FINAL PERFORMANCE REPORT

Federal Aid Grant No. F18AF00625 (T-105-R-1)

Remote Acoustic Biomonitoring and Habitat Modeling to Establish Current Range and Critical Habitat of the Prairie Mole Cricket in Oklahoma

Oklahoma Department of Wildlife Conservation

October 1, 2018 through September 30, 2021

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Grant Program: State Wildlife Grants

Grant Title: Remote Acoustic Biomonitoring and Habitat Modeling to Establish Current Range and Critical Habitat of the Prairie Mole Cricket in Oklahoma

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Principal Investigator: Dr. Daniel Howard and Dr. Carrie Hall, Department of Biological Sciences, University of New Hampshire and Dr. Peggy Hill, Department of Biological Science, University of Tulsa

Abstract:

The prairie mole cricket (*Gryllotalpa major*; PMC;) is a native insect of conservation interest found in Oklahoma. Our team conducted a three-part investigation into the spatial ecology and distribution of PMCs across landscape scales in the spring active seasons of 2019-2021, taking an acoustic approach to biomonitoring for this rate and cryptic species, to produce a local scale habitat suitability map from presence data. First in 2019, we conducted an acoustic survey of 106sites at The Nature Conservancy's Tallgrass Prairie Preserve and documented the location of new PMC leks (mating aggregations) across the site. That same year, we revisited 61 historical sites of PMC presence using a highly experienced observer to ascertain current presence/absenceof the species in the 25+ years since biomonitoring last occurred. Due to COVID-related project impacts, no data were collected in support of the project during the spring of 2020. During the spring of 2021, we revisited twelve additional historical PMC sites, and documented presence/absence at these locations to supplement the 2019 biomonitoring data. Our findings show that acoustic monitoring can be an effective and low-cost approach for the monitoring of PMCs across the 60-day active season, when males produce a 2kHz low-frequency chirping mating call at dusk from established mating aggregations. At a local scale, PMC mating aggregations appear most dependent upon sites with suitable soils, and away from disturbance effects related to energy extraction, but are not always found in wide open, treeless prairie as previously thought. While some PMC leks have remained resilient over the past two decades since surveys were last conducted to evaluate a proposed federal Threatened species listing, and were still extant in ten Oklahoma counties, many historical sites (68% of 53 surveyed) appear to no longer support prairie mole cricket populations, indicative of a significant range contraction. We recommend the initiation of a limited but range wide Oklahoma PMC acoustic monitoring network (OPAMN) to collect annual presence/absence data on this sensitive Oklahoma species and to understand phenological shifts in its annual mating seasonality.

Objectives:

<u>Objective 1:</u> Document the spatial distribution of mating aggregations of *Gryllotalpa major* at the Tallgrass Prairie Preserve (TPP) using remotely deployed programmable acoustic sensors.

<u>Objective 2:</u> Use these data to construct a habitat model for *G. major*.

Objective 3: Reconstruct the current Oklahoma range map for *G. major* using data collected from surveying both historic sites where prairie mole crickets were documented, 1989-1996, and sites predicted to hold populations by a regional presence/absence model.

Introduction:

The prairie mole cricket (*Gryllotalpa major*; Fig. 1) is a rare grassland insect found in tallgrass prairie remnants in the southern plains of the U.S., identified as a one of Oklahoma's species of greatest conservation need by its recent Tier 1 designation. While recent studies hadcontributed a wealth of data describing the behavior and genetic structure of the species, thosefindings have been derived from studies occurring at a few intensely studied populations in NE Oklahoma, and no population distribution data for *G. major* hadbeen collected in over twenty years. Here weconducted research that updated our understanding of the statewide range of the species and produced a habitat model instruments that identified critical habitat elements at the local scale of the TNC study site. The project leveraged recent advancements in automated acoustic sensorsto survey across remote regions during the brief spring reproductive season and used machine learning techniques coupled with habitat modeling to generate data critical for species management and conservation.

Figure 1 – Illustration of a calling male prairie mole cricket, and a female responding at the burrow's surface opening. Used with permission of the original artist, Evan Haller-Hiser.

As background, in 1984 the prairie mole cricket, *Gryllotalpa major* Saussure, was thought to be extinct, and initial spot surveys led to an Invertebrate Species Notice of Review being issued by the US Fish and Wildlife Service (USFWS 1990). Subsequent surveys of historic ranges in Oklahoma, Kansas, Missouri and Arkansas in 1990-1991 (Figg and Calvert 1987; Busby 1991; USFWS 1991; Vaughn & Rudman 1991; Caire *et al.* 1993; Vaughn *et al.* 1993) located populations (Oklahoma's first PMC was located in Norman, Cleveland County, by Dr. Harley Brown in 1987), but insufficient information was available on the species to support either listing or elimination from consideration (USFWS 1992). This led to additional surveys in the late 1990s. From 1987 to 1991 the USFWS reported 120 sites where PMC males were calling across 18 counties in Oklahoma (USFWS 1991). The Oklahoma Natural Heritage Inventory's (OHNI) database in February 1995 listed 74 sites in 17 counties. (The OHNI did not include Ottawa, Pawnee, or Murray counties from the USFWS report, but did include Lincoln and Canadian, which were noton the USFWS list.) Based on data from the OHNI survey sheets, new surveys were conducted in 1994-1996 in 14 of those counties, sponsored by the U.S. National Biological Service (Hill 1996a). Visits were made to 36 of the sites during the known active calling period, and an additional 13 sites were evaluated outside that time. Of the 36 sites sampled, 23 (63.9%) no longer supported PMCs, including the only ONHI sites in Caddo and Tulsa Counties. However, 12 new sites were found in 1995-1996, including new sites in Tulsa County and new county records for Logan and Pottawatomie. Most of the sites identified in 1990-1995 had not been revisited in 20 years, and the data gathered in subsequent yearscame only from two primary study sites in Craig and Osage Counties that are part of a long-term study of the species conducted by the PIs of this project.

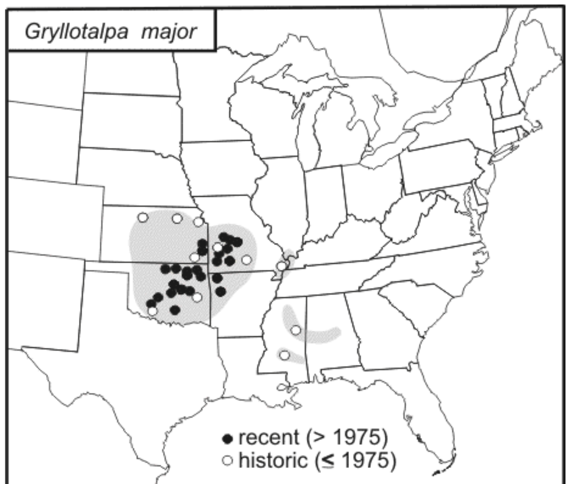

Figure 2 - Prairie mole cricket range map. From https://orthsoc.org/sina/361a.htm

Much of what was learned in those intervening years at those two study sites was related to the species reproductive biology and mating behavior. The adult mating period is brief, and occurs in spring from late March until earlyMay most years (Figg and Calvert 1987). Malesemerge onto mating aggregations (leks) in the spring (Hill 1999) and construct an acoustic burrow from which they call to attract flying females (Walker and Figg 1990, Hill et al 2006). The male's loud acoustic call (Hill 2000) is produced at dusk, with individual males calling for approximately 40 minutes each, and an entirelek active for only ~ an hour after sunset. Calling behavior in an aggregation is highly dependent upon local microclimate conditions at a site (Hill 1999), and males are highly sensitive to disturbance by substrate-borne vibration during calling (Hill and Shadley 2001). Males are thought to position themselves across the lek such that they can detect other calling males (Howard et al 2008), and clusters of males within the lek exhibit high levels of genetic relatedness (Keane et al 2016). Female are attracted to male calls, which carry information on thesender's size (Howard and Hill 2006) and position on the lek (Howard et al 2011) and are similarly sensitive to acoustic and substrate-borne noise (Howard unpublished data). Courtship occurs in the male borrow, but the details of where mating and oviposition takes place remain a mystery. Adults are thought to survive for a single reproductive season, but details regarding development, diet, predator-prey dynamics, or invasive species interactions remain undescribed in the species.

Prairie mole crickets are tallgrass prairie endemics, found historically in untilled grassland sites where range management often combines grazing with prescribed burning regimes. While this grassland ecosystem has declined in geographic extent due to land use changes over the past 150 years, the formerly vast ecosystem once spanned 150 million acres across 14 North American states (OCWCS

2015). Intact tallgrass prairie remnants exist across portions of Oklahoma, and it is in these remaining grassland tracts where the species is thought to persist, in most cases undetected due to its cryptic fossorial biology. The last remaining continuous tallgrass prairie habitat in Oklahoma occurs in the Flint Hills Ecoregion and in more fragmented form in the Central Irregular Plains Ecoregion (OCWCS 2015), which break down into the Flint Hills, Osage Cuestas and Cherokee Plains. In the Flint Hills, much of which lay in Osage County, large tracts of undisturbed grasslands, mixed with oak savannahs, represent the likely population reservoir for the species. Despite its well-known reliance on tallgrass prairie for ecological persistence, relatively little was known regarding habitat preference or how landscape-level features influence distributions. Studies have shown that prairie mole crickets may represent a fire dependent species, with mating aggregations found preferentially on recently burned sites (Howard and Hill 2007). At a fine scale, males do not appear to discriminate between soil types in setting up leks in the spring (Hill et al 2009), but grassland botanical structure was shown to influence the spatial arrangement of leks (Howard and Hill 2009). Constructing a more comprehensive understanding of where PMC populations are currently located along with identifying factors that contribute to suitable habitat at a local scalerepresented the critical needs that led to this project.

Approach:

The framework for this study revolved around a single broad question: *Where are prairie mole crickets (PMCs) located in Oklahoma and why are they found there?* We hypothesized that: 1) mating aggregations of the species might be surveyed more accurately and reliably than traditional observation techniques by using automated acoustic detection technologies; that 2) PMC lek locations could reveal patterns of habitat preference, and that 3) statewide PMC population distributions will reflect current patterns of land use in Oklahoma.

Objective 1 Approach - Document the spatial distribution of mating aggregations of <u>Gryllotalpa major</u> at the Tallgrass Prairie Preserve (TPP) using remotely deployed programmable acoustic sensors.

PMC Acoustic biomonitoring techniques

For detecting PMC during the brief one-hour calling period that occurs at dusk during a short 4-8 week period in the spring months of late-March through early-May, we deployed automated acoustic recorders (custom BARIIs, Frontier Labs, Brisbane, AU) programmed to activate 30 minutes prior to sunset, and run for 2 hrs. Recordings were saved as 16 bit/96 KHz WAV files on internal SD cards. The gain settings on the units were set at +45 to allow for the long-range detection of calling PMCs up to ~500 meters, with the spectral signature of the call serving as the key identifying feature examined manually in Adobe Audition 3.0 software and in the *monitoR* package in R software (Katz et al 2016). Adobe Audition allows for visualizing the recording spectrogram, to examine for higher amplitudes in the PMC calling spectral range, indicated by brighter spectrogram colors and greater relative amplitude values compared to non- focal spectral regions. The software R package allows a user to use machine learning techniques to quickly scan recordings to identify signals of interest, with fairly high levels of reliability and specificity if the signal of interest is significantly segregated from background noise. Across 106 recording sites at the TNC TPP, recorders were deployed at five sites simultaneously for two nights each, with recorders mounted on 7’ t-posts set temporarily in the ground, or on suitable trees located at the site. Only nights on which PMCs called at our TPP local reference lek (spring trap pasture, an established and known-active PMC lek) were considered valid sample nights. Acoustic recorders were rotated to new sites once two valid sample nights were documented at each sample site, with acoustic data downloaded and recorder batteries replaced prior to each redeployment. Recordings were analyzed using Adobe Audition spectral analyses and using machine learning techniques in R statistical software to confirm PMC presence at recording sites. Based upon these findings, PMC presence/absence across the TPP sampling sites were mapped using ArcMap 10.6 software and converted into suitable layer files for use in MaxEnt Habitat Suitability Model (HSM) software for project Objective 2. Additionally, at all sites environmental and landscape data were collected, including slope, aspect, land cover, grazing regime, burn history, post-burn interval, recent burn seasonality, and distance to relevant features (hydrology, roads, energy development sites) for use in the HSM.

Objective 2 Approach - Use PMC presence/absence data to construct a habitat model for G.major.

Prairie mole cricket presence/absence data and local habitat parameters from 2019 were integrated into a habitat suitability model (HSM). Habitat estimation on a landscape scale presents challenges that are partially overcome by approaches using presence-only data – sampling from background data to develop a statistical model that extrapolates a species' habitat probability across the landscape. One such method is the use of maximum entropy, implementedin the program MaxEnt (Philips et al. 2006, McMichael et al. 2014, Howey et al. 2016, Algeo et al. 2017). Use of maximum entropy modeling allowed us to characterize the driving environmental, biological, and spatial indices important for PMC mating locations at the TPP study area. We used MaxEnt to estimate habitat probability using a number of the vector-based landcover products (including distance from cover type), roadways and power right of ways, distance to energy development sites, topography, and vegetation structure from remotely sensedimage data, in addition to more fine-scale habitat parameters identified previously. MaxEnt model parameters and training approaches were methodologically identical to those described in Algeo et al (2017). These analyses provided us with estimates of habitat availability and areaspredicted to have suitable habitat for PMC populations. Importantly, these sites may be critically important for conservation, representing potential habitat for future reintroductions.

Objective 3 Approach - Reconstruct the current Oklahoma range map for G. major using data collected from surveying both historic sites where prairie mole crickets were documented, 1989 – 1996, and sites predicted to hold populations by a regional presence/absence model.

The USFWS used sampling methods developed by the Oklahoma Natural Heritage Inventory (Mehlhop-Cifelli 1990) for on-site surveys and a driving survey method adapted from a technique developed by the Kansas Natural Heritage Inventory (Busby 1991; USFWS 1991). Our own work on two sites in 1991 found the previous protocol to be inadequate, and subsequent on-site work in 1994 1996 included location of each active burrow (Hill 1996b), where landowner permissions could be obtained to access a property. Additional driving surveys were conducted to resample routes from the USFWS work in 1987-1991, and the precise locations of listening stops from those route maps were revisited, with only the two most experienced workers switching off the vehicle engine and walking along the roadside to listen for calling males. For this project we set out to revisit 30 of these sites in 2019 (see TRS data in Appendix 2, and Hill 1996a), choosing from those where 5+ males were reported from 1989-1996. Examples of these included the following sites listed by counties within their region of the state: **Northeast**: Craig (White Oak Prairie), Wagoner (Robison's); **Southeast**: McIntosh (Fountainhead Resort); **North Central**: Creek (Sapulpa, Prettywater), Lincoln (Arlington), Nowata (Watova area), Payne (one site), Osage (outside the Tallgrass Prairie Preserve), Rogers (multiple), Washington (Vera area); **Central**: Cleveland (Radio Prairie,Independence Cemetery, #9 and 19-25, Colonial Estates Park), Logan (near Guthrie). Some sites had no confirmed numbers (such as Caddo County in the **South-Central** Region), and others are known to have been heavily developed (several in Mayes, Rogers, and Tulsa Counties). Sites not visited during 2019 due to weather or the shortness of the season, were queued for observation in the second year of the project (extended to 2021 due to the global COVID-19 pandemic). The approach we used for confirming presence/absence of calling PMC males at each visited historic site included driving a transect along the closest adjacent road (withing 400 m of the known site), turning off the vehicle engine, and getting out of the vehicle to listen during the period starting at sunset and continuing for one hour. Data regarding observed presence/absence were recorded digitally, along with notes on the suitability of habitat at each site.

List of the project personnel and a description of the study area(s):
Study personnel for **Objective #1** – Dr. Daniel R. Howard, Dr. Carrie L. Hall, and graduate student Andres Buitrago; study occurred at the TNC Tallgrass Prairie Preserve. **Objective #2** – graduate student Andres Buitrago and collaborator Michael Palace (UNH); effort occurred at the University of New Hampshire. **Objective #3** – Dr. Peggy S. M. Hill; effort occurred in 2019 in the 17 historic counties of *G. major* occurrence. Dr. Daniel Howard and Dr. Carrie Hall; efforts occurred in 2021 in the17 historic counties of *G. major* occurrence.

Results and Discussion:
Results for Objective 1 - Document the spatial distribution of mating aggregations of Gryllotalpa major at the Tallgrass Prairie Preserve (TPP) using remotely deployed programmable acoustic sensors.

During the spring of 2019, we deployed programmable acoustic recorders at 106 sampling sites between 01 April and 15 May 2019 within the TPP study area, collecting recordings on nights validated as suitable calling conditions based upon calling activity atknown reference leks on the TPP. During this period, we identified 42 active lek sites (Fig. 3), increasing by 8.4times the number of sites known from previous studies. Using Adobe Audition in the spectral view, we were able to detect the signature of PMC calling from a distance of up to 700 m in recordingswith low ambient noise. Using *monitoR* in R, in most cases the machine learning approach was limited to the detection of calls in recordings up to 300 m, and at that distance only in recordings with very low wind noise.

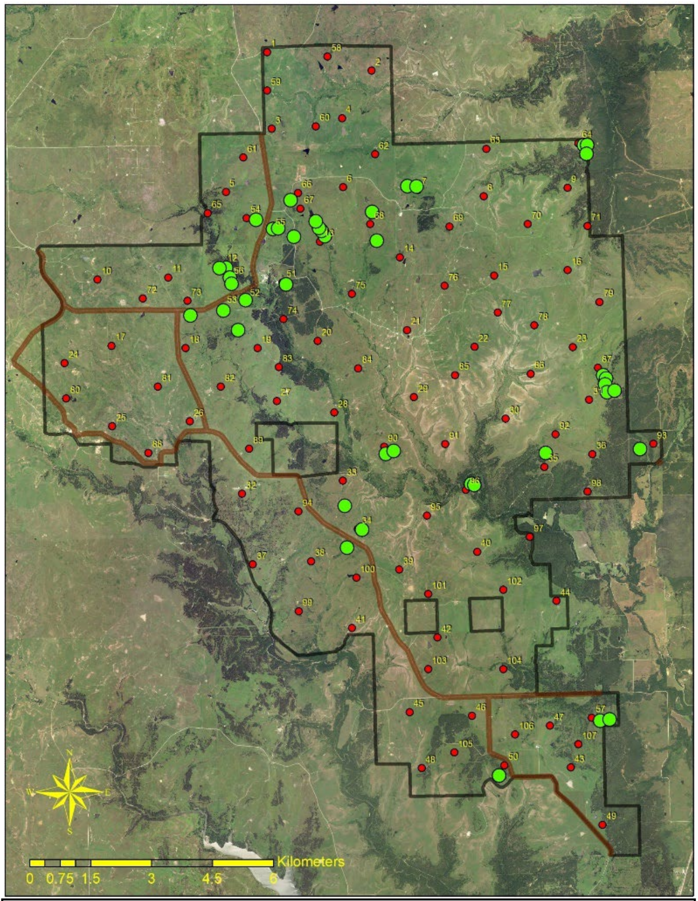

Figure 3 – Map of 106 acoustic monitoring sites at the TPP study location in Osage County monitored in 2019. Green circles indicate sites where males were documented calling, while red circles indicate no PMC presence.

While some of the lek locations were located near preserve infrastructure, of the 42 lek locations documented in the study, 76% of them were located where an observer listening from the road would not detect the calling males (e.g., over 400 m, Fig. 4). Interestingly, rather than being located in the wide-open prairieexpanses the species is named for, 74% of leks were detected within proximity (>400 m) of forested stands at the site (Fig. 5). Atsites where acoustic recorders detected males calling, local weather conditions were significantly associated with calling activity. While males are known to begin calling in the spring once soil temperaturesreach 12.5 C^{o}, maximum soil temperatures later in the season became an important limiting factor. The probability of male calling declined significantly once maximum daily soil temperatures reach between 21.7 – 23.9 C^{o} (Fig. 6). Wind speed was also associated with the detection of calling males using acoustic recorders, with the probability of presence declining significantly once maximum wind speeds at dusk reached 6.3 -7.6 m/s.

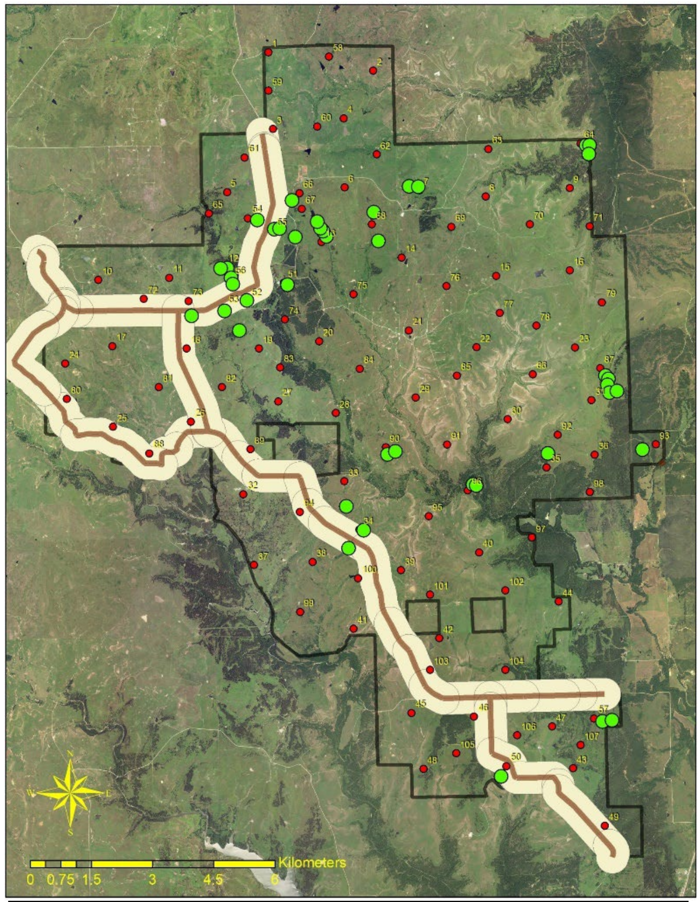

Figure 4 – Map of detection range (> 400 m) of calling male PMCs along roads and the location of observed leks at the TPP study site.

These findings have important implications for how we manage the species, especially with respect to monitoring, but also regarding what we may or may not consider suitable habitat with respect to land cover. Importantly, acoustic monitoring would present a robust option for detecting populations of PMCs during the active mating season of April-May, and forlong term monitoring plans across the species range. With a limited investment in recorders and field and lab labor, acoustic recorders can be deployed at sites at the outset of the season, and retrieved in early June, to collect data on the presence of PMC reproductive aggregations and the seasonality of calling. Free acoustic software like Audacity (https://www.audacityteam.org/) can be used to review spectrograms to detect the unique signature of calling males. However, when monitoring for the species, local soil temperature and wind conditions during the dusk calling period are critical indicators of whether males call and can be detected by acoustic recorders or observers and must be accounted for to avoid false negative survey results. Moreover, leks of PMCs may not always be located only in open prairie as presupposed. Our results support the notion that males may establish leks in location near or even under forest stands associated with tallgrass prairie expanses if other conditions like soils are suitable.

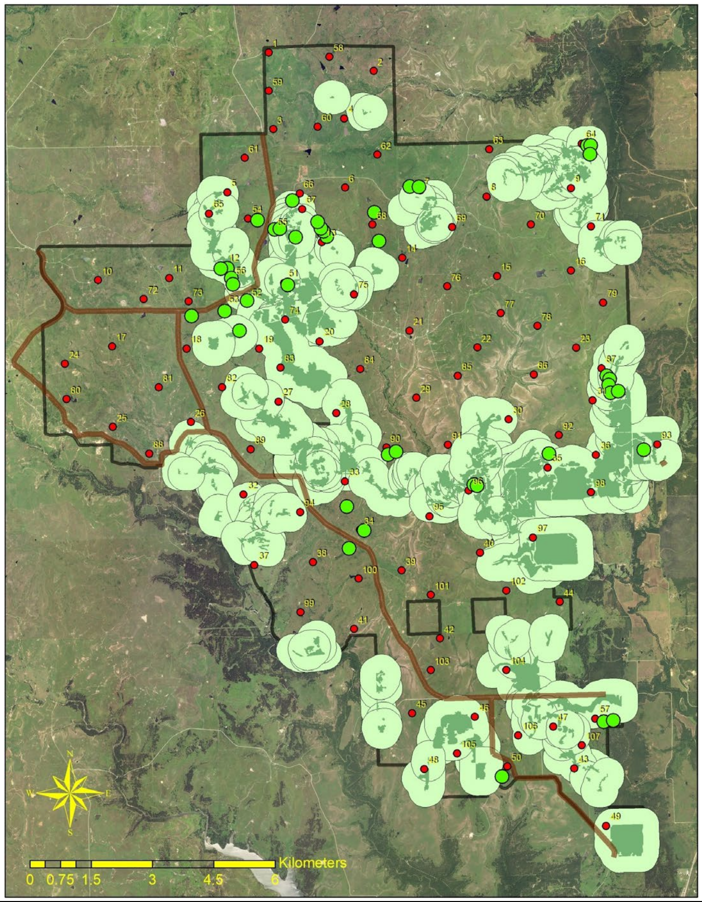

Figure 5 – Map of PMC sampling sites and 400 m buffers around forested regions of the TPP study site.

Figure 6 – Violin plot of nights where males were and were not observed calling, using an acoustic recording approach. Most calling occurred when 10 cm soil temperatures rose above 60 F but declined dramatically once soil temperatures rose to near 80 F (data obtained from Oklahoma Mesonet).

Results for Objective 2 - Use these data to construct a habitat model for G. major.

We used presence data obtained in 2019 at the TPP study site to construct a habitat suitability map using MaxEnt niche modeling software. After testing a larger dataset of environmental layers for effects, we included the most relevant environmental layers in the MaxEnt model, including spring burn status (Y/N), distance from streams, distance from roads, distance from oil/gas wells, soils (type), aspect, elevation, landcover, and slope (Table 1). These layers produced a strong predictive model (Figs 7 & 8), with three variables standing out as mostcritical at the local study site: soils, distance from streams, and distance from oil/gas sites.

These findings have implications for how we assess sites for PMC suitability. First, we know that PMCs are limited in range to tallgrass and mixed grass prairie regions. Aside from thislarger scale habitat indicator, here we find that soil type (loamy soils with some silt/sand but lowin rock content) are important at a more local scale. Moreover, as indicated previously, PMC mating aggregations at the TPP site were often co-located within proximity to forested riparian zones associated with small streams. Finally, our presence data indicate a non-trivial role of disturbance in driving PMC lek locations, with the distance from oil wells and roads as predictive indicators.

Table 1 – Relevant environmental layers included in final Maxent PMC Habitat Model.

Variable	**Percent contribution**	**Permutation importance**
Soils	40.2	30.5
Distance from streams	22.7	33.6
Distance from oil wells	15.3	18
Distance from roads	7.4	6.3
Aspect	6.1	1.9
Elevation	4.6	4.5
Land cover	2	0.4
Slope	1.6	4.6
Burn status	0	0

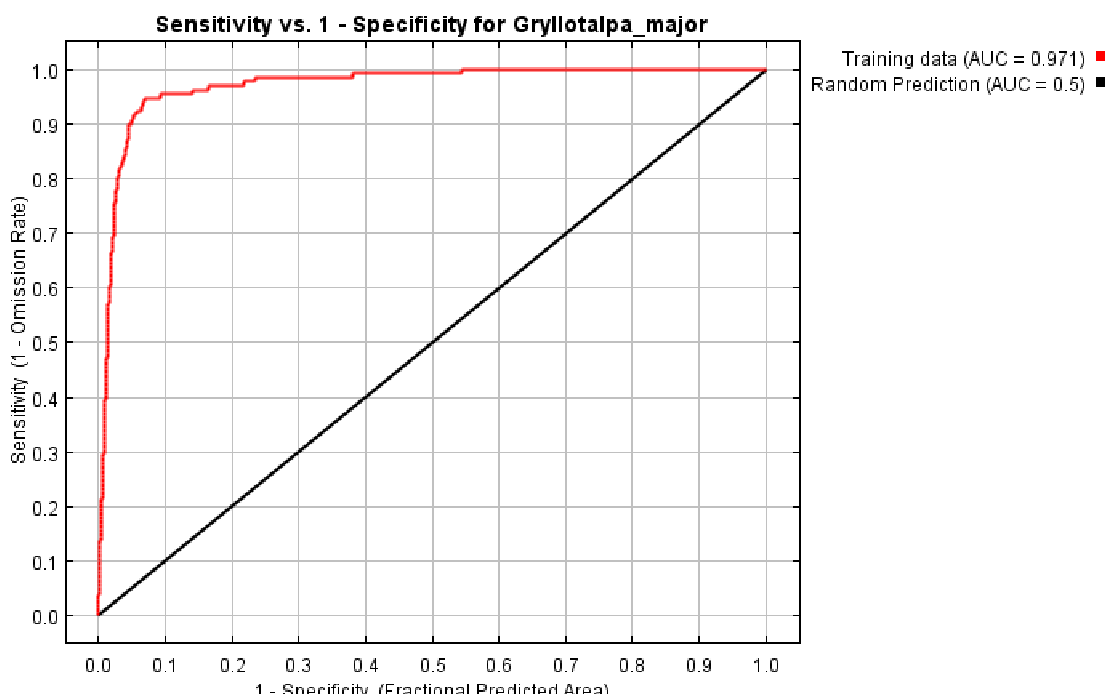

Figure 7 – Performance chart for relevant environmental layers included in the MaxEnt HSM model. The model exhibited an AUC value of 0.97, while models with a score of 0.76 or higher are considered reliable.

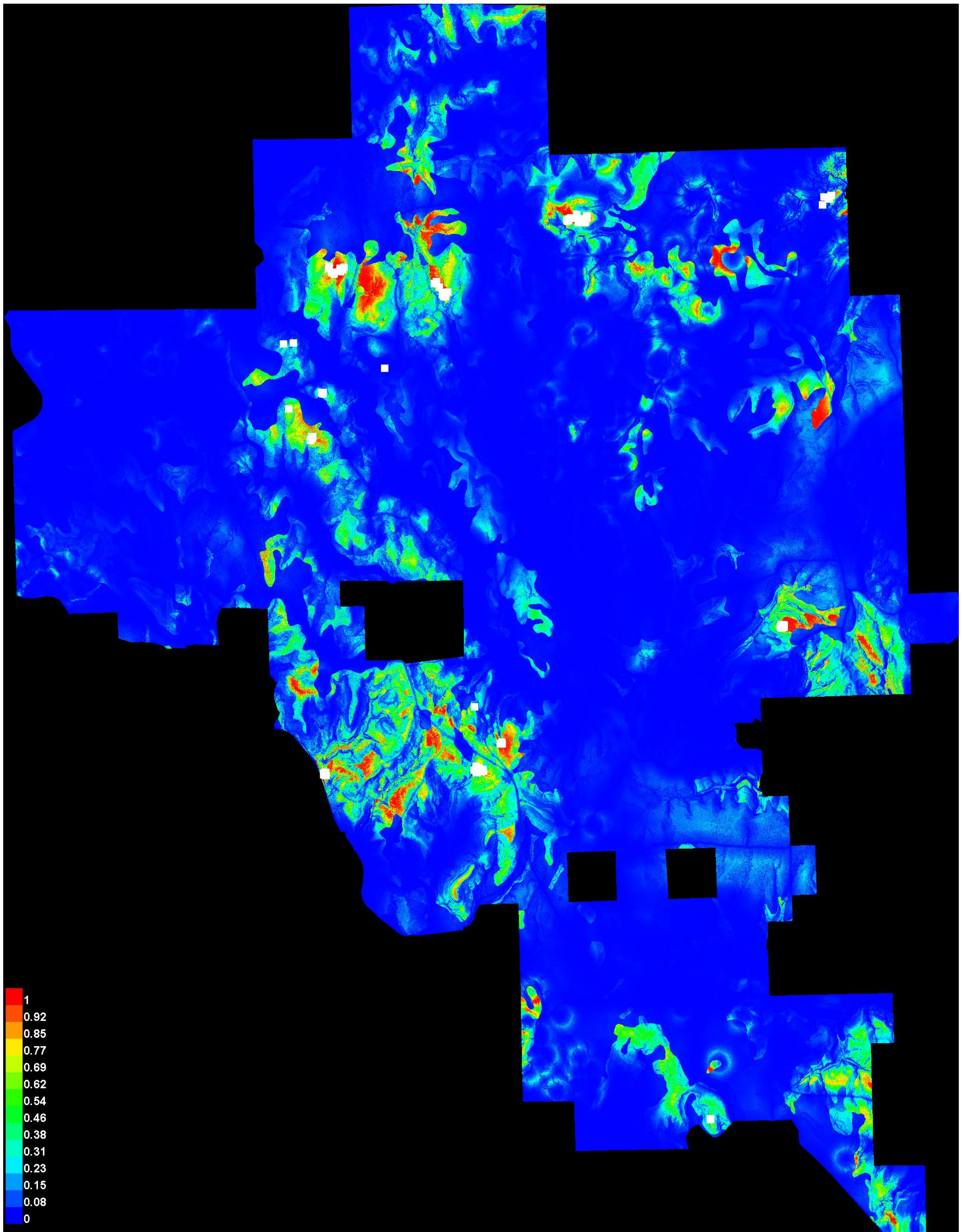

Figure 8 – MaxEnt Habitat Suitability Map for PMCs at the TPP study site. The model predicted highest probability of presence based upon suitable soil type, along with distances from stream riparian zones. Distance to oil wells was also a relevant contributor to the model at the study site, which has over 100 active and historic well sites (as of 2019).

Results for Objective 3 - Reconstruct the current Oklahoma range map for G. major using data collected from surveying both historic sites where prairie mole crickets weredocumented, 1989 – 1996, and sites predicted to hold populations by a regional presence/absence model.

In year one of the project (2019) and completed under the project leadership and effort of co-PI Dr. Peggy S. M. Hill, we identified a total of 61 historical PMC sites and conducted field surveys from 28 March to 15 May 2019. Of these 61 sites we were able to visit 46 sites during the 2019 survey period and the remaining 15 sites were not visited. Of the 46 sites visited, five were seen only in the daytime, but the habitat was assessed to estimate the site's suitability for supporting prairie mole cricket populations based upon known criteria. The remaining 41 sites were visited both during daylight hours and during the evening calling period after sunset. Habitat suitability was assessed for those sites that did not have males calling during the eveningvisit. The number of calling males was not estimated for historic sites, but merely presence or absence of calling was documented.

Of the five sites visited only during daylight hours, one was assessed to be suitable for supporting populations, while one was of marginal quality and three were no longer suitable for prairie mole crickets. A total of 12 of the 41 sites visited during the evening calling period had calling males on the night of the visit. No males were calling on the other 29 sites. One of the 29was of marginal quality, while 16 appeared suitable for supporting populations and 12 were not. Incidental to revisiting the historic sites, 16 new sites were found and were confirmed by calling males. Two other sites near the Robison site in Wagoner County were identified as potential sites based on habitat quality, as were multiple sites near the historic location in Kay County, but no calling males were heard there. Confirmed sites in both Tulsa and Mayes counties were located, while most of the historic sites in those two counties no longer supported prairie mole cricket populations. Also in 2019, sites with potential PMC habitat were identified in the following counties: Hughes, Lincoln, McClain, Muskogee, Okfuskee, and Pottawatomie. One historic site each was known for Hughes, Lincoln, and Okfuskee counties, but we were unable to visit those sites during the evening in the 2019 season. All sites were monitored using the driving survey method adapted from the technique developed by the Kansas Natural Heritage Inventory (Busby 1991; USFWS 1991).

In April and May 2021, PI Howard and Co-PI Hall visited twelve additional sites in six counties (Delaware, Mayes, Okfuskee, Payne, Rogers, Tulsa) that were predicted to support PMCs based on the habitat model. Callers were documented in Mayes and Payne County, but not at the sites visited in Delaware, Okfuskee, Rogers, or Tulsa counties (calling males detected at 5 of the 12 sites). A map of the survey results indicates the species is most prevalent inthe seven northeastern Oklahoma counties: Craig, Mayes, Nowata, Osage, Washington, Rogers, and Tulsa. Relict but locally abundant populations of PMCs were documented in Cleveland, McIntosh, and Payne counties (Fig. 9).

While we were unable to get to all of the historic sites planned for visitation during theproject due to COVID-related impacts, we were able to visit 53 historic sites. Of these 53 siteswith presence observed in the 1990s, 17 of the 53 (32%) sites still held active mating aggregations as documented during our site visits. Approximately half of the sites with no observed calling males were degraded with respect to PMC habitat suitability.

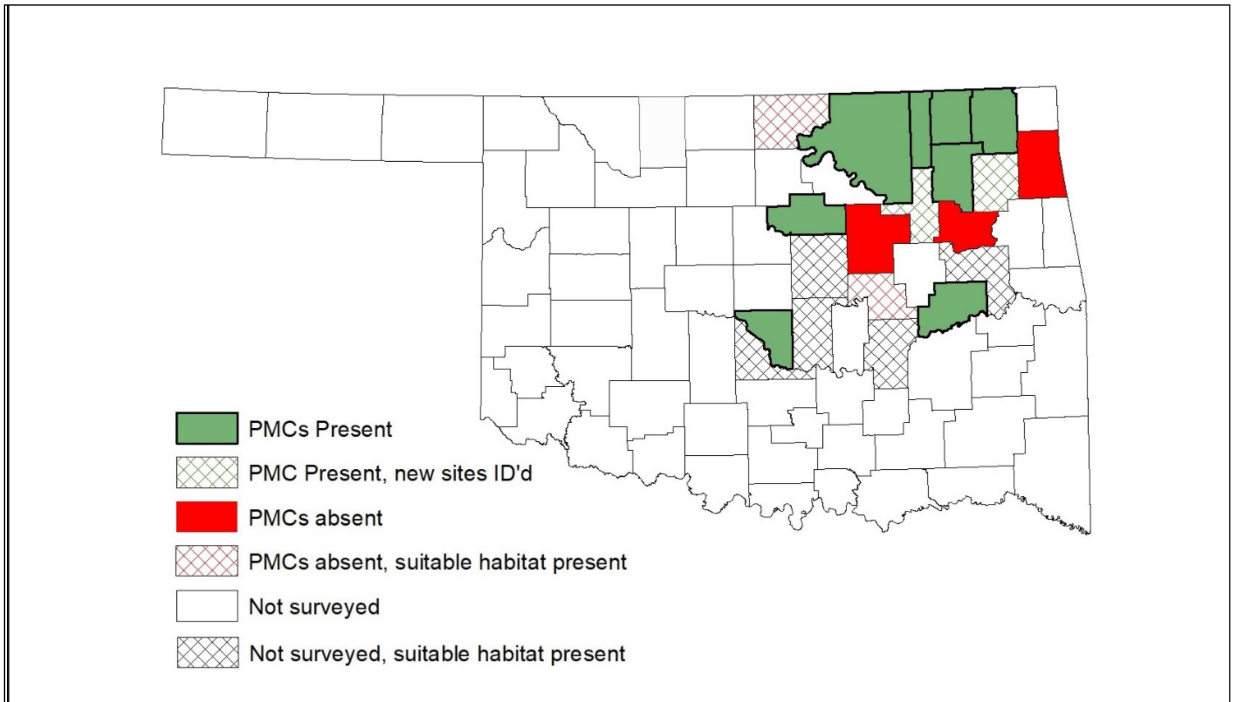

Figure 9 – Statewide County map of PMC presence, absence, and availability of suitable habitat at observed sites.

Recommendations:
Our findings support the general model that PMC populations have declined in geographic extent since surveys were conducted during the mid-late 1990s. In many cases, the reason is readily tied to land use changes at the historic sites. In other cases, habitat appeared suitable, but no calling males were observed during site visits. Our findings support that extant relict populations of PMCs likely persist in pockets of suitable habitat, associated with tallgrass or mixed grass grassland ecosystems, supported by loamy soils, and located in association with or near hydrological features that maintain soil moisture levels as the mating season persists intothe warmer late spring months. Acoustic monitoring holds promise as an effective means to monitor for this rare species. Here we recommend Oklahoma conservation stakeholders continueto focus on the preservation and annual monitoring of existing sites holding relict populations ofPMCs, while also considering how future land use changes coupled with climate-related shifts might hasten the decline of this already rare species. Several sites visited during this project holdrobust populations of PMCs, and 3-5 of these properties (assuming permissions were secured from landowners) could serve as annual biomonitoring sites for an Oklahoma Prairie Mole Cricket Acoustic Monitoring Network (OPAMN). We remain available to consult with stakeholders on this idea, as well as to assist with its technical implementation.

Significant Deviations:
The primary significant deviation on this project was the loss of the 2020 spring active-season for field data collection due to the COVID-19 pandemic, and its continued direct and indirect impacts during the no-cost extension year of 2021. We were able to collect additional statewide presence/absence data during the spring of 2021, but one collaborator and our graduate research student were unable to contribute to field work in support of the project after the spring of 2019. This restricted our ability to

visit or revisit some of the sites that were originally targeted for observation during the study because fewer people were available to survey on suitable evenings during the short calling season. Despite these unexpected setbacks, our extensive success in 2019 set us up to accomplish our primary objectives for this exciting project.

Equipment:
No equipment was purchased.

Prepared by: Daniel R. Howard

Date Prepared: November 30, 2021

Approved by: Russ Horton, Assistant Chief of Wildlife
Oklahoma Department of Wildlife Conservation

Andrea K. Crews, Federal Aid Coordinator
Oklahoma Department of Wildlife Conservation

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