]					
		State	County	WPA	FERA	ECW	Total
	Acres	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1935:							
Idaho	9,725	.....	8,130	.....	14,888	.....	23,018
Montana	.....	.....	[3]	.....	.....	.....	.....
Nevada	.....	1,881	.....	.....	33,118	.....	34,999
Washington	.....	[3]	[3]	.....	.....	.....	.....
Wyoming	24,568	.....	[3]	[3]	.....	.....	[4]36,553
1936:							
Idaho	45,342	.....	9,230	.....	85,342	.....	94,572
Montana	10,000	2,000	[3]	[3]	.....	.....	2,000
Nevada	61,000	3,900	[3]	123,447	.....	24,431	151,778
Washington	2,600	3,375	4,171	760	.....	.....	8,306
Wyoming	[3]	500	.....	.....	.....	.....	[5]500
All expenditures	.....	.....	.....	.....	.....	.....	351,726

[1]Works Progress Administration (WPA), Federal Emergency Relief Administration (FERA), Emergency Conservation Work (ECW).

[2]Information from State reports and correspondence with States.

[3]Agency made expenditures but amount not shown.

[4]Not broken down for participating agencies.

[5]Cost of materials only; control work was done by individuals.

The need for checking the outbreak had become so urgent and general that entomologists in all States concerned with the problem, though appreciating the help that relief agencies had given, concluded that the outbreak could not be halted until means were available to provide adequate labor responsible to competent supervisors and to purchase needed equipment and supplies. The entomologists met in conference in Salt Lake City on November

8, 1935 (*106**). Participating were representatives of many interested agencies, including the former U.S. Bureau of Entomology and Plant Quarantine. The problem was treated as a regional one. The conference requested a Federal appropriation that could be used to finance control in cooperation with all infested States. A second conference was held in Pocatello, on October 23, 1936, (*192*) for the same purpose. Although Federal representatives were sympathetic to the need for a regional undertaking, action to finance a campaign did not follow as a result of either conference.

In 1937, WPA money had been allocated for cooperative work with certain infested States where the control work would be under the general direction of the Bureau. The States were Colorado, Montana, Oregon, Utah, Washington, and Wyoming. Idaho and Nevada carried on control work with State relief funds, and the Bureau gave some aid to South Dakota from grasshopper control funds for the purchase of equipment and materials (*35**). A regional office, headed by Frank T. Cowan, was established at Helena, Mont. State leaders, who were official entomologists in their own States, assumed State responsibility for the campaign. Their assistants were paid out of project funds. The chief means of control was a dust containing sodium arsenite applied with hand dust guns by paid laborers. Supplemental control means were traps, and oil-on-water, metal and wood, and trench barriers.

Mormon crickets were cleaned out of two counties in Montana and only a light infestation remained in Colorado. Otherwise, there was a decided increase in the size of the infested area, although in general there were fewer Mormon crickets per unit area than before the control work was done.

Mormon cricket and grasshopper outbreaks had become so widespread that a general conference was called at Sioux Falls, S. Dak., on August 6, 1937, to consider means for quelling them. The conference, attended by representatives of railroads and 13 States, including farmers, bankers, and entomologists, recommended that Federal funds be provided for cooperative work with affected States (*28*).

Following a third regional conference in Pocatello on November 18–19, 1937 (*111**), the Bureau recommended and Congress ultimately passed a bill appropriating $600,000 for Mormon cricket control work in 1938. The bill stipulated that the fund would be available to the Secretary of Agriculture to use, at his discretion, for cooperative work with the various States.

The Bureau created a Mormon Cricket Control Project in 1938, and established a regional office at Salt Lake City, with Claude Wakeland in charge. Annual appropriations were made thereafter, so the project, though changed in form from time to time, has continued Federal cooperation with States for the purpose of controlling Mormon crickets. At the end of the 1939 control season, the regional office was moved to Denver, Colo. In 1951 and 1952, the project was headed by P. A. Hoidale, and thereafter by James R. Dutton.

The basic plan has been to employ a trained supervisor to be

in charge in a State, or in an area comprised of two or more States, working under the direction of the regional office. He employs assistant supervisors, foremen, and laborers to make surveys and carry out control work. He plans survey and control work in his area in cooperation with State and local agencies interested. The work plans of all States, or areas, are coordinated in the regional office and approved according to the regional need and the means available.

Plans for control in any year are made after results are known of an adult survey conducted late in the previous summer to determine where the infested areas are and the population density of each. The areas appearing to justify control after that survey may have become enlarged after eggs were deposited or smaller owing to winter and early spring mortality caused by such factors as adverse weather, predators, and egg parasites. Therefore, in the spring, after the eggs have hatched, the infested areas are again surveyed to determine where control is justified. Categories to classify degrees of infestations are heavy, moderate, and light. A heavy infestation has 15 or more Mormon crickets per square yard, a moderate infestation has from 5 to 15, and a light one has less than 5 crickets (*54*). Control work is directed chiefly against heavy infestations and to a lesser extent against moderate ones.

Control of light infestations is often done, however, when the infested areas are small, as at the beginning of an outbreak, or to finish "cleaning up" where extensive control work has left a small population in parts of a large area. This work is considered to be justified, for small expenditures then prevent the buildup of outbreaks that would be difficult and expensive to control later.

When the regional project was established in 1938, counties desiring to cooperate were required to provide a third of the cost of the control programs. Then, because control work was usually on Govenment-owned or -controlled lands, this policy was modified and the general plan of procedure was for the Federal Government to provide funds for hiring required supervision and labor and for the purchase and transportation of materials. Cooperating counties and States provided mainly for the hire and transportation of laborers, local supervisors, and supplies, each according to what it was best able to furnish.

Control practices have been changed from year to year to take advantage of any new research findings that would increase the speed and efficiency, or reduce the cost of operations. Such changes have been made only after improvements discovered by research have been proved practical and effective in actual field work. For example, when sodium fluosilicate bait was discovered, before it was adopted for general field use, the control division of the Bureau cooperated with the research division in trial-baiting a large area. Changes made in control practices are briefly described under "Evolution of Control Methods," page 30. How and to what extent these changes were made after cooperative control on a regional basis was undertaken, 1937–49, are shown in table 3.

TABLE 3.—*Control accomplishments, 1937–49, showing changes in control methods* [1]

Year	Size of known infestation	Dusted				Pen and pit traps	Barriers			Bait (dry weight)	Baited		
		Total area	With sodium arsenite	By hand duster	By power duster		Oil-on-water	Metal and metal-wood	Trench		Total area	By power ground spreader	By airplane
	Acres	*Acres*	*Tons*	*Number*	*Number*	*Number*	*Mile-days*	*Mile-days*	*Miles*	*Tons*	*Acres*	*Acres*	*Acres*
1937	14,165,601	396,385	935	2,017	15	1,950	[2]200	[3]489	247	[4]772	0	0	0
1938	18,919,340	290,026	775	1,973	161	1,604	[2]3,775	[3]1,331	63	0	0	0	0
1939	14,278,500	353,499	831	1,254	205	2,814	[2]495	[3]440	33	[5]263	44,043	33,032	0
1940	8,957,590	159,835	382	790	117	899	960	1,583	[6]114	742	162,819	115,349	7,058
1941	7,474,036	38,317	101	225	56	169	169	906	0	2,233	512,114	278,673	120,377
1942	2,026,920	6,275	15	[7]	[7]	9	109	6	.....	1,399	353,271	138,603	183,141
1943	936,050	0	0	0	0	0	46	2	.....	2,536	531,358	201,360	297,479
1944	295,100	.....	.....	.....	.....	.....	40	0	.....	1,820	243,617	79,389	155,477
1945	312,400	.....	.....	.....	.....	.....	70	.....	.....	1,536	157,811	65,646	90,794
1946	585,860	.....	.....	.....	.....	.....	54	.....	.....	1,654	255,467	132,930	46,179
1947	536,240	.....	.....	.....	.....	.....	0	.....	.....	1,666	257,729	195,736	5,996
1948	116,000	.....	.....	.....	.....	.....	.....	.....	.....	1,833	210,751	170,146	19,156
1949	138,200	.....	.....	.....	.....	.....	.....	.....	.....	216	82,450	79,450	3,000

[1] Includes data for State projects in Idaho and Nevada and the regional WPA project in 1937. Data derived from *35** and *90**, and annual reports of the control project for the period.

[2] Miles placed.

[3] Miles erected.

[4] Sodium arsenite bait.

[5] Sodium fluosilicate bait was used until 1948, after which organic chemicals were used as soon as the supply of sodium fluosilicate on hand was exhausted.

[6] Mile-days.

[7] Unknown.

The use of sodium arsenite dust decreased rapidly after sodium fluosilicate bait was proved to be effective, and it was discontinued after 1942. Pen and pit traps, and barriers that had been used to supplement sodium arsenite dust then ceased to have a place in the control program. Baiting reached its peak in 1943. The use of bait thereafter decreased as the infested area was reduced, but proportionately, more bait was used because more concentrated work could be directed against remaining infestations. In 1948, sodium fluosilicate bait began to be replaced by bait containing one of the organic chemicals. Bait was spread chiefly by power ground spreaders in 1939, but airplanes began to be used in 1940. The acreage baited by airplanes annually soon exceeded that baited by ground spreaders. It will be noticed that between 1945 and 1950 the acreage baited by ground spreaders exceeded that baited by airplanes. It was then feasible and more economical to use ground spreaders to control Mormon crickets where they justified control but where the infested areas were not extensive enough to warrant the use of airplanes.

The basis of cooperation was changed after 1949. The Bureau assumed full responsibility for Mormon cricket control on Federal lands. The Federal land management agencies, such as the Forest Service, which were involved in each area baited, provided as much help as they could within their regular budgets. The Bureau did not undertake Mormon cricket control on rangelands owned or controlled by States or individuals unless two-thirds of the cost was borne by the cooperators. Baiting such lands was usually done by airplane, with States and individuals contracting and paying for the airplanes and the Bureau furnishing technical assistance, supervision, and bait materials. Information available on control of Mormon crickets with baits for 1950–55 is shown in table 4.

TABLE 4.—*Control of Mormon crickets with baits, 1950–55*

Year[1]	Area infested	Baited by		Bait used
		Airplane	Ground spreaders	
	Acres	*Acres*	*Acres*	*Tons*
1950		43,097	24,796	246
1951[2]	231,000	0	23,322	100
1952		159,675	7,625	582
1953	850,000	585,044	32,900	1,622
1954	122,000	119,308	2,200	303
1955	122,000	74,044	21,126	245

[1]Data derived from the 1950–56 Mormon cricket annual reports.
[2]510 acres sprayed with an emulsion containing 95 pounds of chlordane.

The approximate costs of Mormon cricket control in the United States from the time organized control was undertaken in 1937 through 1955 are shown in table 5. Only costs on record are shown; contributions of many voluntary workers or of individuals who protected their own crops are not included. Counties in

which control work of any form has been done at any time are shown in figure 1, page 2. For some counties shown, control may have been necessary in only a single year, but for others it was required for many, often consecutive, years.

TABLE 5.—*Expenditures for Mormon cricket control, 1937–55*[1]

Year	States	Counties and individuals	Other Federal agencies	Bureau of Entomology & Plant Quar.	Total
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1937	47,851	[2]152,151	25,650	598,733	824,385
1938	27,617	173,941	.....	421,813	623,371
1939	.....	[3]165,829	21,771	381,054	568,654
1940	.....	91,786	.....	240,714	332,500
1941	9,265	29,444	21,869	263,504	324,082
1942	6,876	10,503	3,029	207,528	227,936
1943	3,922	11,650	2,879	274,284	292,735
1944	.....	[3]17,124	.....	252,119	269,243
1945	.....	5,913	.....	186,256	192,169
1946	.....	[3]10,974	.....	202,584	213,558
1947	.....	[3]21,649	.....	223,454	245,103
1948	.....	[3]2,832	.....	286,330	299,162
1949	.....	4,034	.....	43,664	47,698
1950	790	9,096	2,053	32,320	44,259
1951	2,527	4,040	1,737	8,098	16,402
1952	3,980	6,551	2,599	103,512	116,642
1953	17,373	19,421	12,334	300,484	349,612
1954	.....	8,887	4,713	70,086	83,686
1955	.....	8,216	1,911	48,723	58,850
All expenditures					5,130,047

[1]Data derived from *35** and *90**, and from annual reports of the control project.

[2]Includes all regional or State WPA or relief projects.

[3]Where records were not broken down to show the different cooperating agencies, the non-Bureau expenditures are lumped in this column which include also expenditures by States and other Federal agencies.

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(103*) UNIVERSITY OF MINNESOTA.
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(105*) WAKELAND, CLAUDE.
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(128*) WHELAN, DON B.
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(130*) WHITEHEAD, F. E.
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(132*) WRIGHT, LE ROY C.
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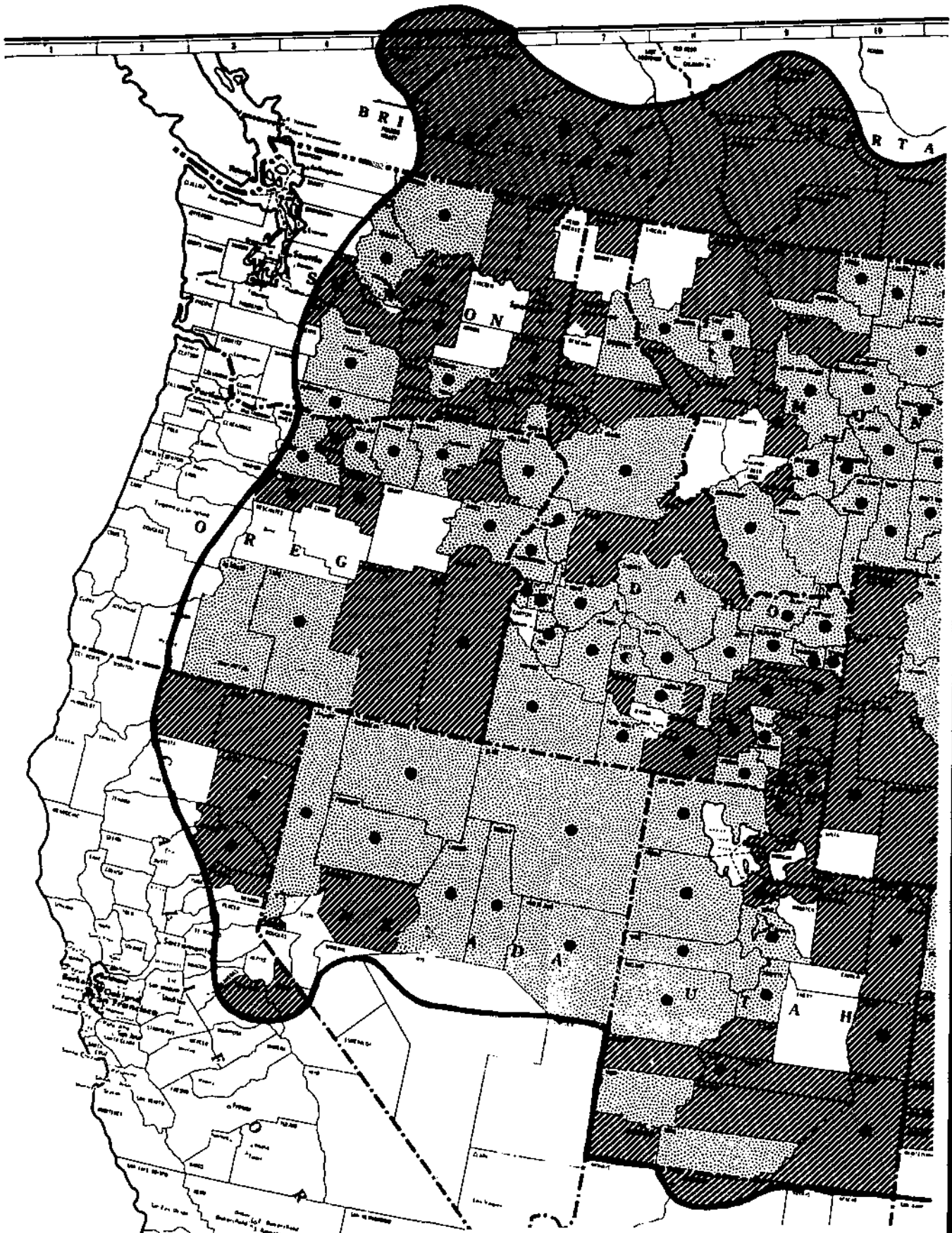
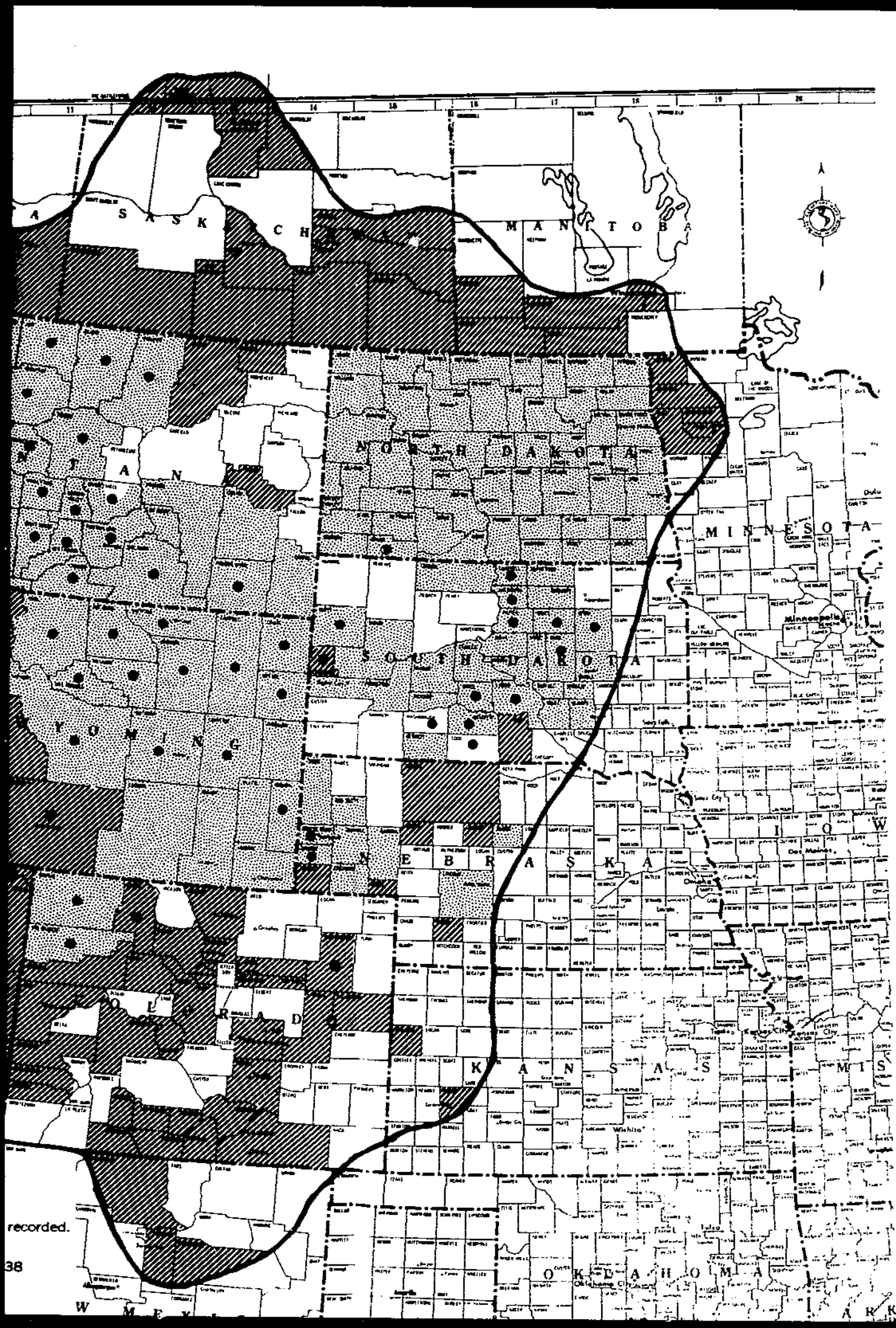
[5]See footnote, page 70.


MORMON CRICKETS
All counties shaded are those in which populations have been recc
Counties in which they were recorded in the 1938 survey.


SASKATCHEWAN
MANITOBA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
COLORADO
KANSAS
MISSOURI
OKLAHOMA
Minneapolis
Omaha
Wichita
Oklahoma City

recorded.

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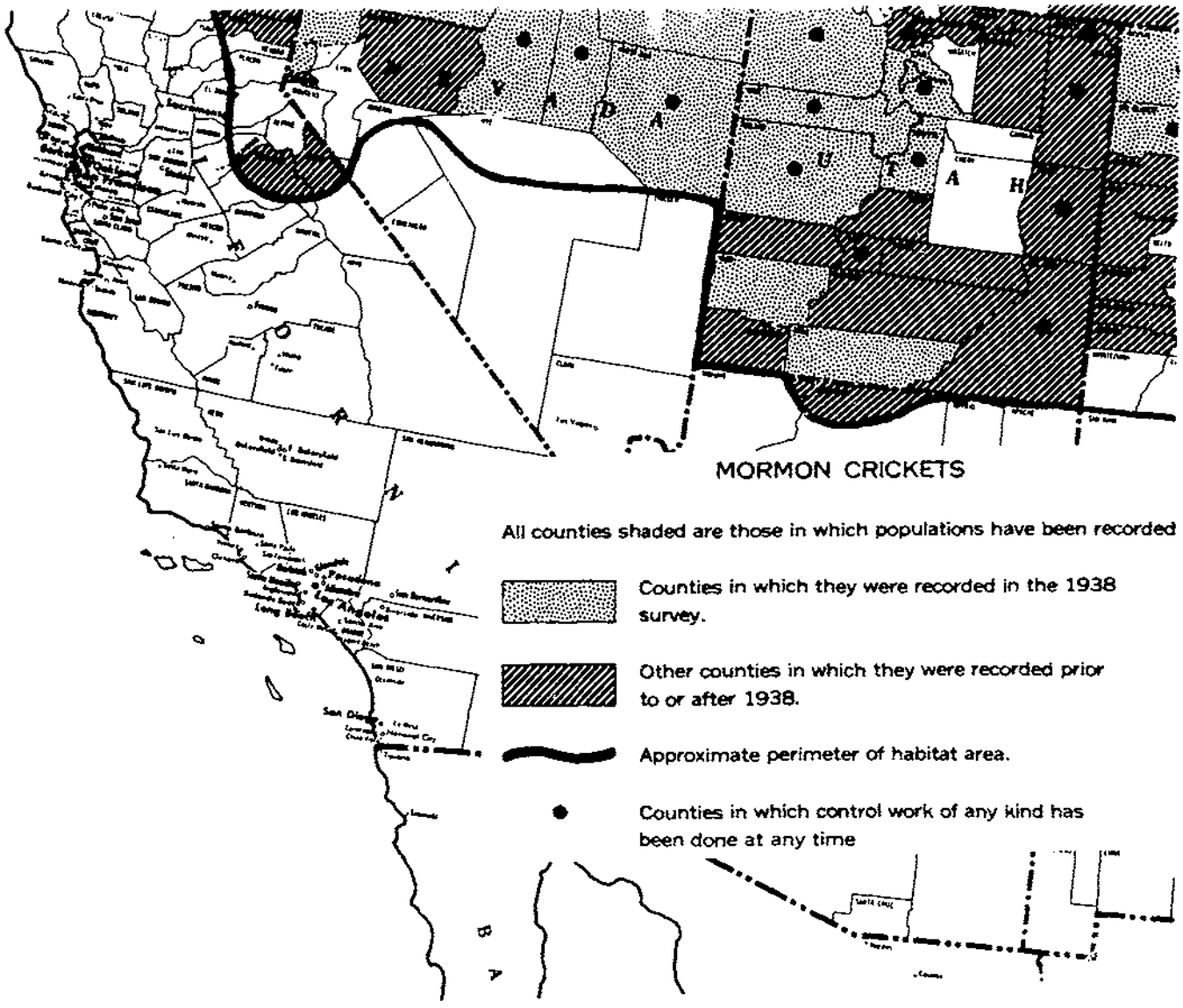

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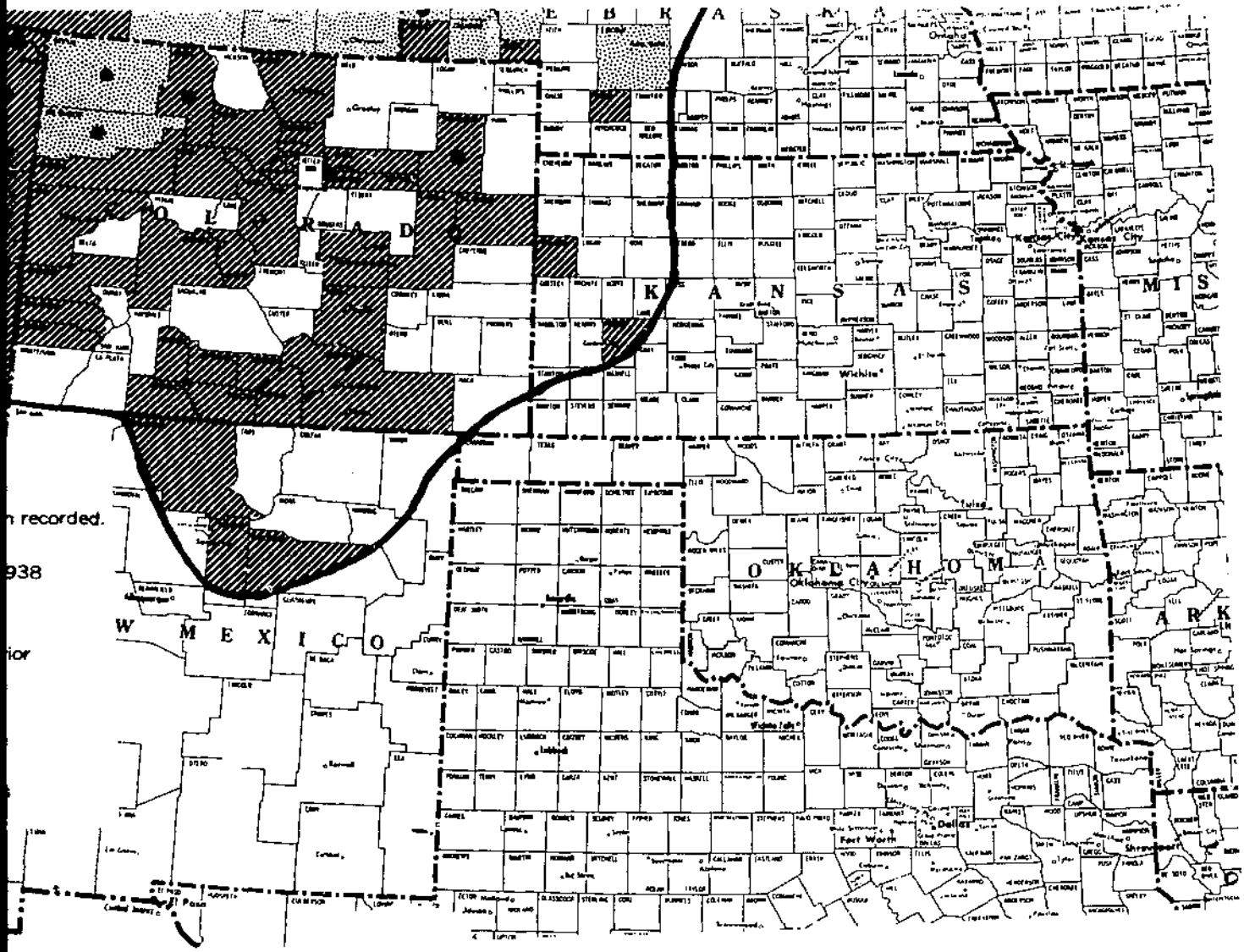
Figure 1.—Habitat and distribution of Mormon crickets in North America. The outline map on which distribution and control data are recorded is copyrighted by the American Map Co.; used with their permission. (Many counties recorded as being infested in 1938 were also recorded previously or afterward.)



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