BioOne COMPLETE

Factors affecting the distribution of the threatened Lake Huron locust (Orthoptera: Acrididae)

Authors: Scholtens, Brian G., Reznik, Joseph, and Holland, Janet

Source: Journal of Orthoptera Research, 14(1) : 45-52

Published By: Orthopterists' Society

URL: https://doi.org/10.1665/1082-6467(2005)14[45:FATDOT]2.0.CO;2

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://bioone.org/journals/Journal-of-Orthoptera-Research on 25 Apr 2024
Terms of Use: https://bioone.org/terms-of-use

Factors affecting the distribution of the threatened Lake Huron locust (Orthoptera: Acrididae)

Brian G. Scholtens, Joseph Reznik and Janet Holland

(BGS) Biology Department, College of Charleston, 66 George St., Charleston, SC 29424. Email: scholtensb@cofc.edu
(JR)Department of Biology, University of Vermont, 102A Marsh Life Science, Burlington, VT 05405. Email: Joseph.Reznik@uvm.edu
(JH) 1223 Redeemer Dr., Hanahan, SC 29406. Email: Janet_Holland@gmail.charleston.k12.sc.us

Abstract

We surveyed the lakeshore dunes on Lakes Michigan, Huron, and Superior in the state of Michigan to determine the extent of the range and number of populations of the threatened Lake Huron locust (*Trimerotropis huroniana* Wlk.) (Orthoptera: Acrididae). The locust's distribution is determined by a combination of historical and recent influences. Historical factors include the glacial history of the state and probable competition from other banded-wing locusts. Recent factors are primarily anthropogenic, including major habitat disturbances in the form of development, recreational use, and revegetation efforts; but lake level changes may also influence small local populations. Our surveys indicate that the species is fairly tolerant of disturbance and currently secure in Michigan. The status of the species in adjoining Wisconsin and Ontario is not well known.

Key words

Trimerotropis huroniana, distribution, threatened species

Introduction

The distributions of animal species are determined by many things, including historical (biogeography), ecological (competitors, predators and parasites, food sources), and anthropogenic (development, overuse, invasives) factors. To make informed recommendations on how best to prevent the decline of threatened and endangered species, we must examine the influence of these factors on the species' distributions. This is especially true because the distributions of threatened and endangered species are very often limited in geographic or ecological extent.

The crucial first step is determining the entire range of habitats in which a rare species occurs and those in which it does not. Thus, when feasible, surveys for populations should be done in all potentially appropriate habitats so that informed conservation recommendations can be made. This is particularly true for many threatened or endangered insect species, because they are generally poorly studied, often overlooked in habitat assessments, and seasonal, so that surveys at inappropriate times will not detect their presence (Evers 1994, Wisconsin Dept. of Natural Resources 1999).

The Lake Huron locust (*Trimerotropis huroniana* Wlk.), threatened in both Michigan and Wisconsin, is an excellent example of a species where gathering detailed information about the distribution of populations has direct bearing on conservation recommendations. Our previous knowledge of the distribution of this species was based primarily on work by Hubbell (1929) and Otte (1984), who compiled the existing museum records and examined several populations in the field. Both studies indicated that the species is restricted to northern Great Lakes dune habitats. This was the basis for its listing as threatened in both states (Evers 1994, Wisconsin Dept. of Natural Resources 1999). The extent of these earlier surveys was very limited, for Hubbell, probably because of travel difficulties and for Otte, because the main focus of his work was on communication behavior (Otte 1970). Together they documented 20 populations (16 by Hubbell, at least 8 by Otte, with some overlap) of the species in Ontario and Michigan. Ballard (1987; 1989; 1991a,b) did additional work in the late 1980s and early 1990s. He located several additional populations, including the first Wisconsin population (Ballard 1989). Occasional sampling in Michigan by Nature Conservancy personnel detected a few more populations. In total, before the start of this study, 25 different populations had been documented.

Otte (1984) noted that the southern limits of the locust appeared to have changed between Hubbell's survey and his. Along the Lake Huron shore in Michigan, the locust was no longer present at southern localities noted by Hubbell, but had been replaced by its congener, *T. maritima* (Harris). In addition, on the eastern Lake Michigan shoreline the locust appeared to have extended its range to the south. Ballard's studies did not address these apparent range changes. None of the studies specifically mention dune sites where the locust was not found. Comparing known absences with known occurrences can be important in determining the most important factors influencing the distribution of the locust.

The purpose of the current study was to fully document the range of the Lake Huron locust in Michigan by surveying as many dune habitats for populations as possible. The information gathered from these surveys was used to assess the influence of historical and recent influences on the distribution and conservation status of the species.

Methods

We surveyed for populations of the locust over the course of 3 summers (1996 to 98) following preliminary work in 1995 (and one incidental observation in 2002). We visited every dune habitat to which we could gain access within the state of Michigan. These locations were along the shores of Lake Michigan, Lake Huron and eastern Lake Superior to Pictured Rocks National Lakeshore. During 1995, scattered localities were surveyed in connection with an ongoing project on nesting success in the piping plover (Wemmer unpub. data). The remainder of the shoreline was covered in sections, always during the adult flight season so that locusts could be detected both visually and auditorily. The northern section of

Downloaded From: https://bioone.org/journals/Journal-of-Orthoptera-Research on 25 Apr 2024
Terms of Use: https://bioone.org/terms-of-use

the Lake Huron shoreline along the Lower Peninsula was surveyed during 1996. The shores of Lake Michigan, Lake Huron and eastern Lake Superior in the Upper Peninsula were surveyed during 1997. The southern section of the Lake Huron shoreline along the Lower Peninsula was surveyed during 1998. The southern section of the shore of Lake Michigan, along the Lower Peninsula, was surveyed during 1998.

At each site we checked for the presence of the locust and estimated the relative size of the population by estimating how many individuals were seen. At each site, except those inside Pictured Rocks and Sleeping Bear Dunes National Lakeshores, vouchers were taken. These samples generally consisted of 2 males; females were collected only occasionally. These vouchers are deposited in the University of Michigan Museum of Zoology. Sample days were chosen to be mostly sunny, warm days, suitable for locust activity. At each location we surveyed most of the available habitat (with the exception of localities with many miles of dunes). Thus it is unlikely that populations were overlooked at localities where we recorded no locusts.

We surveyed many localities each sampling day, and thus limited our assessment of habitat variables to qualitative measures. At each locality we noted the dominant species of plants: particularly known hosts, dune specialists, and known invasive species. The extent of invasion was recorded as none, small amount or large amount. The extent of other disturbances was noted (*e.g.*, foot traffic, off-road vehicle use, recreational use, known or suspected revegetation efforts). We noted other grasshopper species present, particularly banded-winged locusts (subfamily Oedipodinae). In general, we did not observe locust behaviors, instead focusing our limited on-site time to determining presence/absence and habitat characteristics.

Results

The general distribution of the Lake Huron Locust is very similar to that previously indicated by Hubbell (1929) and Otte (1984). Overall we located 64 populations of *T. huroniana* (Table 1), although defining the limits of some of the populations is difficult [we were unable to survey several populations previously recorded by Otte (1984) and Hubbell (1929), especially those on islands]. The locust occurs on most suitable beaches in the northern Great Lakes, including the northern shores of Lakes Michigan and Huron, the eastern shore of Lake Michigan (also at least 2 locations on the western shore in Wisconsin), the western shore of Lake Huron, and the eastern part of the southern shore of Lake Superior. *T. huroniana* is not found south of Ludington St. Pk. in Mason County on the eastern shore of Lake Michigan or south of Au Sable Pt. in Iosco County on the western shore of Lake Huron. The westernmost locality on the southern shore of Lake Superior is the dunes at Grand Marais in Pictured Rocks National Lakeshore. *T. huroniana* is also present on several islands in northern Lake Michigan, including North (historical) and South Fox Islands, Hog Island (historical), High Island, Beaver Island and likely North and South Manitou Islands (habitat is appropriate and park service rangers report dune locusts). The locust is absent from the Green Bay section of Lake Michigan, both the east and west shores, even though suitable, relatively undisturbed habitat, is present (Fig. 1).

All survey localities were chosen because they had some habitat that could be classified as dune. These habitats ranged from small, single dunes to large multiple-dune complexes that extend for many miles. The dunes included relatively pristine habitats with few invasives through severely disturbed dunes with vegetation more similar to an old field. The size of the dune system (length and/or depth) was not correlated with the presence or absence of the locust. Dunes systems with and without locusts were found at both ends of the size continuum (Table 1).

The presence or absence of the locust was also not correlated with the presence or absence of native plant species (Table 1). Particular dune plant species are just as likely to be present at sites where the locust is not found as those where it is. The most commonly noted plant species upon which the locust is known to feed (pers. obs.) were *Ammophila breviligulata* (present at all surveyed sites but one), *Calamovilfa longifolia* (at nearly all sites except those on Lake Superior), and *Artemisia campestris* (at most sites). *Cirsium pitcheri* occurred at a smaller percentage of the sites. Since an exhaustive search of habitats was not done due to time constraints, some species are, in fact, present at sites where they were not noted.

Within the known range of the locust, the occurrence of non-native, invasive plant species is somewhat correlated with locust presence or absence. Table 1 indicates that most sites have invasives present (most commonly *Centauria maculosa*, *Asclepias syriaca*, *Gypsophila* spp. and old-field grasses), but only at high levels of disturbance are locust populations strongly affected. Horseshoe Bay in Mackinac County and Alcona Rd in Alcona County, are good examples of a high level of disturbance. At these sites, vegetation resembles an old field with many species of invasive plants and sand, the sand mainly stabilized. On some of these highly disturbed sites, *Spharagemon collare*, a banded-wing grasshopper commonly found in old fields, has become established, in 2 cases co-occurring with *T. huroniana* (Alcona Rd in Alcona Co. and Acme Twp Pk in Grand Traverse Co.).

Although state parks contain some of the largest and most stable populations, several sites without locusts (inside its known range) have been heavily developed for recreation within state parks (*e.g.*, Tawas St. Pk in Iosco Co.). Some parks have extensive beachfront housing (*e.g.*, near the city beach in Traverse City, Grand Traverse Co. and just north of Bay City St. Pk in Bay Co.)(Table 1). In these cases, dunes are effectively eliminated by development, leaving no suitable habitat for *T. huroniana*.

The locust is replaced along the southern part of the Lake Michigan shoreline by its congener, *T. maritima*. This replacement is fairly abrupt, with only one known interdigitation of populations of the 2 species. *T. maritima* occurs at the 5th Ave. beach in Manistee (Manistee Co.), with *T. huroniana* to the south at several localities in Mason Co. (Fig. 1). Further south, all populations are of *T. maritima*. A similar replacement does not occur along the western shoreline of Lake Huron. South of the range of *T. huroniana*, few suitable habitats exist until the thumb region of the state is reached (Fig. 1). Here, several *T. huroniana* populations reported by Hubbell (1929) were noted by Otte (1984) as having been replaced by *T. maritima* populations. When we rechecked these same localities in 1998, no populations of either species were located. At both Sand Pt. (where housing has eliminated nearly all dune habitat) and at Port Crescent State Park, the only banded-wing locust present was *Spharagemon collare* (Scudder)(Fig. 1). At Port Crescent St. Pk an extensive revegetation effort has been undertaken to re-establish typical dune grasses on previously highly disturbed dunes.

Off-road vehicle (ORV) use by itself does not appear to cause extirpation of the locust, but may significantly reduce populations. Population estimates were not made, but most sites that are heavily impacted by ORVs (now confined to the Upper Peninsula) seemed to have relatively smaller population sizes.

Downloaded From: https://bioone.org/journals/Journal-of-Orthoptera-Research on 25 Apr 2024
Terms of Use: https://bioone.org/terms-of-use

Species in the genus *Melanoplus* (not determined to species) co-occur with *T. huroniana* at 38 out of 45 sites where other grasshoppers were noted, and it probably occurs at all sites (see Table 1 for data on co-occuring species). The most common banded-wing locust occurring with *T. huroniana* is *Dissosteira carolina*, found at approximately half the sites. *S. collare* (at sites with some disturbance), *Trimerotropis verruculata* (Kirby), *Camnula pellucida* (Scudder) and *Arphia sulphurea* (F.), all occur on dunes with *T. huroniana* at a limited number of sites. During the early part of the summer, *Chortophaga viridifasciata* (DeGeer) also occurs at some of these sites. It is known to occur at Grass Bay on Lake Huron and at Wilderness State Park on Lake Michigan, at sites where the locust was monitored over the course of an entire summer. Adults of this species were not present during our mid-and late-summer surveys of the dune habitats.

Discussion

A species' distribution is defined by sites where the species is present, but the characteristics of potential habitat sites where the species is not present are key in determining the importance of the various factors for the overall species distribution. It is crucial to examine not just occupied sites, but also potential, unoccupied sites to determine the factors affecting the current distribution.

For the Lake Huron locust, whether or not a dune site is occupied is determined by a combination of historical and recent factors. The historical factors include the rise and fall of lakes during the previous several thousand years and probable competition with a congener. The recent factors are mostly anthropogenic in origin, including development and a variety of human disturbances; but the current rise and fall of lake levels may also play a significant role in the distribution pattern of the locust.

Historical factors

The historical factors that influence the distribution of the locust have their greatest influence at the periphery of its range. Past biological interactions among species are commonly considered (and will be here) when examining species distributions (*e.g.*, insect competition studies). Geological factors are less often considered for animals which are thought to be quite mobile. However, these factors are likely to be very important in areas such as the Great Lakes with a complex glacial history (Dorr & Eschman 1970). The movement of glaciers and the resulting drastic changes in water levels in the Great Lakes have left a historical legacy in the habitats of the area, and in the distributions of plants and animals.

The original segregate population of *T. huroniana* [from its west-

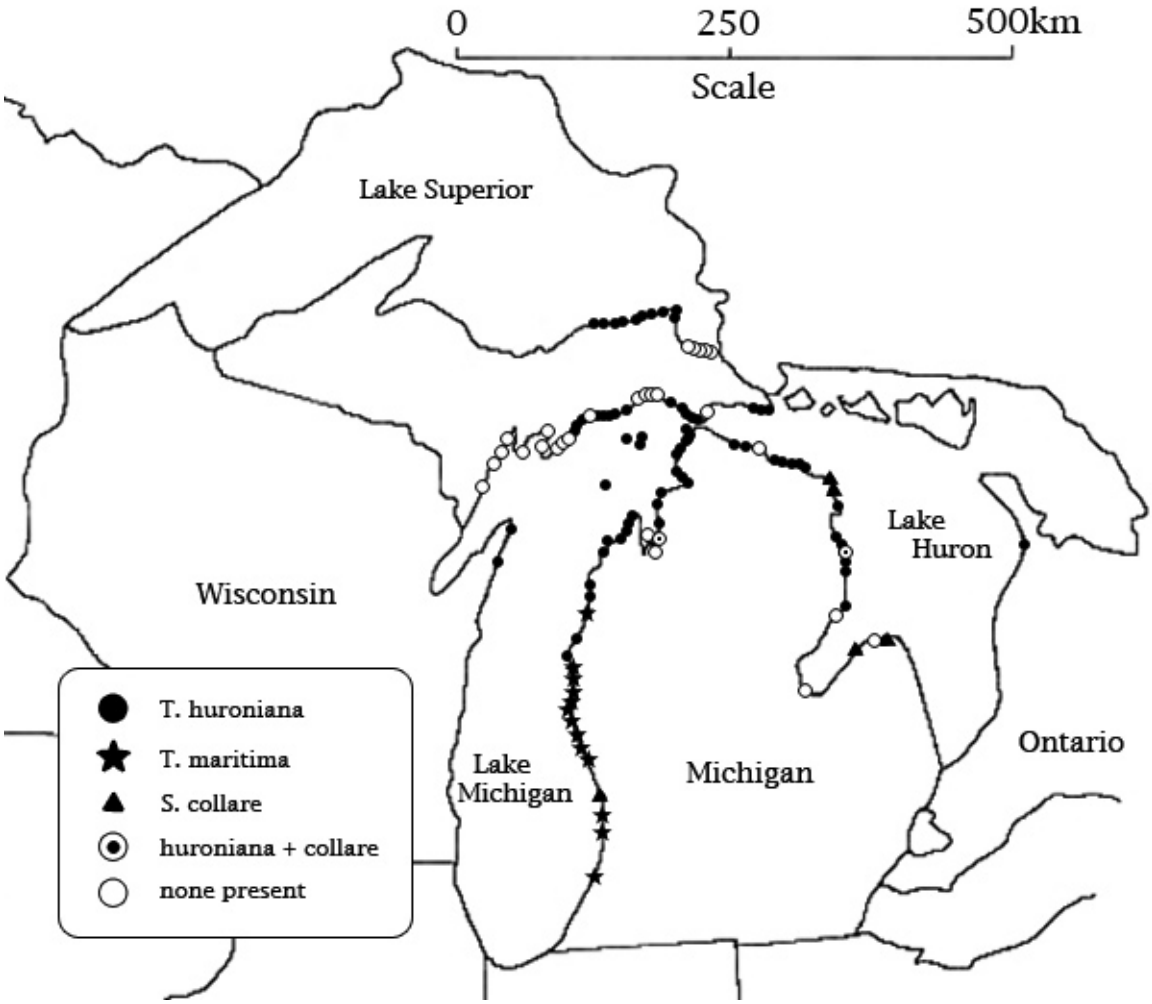

Fig. 1. Distribution of *Trimerotropis huroniana*, *T. maritima* and *Spharagemon collare* on dunes of the Great Lakes.

Downloaded From: https://bioone.org/journals/Journal-of-Orthoptera-Research on 25 Apr 2024
Terms of Use: https://bioone.org/terms-of-use

ern relative *T. pallidipennis* (Burm.); see Otte 1984] was probably isolated by the movement of glaciers and then stranded on a limited number of suitable dune habitats. This same pattern of isolation from western relatives is seen in other Great Lakes species, including 2 endangered species, Hungerford's crawling water beetle (*Brychius hungerfordi* Spangler) and Pitcher's thistle (*Cirsium pitcheri*) (Voss 1996). These species with western affinities have often adapted to dry, dune areas most similar to the arid western Great Basin. The time frame for this isolation is on the order of 10,000 y (Dorr & Eschman 1970).

The locust was presumably first isolated on dunes at the edges of the ancient Great Lakes. Over the next several thousand years lake levels rose and fell dramatically, shifting the location of the coastal dune habitat (Dorr & Eschman 1970). The locust certainly moved along with the dunes, sometimes being extirpated if dunes disappeared, and other times colonizing newly forming dunes or previously unavailable ones. The absence of the locust from the dunes on the shores of the western arm of Lake Michigan (no populations found despite extensive search), including Green Bay, is a striking remnant of historical changes in lake levels. The locust occurs consistently along the shoreline of Lake Michigan from the Straits of Mackinac up to the rocky sections on the eastern shore of the Garden Peninsula in Michigan. It is then absent from all dune habitats on the western shore of the Garden Peninsula and both shores of Green Bay, even though the habitats are apparently suitable for the locust. Populations reappear again on the eastern shore of the Door Peninsula in Wisconsin (Fig. 1).

Glacial history provides a likely explanation for this absence. About 9500 y ago, when a northern outlet from the lakes opened as the glaciers receded, lake levels dropped more than 350 ft below current lake levels, drying the western arm of Lake Michigan (named Lake Chippewa at that stage) and leaving no coastal dunes in this region. Any existing locust populations would have been extirpated during this period. Subsequently, this northern outlet closed, following glacial rebound, and lake levels rose once again, refilling the western basin and re-establishing coastal dune habitats (Dorr & Eschman 1970). Although this occurred at least 4000 y ago, locusts have not recolonized these dunes, perhaps because of low vagility of the locust and unsuitable rocky habitat along the Garden and Door Peninsulas separating the existing populations from the re-established dunes.

Competition with *T. maritima* has left a clear pattern in *T. huroniana*'s distribution, although the biological basis of this competition is undocumented. No locations have been found where the 2 species co-occur, even though their distributions interdigitate along the eastern Lake Michigan shoreline. Possible causes of this competition that should be investigated include interference during mating, access to food resources, or the ability to survive severe winter temperatures.

In undisturbed habitat along the southern edge of the range of the Lake Huron locust, its congener *T. maritima* replaces *T. huroniana* on lakeshore dunes as noted by Hubbell (1929) and Otte (1984). This occurs on the eastern shore of Lake Michigan in Mason Co. The cutoff is not a perfect dividing line as had been assumed by the earlier workers. At least one population of *maritima* (at Manistee) occurs north of some *huroniana* populations. Because this population is easily accessible and early surveys were spotty, this may explain the apparent discrepancy between Hubbell (1929) and Otte (1984) in their determination of the southern limits of *huroniana*. At the moment there is no conclusive evidence that the range of *huroniana* has been significantly expanding or contracting along this lakeshore.

A similar replacement of *huroniana* by *maritima* once occurred on the western shore of Lake Huron. Hubbell (1929) noted *huroniana* in the thumb region of Michigan (Huron Co.) and *maritima* farther south. Otte (1984) noted that by the 1960's *maritima* had replaced *huroniana* in the thumb region. Our current surveys indicate that neither species is present in appropriate habitats in the thumb region, but *huroniana* populations start again at about Au Sable Pt and continue north from there. We located no *maritima* populations on the eastern shore of Lake Huron, but did not examine dune systems south of the thumb region. The presumed reasons for these absences will be discussed below. Extensive surveys have not been done to determine if these 2 species show a similar pattern on the western shore of Lake Michigan in Wisconsin or on the eastern shore of Lake Huron in Ontario.

Recent factors

Our surveys indicate that anthropogenic disturbances have significantly affected populations of the Lake Huron locust. Where dunes remain, these disturbances are generally in the form of heavy human use by foot traffic and ORVs, which encourages invasive plant species to become established on the dunes. As this proceeds the habitat ceases to resemble a dune and appears much more like an old field, a habitat not used by the locust.

In the most heavily disturbed habitats, *huroniana* is replaced by *Spharagemon collare*, a banded-wing grasshopper that is common in many sandy, disturbed habitats throughout the state. This replacement may be due to either competition from *S. collare* or because of the habitat change leading to the replacement.

Our evidence argues for the second of these possibilities. *S. collare* does not replace *T. huroniana*, except on sites where heavy disturbance has occurred, even though it occurs on inland sites with dune-like characteristics (Otte 1984). Also, some sites exist (*e.g.*, Horseshoe Bay in Mackinac Co.) where *huroniana* has disappeared, but *collare* has not invaded. This argues that habitat change is the key factor in the disappearance of the locust. *S. collare* simply invades a familiar habitat after it is established due to disturbance.

More problematic is explaining the presence of *S. collare* on revegetated dunes (*e.g.*, Port Crescent St. Pk and Presque Isle Harbor Beach). These dunes have the appearance of normal *T. huroniana* habitat, but lack typical dune locusts. It is likely that past levels of disturbance are the key to understanding these absences. Dune revegetation is likely to occur only after dunes have been significantly affected by disturbance. This is likely to have led to enough habitat degradation that *T. huroniana* was eliminated from the site and *S. collare* became established. After revegetation of the dune, *T. huroniana* has not reinvaded, possibly because no source population exists (particularly true for Port Crescent St Pk) and *S. collare* has remained. Alternatively, the revegetation itself may have a negative impact on the Lake Huron locust. It would be very instructive to monitor future revegetation efforts as they occur, to determine their effect on *T. huroniana* populations.

As illustrated by the replacement of *huroniana* by *S. collare*, nearly all recent factors are associated with human disturbances. Of these, development of lakeshore dunes has resulted in much loss of habitat (*e.g.*, much of the western shore of Lake Huron is now beachfront homes). Development has also eliminated dunes along some stretches of Lake Michigan in the Lower and Upper Peninsulas, particularly near towns or cities. For example, Hubbell (1929) noted populations of *T. huroniana* on the dunes near Traverse

Downloaded From: https://bioone.org/journals/Journal-of-Orthoptera-Research on 25 Apr 2024
Terms of Use: https://bioone.org/terms-of-use

City. These populations are now extirpated by growth of the city. Similarly, new development east of Manistique in Schoolcraft Co. is likely to affect a population of *T. huroniana* that now exists there.

Some developments have maintained significant dune habitat and the locust remains (*e.g.*, 7-mile Pt In Emmet Co. or Cathead Bay Drive in Leelanau Co.). The key difference seems to be maintaining not just the beach, but also a significant stretch of dune in front of or behind the housing. These examples illustrate the tolerance of the locust for moderate disturbance, along with its requirement for typical dune habitat.

Probably the most important non-anthropogenic, recent factor affecting Lake Huron locust populations is change in lake levels. At the time of our surveys, lake levels were at or above their historical average. Data from NOAA (2005) indicates that Lakes Michigan, Huron and Superior were all above the long-term average at least through 1998 (when the majority of this survey was completed). Recording stations at Mackinac City, De Tour Village, Ludington and Harrisville all indicate that the levels of Lakes Michigan and Huron were between 0.2 and 0.5 m above the long-term average of 176.6 m above IGLD 1985. These higher lake levels eliminated some potential dune habitats (particularly those linking larger dune areas), and severely reduced others. Following 1998, lake levels fell below these long-term averages.

At Grass Bay in Cheboygan Co., locust population size was monitored over a period of 8 y. Ballard (1991b) first estimated the population size at 4000 to 6000. Subsequently, the summer Biology of Insects class at the University of Michigan Biological Station estimated the population yearly from 1996 to 2000. Our first estimates in 1996 and 1997 were about 1500 individuals. The estimate decreased to 750 by 1999 and then increased again to 1300 in 2000. These population changes track changes in lake levels with a slight lag. Lake levels were 0.2 to 0.3 m below the long-term average just before Ballard's estimate. They then rose through the middle 1990's and fell again in the late 90's. Although not conclusive, this suggests that larger (and more) populations may exist when lake levels fall, while populations shrink (or become extirpated) when lake levels rise.

Understanding the links between species distributions and historical and recent factors is crucial to understanding the biology of a species, but particularly important for threatened and endangered species such as *T. huroniana*. The unique biology of this species limits it to a very narrow, coastal dune habitat in the northern Great Lakes. This range is further restricted by competition, the geological history of the area, and anthropogenic disturbances. This species historically had a restricted range, which has been further limited by human disturbances. Presently, this species is secure in Michigan (60+ known populations), but rare in Wisconsin and Ontario. Because of the limited and changing nature of its chosen dune habitat, it is appropriately listed as threatened in Michigan and Wisconsin.

The most important steps we could take to positively affect the conservation status of this species would be to limit lakeshore development and destruction of dune habitat. In the case of the Lake Huron locust, this does not mean a total restriction of use of the dunes. The locust appears to be quite tolerant of moderate disturbance, and may in fact depend on some disturbance to maintain its habitat. Only in cases where dunes have been effectively destroyed, either through development or overuse, has the locust been extirpated. Currently the locust is secure over most of its range.

Acknowledgements

We would like to thank the Michigan Department of Natural Resources for issuing the appropriate permits for this work (permit # 1614) and the Michigan Non-game Wildlife Fund (1997 grant to BGS) and the University of Michigan Biological Station, for supporting this research. The Michigan Chapter of the Nature Conservancy allowed the work at Grass Bay Preserve. Nathan Welch and Samara Hamze were wonderful field trip companions on long sampling days. Dr. Francesca Cuthbert provided us space on a seaplane to reach several of the islands in Lake Michigan. The Biology of Insect classes at the University of Michigan Biological Station participated enthusiastically in the mark-recapture study from 1996 to 2000. Comments from reviewers greatly improved the manuscript.

Literature Cited

Ballard H.E. Jr. 1987. Brainstormings on *Trimerotropis huroniana* Walker (Lake Huron Locust). Report to the Michigan Department of Natural Resources.

Ballard H.E. Jr. 1989. *Trimerotropis huroniana* (Orthoptera: Acrididae), a new record for Wisconsin. The Great Lakes Entomologist 22: 45-6.

Ballard H.E. Jr. 1991a. Preliminary survey of insects in Michigan coastal plain marshes and northern dune communities. Report to Michigan Department of Natural Resources.

Ballard H.E. Jr. 1991b. Observations on the Lake Huron Locust (T*rimerotropis huroniana*) at Grass Bay Preserve, Cheboygan County, Michigan. Report to Michigan Chapter of Nature Conservancy.

Dorr J.A. Jr., Eschman D.F. 1970. Geology of Michigan. Ann Arbor, MI, University of Michigan Press.

Evers D.C. (Editor). 1994. Endangered and threatened wildlife of Michigan. Ann Arbor, MI, The University of Michigan Press.

Hubbell T.H. 1929. The distribution of the beach-grasshoppers *Trimerotropis huroniana* and *Trimerotropis maritima* interior in the Great Lakes region. Journal of the New York Entomological Society 37: 31-8.

NOAA. 2005. http://www.glerl.noaa.gov/data/now/wlevels/levels.html

Otte D. 1970. A comparative study of communicative behavior in grasshoppers. Miscellaneous Publications of the University of Michigan Museum of Zoology 141: 1-168.

Otte D. 1984. The North American grasshoppers. Volume II. Acridinae, Oedipodinae., Cambridge, MA, Harvard University Press.

Voss E.G. 1996. Michigan flora. Part III. Ann Arbor, MI, Cranbrook Institute of Science Bulletin 61 and University of Michigan Herbarium.

Wisconsin Department of Natural Resources. 1999. The endangered and threatened invertebrates of Wisconsin. Bureau of Endangered Resources, Wisconsin Department of Natural Resources PUB-ER-085-99.

Downloaded From: https://bioone.org/journals/Journal-of-Orthoptera-Research on 25 Apr 2024
Terms of Use: https://bioone.org/terms-of-use

Table 1. Characteristics of surveyed locations in Michigan (1995-2002).

County	Location	Lake	Year of visit	Dune locusts[1]	Other grasshoppers[2]	Population size[3]	Extent of dune (length, depth[4])	Impacts on dune[5]	Hostplant occurrence[6]
Alcona									
	Alcona Rd at lake	Huron	1996	TH	SC, DC, Msp	small	1/4mi, 2	FT, ORV, I	AB, CL, AC
	Negwegon St. Pk	Huron	1996	TH	Msp	small	>1mi, 1	none	AB, CL, AC
	Point Rd at lighthouse	Huron	1996	TH	Msp	medium	1/2mi, 1	FT, I, D	AB, CL, AC
	south of Harrisville St. Pk	Huron	1996	TH	Msp	small	1/2-1mi, 2	FT, V, D	AB, CL, AC
Alger									
	dunes by Grand Sable Lake	Superior	1997	TH	DC, Msp	large	>2mi, 3+	FT, I	AB, AC, CP
	Grand Marais harbor	Superior	1997	TH	Msp	small	1mi, 1	FT, I	AB, AC
Allegan									
	Saugatuck St. Pk	Michigan	1998	TM	not noted	none	>1mi, 2-3	FT, I	AB, CL, others?
Alpena									
	Hamilton Rd on Huron Bay	Huron	1996	TH	none	small	1/4-1/2mi, 1-2	FT, D	AB, CL, AC, CP
	Ossineke St. Forest Cmpgrd	Huron	1996	TH	DC	small	1/4mi, 1-2	FT, I	AB, CL, AC
Antrim									
	west of Torch Lake	Michigan	1998	TH	not noted	small	1/2mi, 1	FT, I	AB, CL, AC
Bay									
	Bay City St. Pk	Huron	1996	none	none	none	little to none	FT, D	none
Benzie									
	Elberta Municipal Beach	Michigan	1996	TH	not noted	medium	>1mi, 2+	FT, ORV, I	AB, CL, AC, CP
Charlevoix									
	city park beach south of inlet	Michigan	1998	TH	not noted	medium	1/2mi, 1	FT	AB, CL, AC, CP
	Fisherman's Island St. Pk	Michigan	1998	TH	not noted	large	1mi, 3+	FT, I	AB, CL, AC, CP
	High Island	Michigan	1996	TH	Msp	large	1mi, 2+	FT	AB, CL, AC, CP
Cheboygan									
	Cheboygan St. Pk	Huron	1996	TH	DC, Msp	small	1/4mi, 1-2	FT, V, I	AB, CL, AC, CP
	Grass Bay Nature Preserve	Huron	1996-2000	TH	DC, CV, Msp	large	>1mi, 2+	FT, I	AB, CL, AC, CP
Presque Isle									
	Mast Pt	Huron	1996	none	none	none	1/4-1/2mi, 1-2	I	AB, CL, AC, CP
Chippewa									
	DeTour St. Pk Cmpgrd	Huron	1997	TH	Msp	large	1/4-1/2mi, 1	FT	AB, CL, AC, CP
	east of DeTour St. Pk	Huron	1997	TH	DC, Msp	large	1/2-1mi, 2-3	FT, I	AB, CL, AC, CP
	west of DeTour St. Pk	Huron	1997	TH	DC, Msp	medium	>1mi, 3	FT, I	AB, CL, AC, CP
	just south of Whitefish Pt	Superior	1997	TH	DC, TV, Msp	medium	1/2mi, 1-2	FT, I	AB, AC
	Vermillion	Superior	1995	TH	DC, AS, Msp	large	>1mi, 1	FT	AB, AC
	Whitefish Pt boat landing	Superior	1997	TH	Msp	medium	1mi, 3+	FT, I, D	AB, AC
	Bay Mills	Superior	1997	none	none	none	1/2mi, 1	FT, ORV, I, D	AB
	Big Pine Picnic Area	Superior	1997	none	none	none	1/2mi, 1	FT	AB
	ca North Country Hiking Trail	Superior	1997	none	Msp	none	1/2mi, 1	FT, I	AB
	Hought's Landing	Superior	1997	none	DC, Msp	none	1/2mi, 1	FT, I, D	AB
	Pt Iroquois	Superior	1997	none	Msp	none	<1/4mi, 1	FT, I	AB
Delta									
	Fayette St. Pk	Michigan	1997	none	DC, Msp	none	1/2mi, 1	FT	AB, AC
	Fuller Co. Pk	Michigan	1997	none	DC, Msp	none	<1/4mi, 1	FT, I	AB

[1]TH=*Trimerotropis huroniana*; TM=*Trimerotropis maritima*

[2]SC=*Spharagemon collare*; DC=*Dissosteira carolina*; TV=*Trimerotropis verruculata*; AS=*Arphia sulphurea*; CP=*Camnula pellucida*; CV=*Chortophaga viridifasciata*; Msp=*Melanoplus* sp.

[3]small= < 10 individuals seen; medium=10-50 individuals seen; large=>50 individuals seen

[4]depth refers to # of dunes from shore to treeline

[5]FT=foot traffic; ORV=off-road vehicles; I=invasives; D=development; R=revegetation; V=volleyball court; G=garbage; B=bicycles; H=horses

[6]AB=*Ammophila breviligulata*; AC=*Artemisia campestris*; CL=*Calamovilfa longifolia*; CP=*Cirsium pitcheri*

Downloaded From: https://bioone.org/journals/Journal-of-Orthoptera-Research on 25 Apr 2024
Terms of Use: https://bioone.org/terms-of-use

Table 1. cont.

Garden Corners	Michigan	1997	none	DC, Msp	none	1mi, 1	FT, ORV, I, D	AB, AC
Gladstone City Pk	Michigan	1997	none	Msp	none	1/2mi, 1	FT, D	AB
Kregg Bay	Michigan	1997	none	DC, TV, Msp	none	1mi, 1-2	FT, I, D	AB, AC, CP
Schoolcraft								
Parent Bay	Michigan	1997	none	none	none	<1/4mi, 1	FT, I	AB
Delta								
Portage Bay St. For. Cmpgrd	Michigan	1997	none	Msp	none	1/2mi, 1	FT	AB, AC, CP
Portage Pt	Michigan	1997	none	DC, Msp	none	2mi, 1	FT, I, D	AB, AC
Wilsey Bay	Michigan	1997	none	Msp	none	<1/4mi, 1	FT, I	AB
Emmet								
7-mile Pt	Michigan	1996	TH	Msp	medium	>1mi, 2+	FT, D	AB, CL, AC, CP
Bliss Twp Pk	Michigan	1996	TH	DC, Msp	large	>1mi, 2+	FT, former ORV, I	AB, CL, AC, CP
Cross Village	Michigan	1995, 1996	TH	DC, Msp	medium	>1mi, 2+	FT	AB, CL, AC, CP
Cross Village Shores	Michigan	1996	TH	DC, Msp	large	>1mi, 2+	FT, D	AB, CL, AC, CP
Petoskey St. Pk	Michigan	1996	TH	Msp	large	>1mi, 2+	FT	AB, CL, AC, CP
south Sturgeon Bay	Michigan	1996-2002	TH	DC, Msp	large	>1mi, 2+	FT	AB, CL, AC, CP
Sturgeon Bay Dunes	Michigan	1995-2002	TH	DC, Msp	very large	>2mi, 2+	FT	AB, CL, AC, CP
Thorn Swift Nature Preserve	Michigan	1995	TH	DC, Msp	small	1/4mi, 1-2	FT, D	AB, CL, AC, CP
Waugoshance Pt	Michigan	1995	TH	Msp	medium	>1mi, 1-2	FT	AB, CL, AC, CP
Grand Traverse								
Acme Twp Pk	Michigan	1998	TH	SC	small	1/4mi, 1	FT, I	AB
city beach	Michigan	1998	none	none	none	1/2mi, 1-2	FT, I	AB, CL
tip of peninsula	Michigan	1998	none	Msp	none	1/2mi, 1	FT, I, D	AB
Huron								
Port Crescent St. Pk	Huron	1997	none	SC, DC, Msp	none	>2mi, 1	FT, I, R	AB, others?
Sand Pt	Huron	1997	none	SC, Msp	none	1-2mi, 1	FT, ORV, I, D	AB, others?
Sleeper St. Pk	Huron	1997	none	Msp	none	>2mi, 2-3	FT, V, I, D	AB, others?
Iosco								
Au Sable Pt	Huron	1996	TH	not noted	small	1/2mi, 1-2	FT, I, D	AB, AC
Tawas St. Pk	Huron	1996	none	not noted	none	1/2mi, 1-2	FT, I	AB, AC
Leelanau								
Cathead Bay Drive	Michigan	1998	TH	not noted	large	>2mi, 3+	FT, I	AB, CL, AC, CP
Gill's Pier Rd	Michigan	1998	TH	not noted	small	1/2mi, 1	FT, I	AB
Good Harbor Bay Beach	Michigan	1998	TH	not noted	medium	1mi, 1	FT, D	AB
Leland Twp Pk	Michigan	1998	TH	not noted	small	1/4mi, 1	FT, I	AB
North Bar Lake	Michigan	1998	TH	not noted	large	>2mi, 3+	FT	AB, CL, AC, CP
South Fox Island	Michigan	1996	TH	none	large	1/2-1mi, 2+	ORV	AB, CL, AC, CP
west of Glen Haven	Michigan	1998	TH	not noted	medium	1mi, 1-2	FT, I	AB, CL, AC
Luce								
Crisp Pt	Superior	1997	TH	Msp	large	>2mi, 1	FT, ORV	AB, AC
Lk. Superior St. For. Cmpgrd	Superior	1997	TH	none	small	>2mi, 1	FT, ORV, I	AB, AC
Little Lake Harbor	Superior	1997	TH	none	large	>2mi,2	ORV	AB, AC
mouth of two-hearted River	Superior	1997	TH	Msp	medium	>2mi, 1-2	FT, I	AB, AC
Mackinac								
Horseshoe Bay	Huron	1997	none	DC, Msp	none	1mi, 1	FT, ORV, G, I	AB, AC
along US 2	Michigan	1997	TH	DC, Msp	large	>2mi, 3+	FT, I	AB, CL, AC, CP
along US 2	Michigan	1997	TH	DC, Msp	large	>2mi, 3+	FT, I	AB, CL, AC, CP
along US 2	Michigan	1997	TH	Msp	small	1/2mi,1	FT, I	AB, CL, AC, CP
along US 2	Michigan	1997	TH	Msp	small	1/2mi, 1	FT, I	AB, CL, AC, CP
Cut River Bridge	Michigan	2002	TH	none	small	1/4mi, 1	FT, I	AB

Downloaded From: https://bioone.org/journals/Journal-of-Orthoptera-Research on 25 Apr 2024
Terms of Use: https://bioone.org/terms-of-use

Table 1. cont.

Roadside Pk west of Mattix Pt	Michigan	1997	none	Msp	none	1mi, 1	FT, I, D	AB, CL, AC, CP
Pte. Aux Chenes	Michigan	1995, 1997	TH	DC, Msp	large	>2mi, 3+	FT, I	AB, CL, AC, CP
Simmons Woods Rd at Pt	Michigan	1997	TH	Msp	small	1mi, 2-3	FT, ORV, B, I	AB, CL, AC, CP
South Gould City Rd at beach	Michigan	1997	TH	DC, Msp	small	1/2mi, 2	FT, ORV, H, I	AB, CL, AC, CP
Bay east of Mattix Pt	Michigan	1997	none	Msp	none	1mi, 1	FT, ORV, I, D	AB, CL, AC, CP
Big Knob St. For. Cmpgrd	Michigan	1997	none	none	none	1/2mi, 1	FT	AB
west of Naubinway	Michigan	1997	none	DC, Msp	none	1/4mi, 2+	FT, ORV, I, G	AB, CL, AC, CP
Manistee								
Chamberlain Rd beach	Michigan	1996	TH	not noted	medium	1/2mi, 2-3	FT, ORV, I	AB, CL, AC, CP
5th Ave. beach	Michigan	1996	TM	not noted	none	1/2mi, 2-3	FT, I, D	AB, CL, AC
Mason								
Lake Michigan Rec. Area Rd	Michigan	1998	TH	not noted	large	>2mi, 2+	FT	AB, CL, AC, CP
Ludington St. Pk	Michigan	1996	TH	not noted	large	>2mi, 3+	FT, I	AB, CL, AC, CP
Butterville Pk	Michigan	1998	TM	not noted	none	1/2-1mi, 1-2	FT, I	AB, others?
Summit Twp Pk	Michigan	1998	TM	not noted	none	1/2-1mi, 1	FT, I	AB, others?
Menominee								
Fox Co. Pk	Michi-gan	1997	none	DC, TV, Msp	none	1mi, 1	FT, I	AB
Muskegon								
Meinert Co. Pk	Michigan	1998	TM	not noted	none	1mi, 1-2	FT, I	AB, others?
Michilinda-Duck Lake St. Pk	Michigan	1998	TM	not noted	none	1mi, 3+	FT, I	AB, others?
Muskegon St. Pk	Michigan	1998	TM	not noted	none	>1mi, 2+	FT, I	AB, others?
Oceana								
Camp Miniwanca	Michigan	1998	TM	not noted	none	1/2mi, 2	FT, I, D	AB, others?
Cedar Pt. Co. Pk	Michigan	1998	TM	not noted	none	1/2mi, 1-2	FT, I	AB, others?
Pentwater	Michigan	1998	TM	not noted	none	1/2-1mi, 1-2	FT, I	AB, others?
Silver Lake St. Pk	Michigan	1998	TM	not noted	none	>2mi, 3+	FT, I	AB, others?
Ottawa								
Grand Haven dunes preserve	Michigan	1998	none	SC	none	1/2mi, 3+	FT, I, D	AB, others?
Holland St. Pk	Michigan	1998	TM	not noted	none	1/2-1mi, 1-2	FT, I	AB, others?
Presque Isle								
40 mile Pt. lighthouse	Huron	1996	TH	not noted	medium	1/4-1/2mi, 1-2	FT, I	AB, CL, AC, CP
dunes by creek	Huron	1996	TH	not noted	small-me-dium	1/2-1mi, 1-2	FT, ORV, I	AB, CL, AC, CP
Evergreen beach	Huron	1996	TH	not noted	medium	>1mi, 1-2	FT, ORV, I, D	AB, CL, AC, CP
P. H. Hoeft St. Pk	Huron	1996	TH	not noted	medium	>1mi, 2+	FT, I	AB, CL, AC, CP
Besser State Natural Area	Huron	1996	none	SC, DC, Msp	none	1/2-1mi, 1-2	FT, I	AB, CL, AC, CP
Presque Isle Harbor Beach	Huron	1996	none	SC, Msp	none	1/4-1/2mi, 1	FT, I, R	AB, CL, AC, CP
Schoolcraft								
Frank Rodgers Roadside Pk	Michigan	1997	TH	DC, TV, Msp	medium	>1mi, 2+	FT, I	AB, CL, AC
Gierke Rd	Michigan	1997	TH	Msp	small	1/2mi, 1	FT, I, D	AB, AC, CP
just east of Manistique	Michigan	1997	TH	TV, Msp	small	1mi, 2	FT, ORV	AB, CL, CP
shoreline east of Michibay Rd	Michigan	1997	TH	DC, Msp	large	>2mi, 2-3	FT, D	AB, CL, AC, CP
Twp. Pk. on Michibay Rd	Michigan	1997	TH	TV, Msp	large	1/4mi, 2-3	FT	AB, CL, AC, CP
Woodstar Cmpgrd	Michigan	1997	TH	DC, CP, Msp	medium	1/2mi, 1	FT, ORV, I	AB, AC
west of Manistique	Michigan	1997	none	TV	none	1mi, 2-3	FT, I, R?	AB, CL, AC
Van Buren								
Van Buren St. Pk	Michigan	1998	TM	not noted	none	1mi, 1-2	FT, I	AB, others?

Downloaded From: https://bioone.org/journals/Journal-of-Orthoptera-Research on 25 Apr 2024
Terms of Use: https://bioone.org/terms-of-use