Geographic Information Systems & Niche Modeling of Pocket Gopher Burrows to Predict the Location of Gophers and Symbiotic Insects

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Project Abstract: Diverse insects live symbiotically with pocket gophers in their burrows. New species of burrow-sharing insects continue to be identified thorough fieldwork. A significant challenge is locating pocket gopher burrows. Mapping and Geographic Information Systems (GIS) are a promising approach to locating gopher burrows by modeling the environmental factors favorable to burrow construction. Pocket gophers choose particular habitats: wet, low-lying areas are poorly suited, while higher elevation well-drained areas support burrows. GIS can be used to analyze geological, soil, and physiographic data to determine particular areas suitable for pocket gopher burrows. The result, maps of potential pocket gopher habitat, can guide and focus fieldwork seeking additional burrows and the insects that dwell in them. The nature of this research involves the coalescence of many disciplines. In order to draw conclusions the fields of entomology, biology, GIS, ecology, soil science, and others must be brought together. There is much to be gained by using GIS in such research, with the caveat that data collection and processing is time consuming and labor intensive.

Previous Research

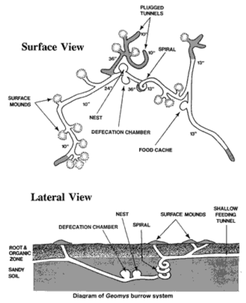
Over 100 years ago, H.G. Hubbard discovered unique species of insects living in gopher tortoise burrows in Florida and ground squirrel and jumping mice burrows in California. Hubbard also studied pocket gopher burrows where he discovered over 60 species, many of them previously unrecorded, in the U.S. southeast. Hubbard's research has been continued by Dr. Peter Kovarik and Dr. Paul Skelley, who have discovered a number of new insect species in the last two decades. This study focuses on the U.S. southeast (Florida, Georgia, Alabama) but the research is expanding to other areas in the U.S., Mexico, and Central America.

Southeastern Pocket Gopher

The Southeastern Pocket Gopher (*Geomys Pinetis*) has been described as a "homely, belligerent sausage." It is found in Alabama, Florida, and Georgia. The pocket gopher has powerful front legs, claws and chisel-like teeth for digging through soil and roots. Their minimalized eyes and ears also allude to their subterranean habitat. They are tan to gray in color and range in length from 9-12 inches including tail. Pocket gophers get their name from their fur-lined cheek pouches used for carrying food. Burrow dwelling pocket gopher species exist throughout North and Central America.

Pocket Burrow Architecture

Animal burrows provide a unique environment within which insect species have evolved. Burrow dwelling insects share some similarities with cave dwelling insects, such as underdeveloped vision and loss of pigment, but they are a distinct group of species. In particular, the symbiotic relationship between the insects and gophers is unique: the gophers provide a habitat for the insects, including a constant temperature, shelter, and food (gopher dung). The insects process gopher dung in the burrows, providing a service to the gophers.



The Insects: Kovarik and Skelly Field Work

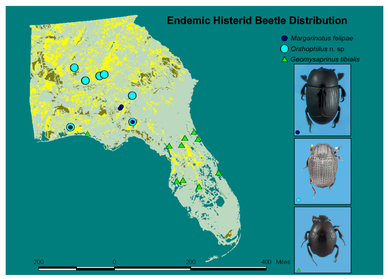
Sampling for insects in the burrows of the southeastern pocket gopher was conducted during the 1990's by Skelley and Kovarik. The unexpected discovery of several new species of beetles precipitated an extensive survey of insects within the entire range of the pocket gopher in Florida, Georgia and Alabama.

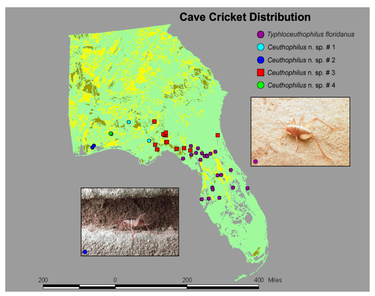
While all insects collected in the burrows were preserved for study, the focus groups for this study were **scarab beetles, hister beetles, and cave crickets** (maps below). The survey (ending in 2001) resulted in the discovery of additional species new to science and substantially increased the known distributions of described species. Some of the beetles were extremely common, widespread, and known to occur in the burrows of other species of pocket gophers in areas west of the Mississippi River. Other beetles were far less common, endemic to the southeast, and mainly confined to isolated localities on sand ridges or upland coastal plain terraces. It is currently thought that the latter group may represent a **relictual fauna.** While the distribution of the relictual beetle fauna appears to be somewhat correlated, a much different pattern of distribution is apparent among the species of flightless cave crickets.

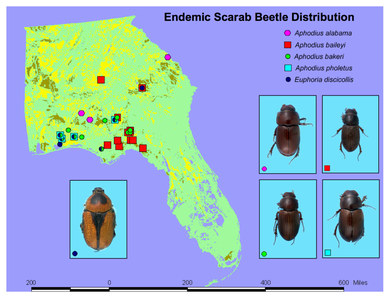
Some of the southeastern burrow insects have close relatives in the Great Plains and this connection may indicate a **migration event** that happened during the last maximum glacial period. Each of the southeastern relicts has an intriguing distribution patterns that likely stems from **dynamic sedimentation processes** that occurred over thousands of years.

Next in the analysis of these burrow-dwelling insects is to look for environmental similarities in the areas now occupied by the relictual fauna which may help to explain their current patterns of distribution and generate a rough time line as to when these groups initially colonized the areas they inhabit. Such an approach will also help predict suitable locations for future insect sampling.

To this end, environmental factors relevant to pocket gopher habitat must be defined, and relevant GIS data located, processed, and combined with the sampled Insect location data.







Current Research

Collecting burrow-dwelling insects is a significant challenge. Just as difficult is locating the gopher burrows. Historical records of burrow locations can be culled from earlier field research, local knowledge (farmers) or fieldwork (depending on serendipitous discovery of burrow complexes). Mapping and Geographic Information Systems (GIS) offer the potential for a more systematic and comprehensive approach to locating the gopher burrows. Maps of potential pocket gopher habitat can guide and focus fieldwork seeking additional burrow networks and the insects that dwell in them.

Field Data Collection: Iowa

To understand pocket gopher **habitat** and the methods for **collecting** the burrow-dwelling insects, Perry traveled with Kovarik to a study site in Iowa. The six locations studied were prairie environments with little human activity, with the exception of one farm field where gopher activity was present. The soils ranged from very sandy to moderately sandy in composition. Locations with recent heavy rains showed little gopher activity. The periodic burning of surface vegetation at several sites did not affect the long term health of known gopher populations.

Insect collection: *images left and below.* After gopher burrows were cleared of gophers, insect traps were set up in the mouth of the burrows. Sampling insects involves using bait (a gopher feces and sugar mixture) to lure the insects out of the burrows, where a pitfall trap containing antifreeze preserves the specimens. Traps are left out for two weeks to ensure an accurate sample.

Characterizing Pocket Gopher Habitat

A review of the literature on pocket gopher habitat identified a series of environmental factors that affect the development of burrows. Soil type, including drainage, is among the most important factors.

Soil type, drainage, depth: Without stable and relatively dry soil burrow construction and maintenance is difficult or impossible.

Elevation: Burrow-dwelling insects are associated with areas above maximum ancient sea levels, having been flooded out of lower elevation areas. Of particular importance are the ancient sand ridges of Florida and Georgia.

Land use: Pocket gopher burrows are unlikely to develop in urban or suburban areas, and are limited in rural areas with significant agriculture. Pocket gophers may, however, construct burrows in limited areas between heavily used human areas, making this factor less relevant in the analysis.

Geographic location: The location of pocket gophers and burrow-dwelling insects correlates with ancient sand ridges, providing limits to their location. In particular, the flightlessness of the cricket species has restricted their location.

Climate and rainfall: Like most gopher species, the southeast pocket gopher tolerates a variety of climates since it spends most of its time underground. Climate and rainfall thus have a limited effect on pocket gopher habitat.

Surface vegetation: Pocket gophers are most frequently found in longleaf pine habitats and other low density forests. Grass and shrub roots and tubers are necessary as a source of food for the gophers. However, an overabundance of vegetation and associated root systems prevents the gophers from tunneling.

GIS Data Relevant to Pocket Gopher Habitat

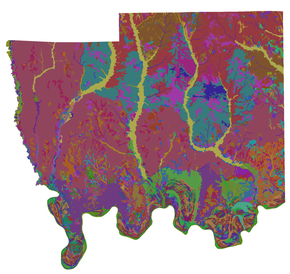
Locating, accessing, processing and using GIS data corresponding to pocket gopher habitat is a complex and difficult process. Key data sources include:

U.S. General Soil Map: Compiled by the US Department of Agriculture. Data are grouped by state and are downloadable. The soil surveys provide GIS data with detailed soil characteristics in an Access database. *Example map, right.*

Web Soil Survey: Used in conjunction with the *General Soil Map* to compile detailed soil reports at the county level corresponding to individual soil types identified through the soil data. Allows correlations to be made between soil types based on characteristics such as soil depth, composition, and drainage.

U.S. Geological Survey Digital Elevation Model & Contour Elevations: Elevation data has been useful for locating ancient sand ridges believed to be an important factor in gopher locations. A goal of the research project is to confirm the relationship between the sand ridges and gopher locations.

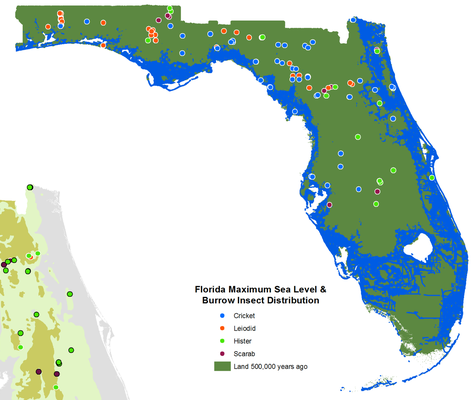
Other Data: including terraces, ecoregions, land use / land cover, climate, vegetation, etc. will be used as this research progresses.

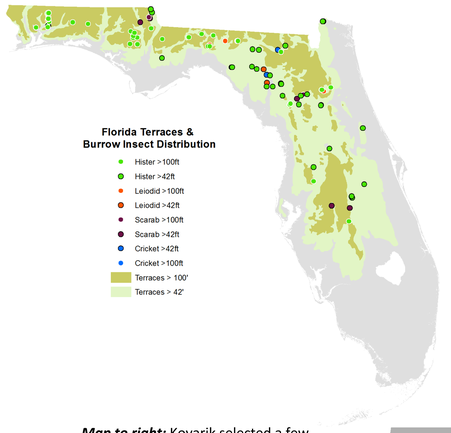


Preliminary Results and Future Research

Once the involved task of assembling appropriate GIS data is complete, myriad spatial correlations and associations can be assessed. Preliminary analysis has assessed the relationship of insect sample locations to areas not flooded by sea level rises in the last 500,000 years, the relationship between insect samples and terrace landforms, and the nature and geographic extents of soils where sample insects were found. Many additional correlations can, and will be investigated as the study proceeds. Kovarik and Skelly are provided with methods that help understand the spatial environmental characteristics of their samples, while also being able to predict potential area for further sample collection.

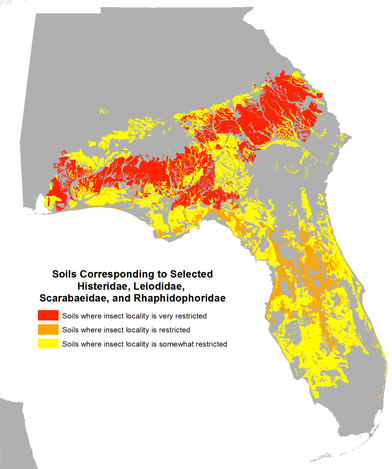
Map to right: Burrow-dwelling insects have been, as hypothesized, largely found in areas not flooded by sea level changes in the last 500,000 years. This supports the relictual fauna hypothesis, and suggests a more limited area where future sampling efforts may focus.

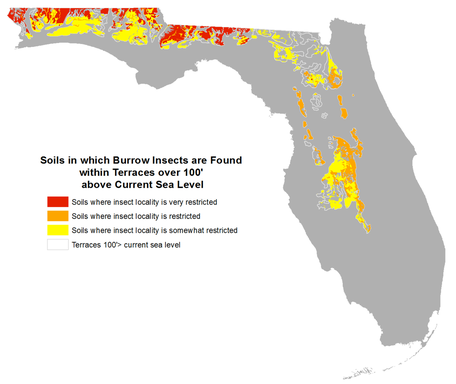




Map to left: Burrow-dwelling insects are also largely restricted to ancient terrace landforms with distinctive soils, elevation, vegetation, etc. Terraces are the result of river (fluvial) and coastal (marine) deposition. Potential gopher and insect habitat for future sampling is thus further focused.

Map to right: Kovarik selected a few insects of particular interest known from unique (very restricted) localities, from unique localities shared by a few other species (restricted) or from unique localities shared by a few other species and also associated with particular environmental characteristics (somewhat restricted). We identified soils similar to those where these three categories of species were found. Characteristics (detailed in the soils database) of these soils can be examined to more fully understand the insect and gopher habitat. In addition, future sampling can be focused on areas with specific soil types (and other specific environmental characteristics).





Map to left: We can further limit the areas for future sampling by selecting soils where new insect species have been identified *within* the +100' terrace areas (we could also select soils that fall in the +42' terrace areas). Additional factors further restrict potential habitat. For example, land use / land cover data includes "built up" areas which are not typically amenable as pocket gopher habitat. These built up areas can be *subtracted* from the areas on the map to the left, further narrowing potential habitat for future sampling.

Work continues on analyzing specific ecological factors (soil, elevation, vegetation) tied to specific burrow-dwelling insects via the GIS data, and developing maps which highlight suitable areas for future sampling. Similar analyses can be performed for other regions in North and Central America.

Ohio Wesleyan

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