Cover Page

Land Snail Abundance And Diversity With Associated Ecological Variables In Six Southern Illinois Counties

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A State Wildlife Grant Project

Executive Summary

Background and Objectives

Land snails are an important component of most terrestrial ecosystems, serving as food items for salamanders, small mammals, birds and some arthropods (e.g., fireflies and harvestmen) as well as processing decaying plant material (Barker, 2001). Land snails may also serve as useful biological indicators of soil quality and chemistry (Burch and Pearce, 1990). The purpose of this project was to assess land snail diversity and abundance in Alexander, Union, Jackson, Randolph, Monroe and St. Clair counties, where land snail species richness is known to be high (Baker, 1939; Hubricht, 1985).

The main objectives of this investigation were 1) *to produce quantitative estimates of terrestrial gastropod species richness and abundance from 60 sites* and 2) *to identify relationships and correlations between terrestrial gastropod species diversity/abundance and selected environmental and ecological factors*.

Methods

Two main methods were used to collect land snails. First, we used timed quantitative searches in stratified, randomly sampled quadrats. In this method, non-overlapping, one-square meter (~1 sq. yard) regions (quadrats) are selected randomly from within areas where terrestrial gastropods are most likely to be found (e.g., leaf litter, areas of high plant diversity, bases of bluffs). Twelve quadrats within a 100 x 100 meter site were chosen and searched for snails for ten minutes. We also collected four one-liter leaf litter plus topsoil samples and searched these samples for land snails. Several aspects of soil chemistry were measured from soil samples taken at each site. Finally, we collected snails opportunistically from substrates that are difficult to sample quantitatively (e.g., under logs) to get a better sense of snail diversity at each site. All specimens were identified using field guides and/or comparison with specimens from museum collections. Shells were retained in vials, and snail bodies were fixed in formalin and preserved in 75-80% ethanol. All specimens were deposited at the Field Museum of Natural History or the Carnegie Museum of Natural History. We ran a battery of statistical tests to 1) check for seasonal differences in snail abundance, 2) estimate species richness, 3) compare land snail diversity at each site, 4) check for correlations between habitat complexity and land snail diversity and abundance, and 5) check for correlations between various soil chemistry parameters (e.g., levels of iron, sulfur, etc.) and land snail diversity and abundance.

Findings

We collected 5,393 snails or shells representing 72 species from 60 sites, most of which were surveyed twice (in the spring and fall of 2007). From combined species records of this study and earlier collections, a total of 108 fossil and extant species have been recorded in the 6-county study area, 91 of which have been collected and recorded as extant species. Based on Field Museum records, there are 124 extant species of land snails in the state of Illinois, thus, approximately 71% of all Illinois land snail species are found within our 6-county study area. Five of the 91 species are non-native to the study area. These species, all introduced slugs from Europe, are *Deroceras reticulatum*, *Arion intermedius*, *Arion subfuscus*, *Lehmannia valentiana*, and *Limax maximus*. The presence of these slugs has not been officially documented in any publications for the 6-county study area. Three North American species that were previously unrecorded in the 6-county area were also collected in this study—*Ventridens demissus*, *Vallonia pulchella*, and *Gastrocopta cristata.* Thus, a total of 8 species are newly recorded for the study area.

Habitat complexity, soil sulfur and soil calcium were all positively associated with land snail abundance. Habitat complexity was also positively associated with land snail diversity, but soil iron was *inversely* correlated with diversity. We were able to develop models that could be used to predict land snail diversity and abundance at a site. The model for abundance contains three parameters (soil pH, soil sulfur, and habitat complexity). The model for diversity also contains three parameters (soil calcium, soil iron and habitat complexity). Our results suggest that land snail abundance and diversity are best treated separately in analyses, as they are influenced by different variables (with the exception of habitat complexity). Our models have potential value in that they can be used to predict snail abundance/diversity in areas that have not been assessed. We found habitat complexity to be the strongest factor affecting snail abundance and diversity, and it could serve as a good "first pass" to estimate snail abundance and diversity in an area without the need for expensive and time-consuming soil tests.

Products

Several products outlined in our proposal have resulted from this investigation:

1) A checklist of terrestrial gastropods collected from the proposed counties, incorporating the historical records of F.C. Baker (1939), Hubricht (1985) and Hutchison (1989), as well as records from the Field Museum of Natural History and the Illinois Natural History Survey.
2) Species lists for each site, to be disseminated to the Illinois Department of Natural Resources and US Forest Service personnel.
3) A web product, consisting of a species checklist, plus an identification key and images of the species collected. The Southern Illinois Land Snails page can be found at http://www.zoology.siu.edu/landsnails.html.
4) A collection of terrestrial gastropods (i.e., dry shells and soft tissue parts preserved in ethanol for both dissection and molecular analysis), donated to the Field Museum of Natural History. Snails found in the pilot study (see report for details) were donated to the Carnegie Museum of Natural History, Pittsburgh, Pennsylvania.
5) An educational poster, entitled *Illinois Land Snails and Slugs*, developed in collaboration with the Illinois Department of Natural Resources Educational Division.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The southern region of Illinois represents an area greater in natural habitats and faunal and floral diversity than any other in the state. Whereas surveys have thoroughly covered aspects of geology, topography and most fauna and flora of this area (Voigt and Mohlenbrock 1964, Critical Trends Assessment Program 2007, USGS 2007), far fewer studies have been done to investigate the diversity and distribution of land snails and slugs (Critical Trends Assessment Program 2007). This trend applies not only in southern Illinois but also in terrestrial gastropod assessments in general (Lydeard *et al*. 2004). Terrestrial gastropods (Gastropoda: Stylommatophora and Basommatophora; hereafter referred to as terrestrial gastropods, gastropods, land snails, or snails) are known to be most abundant and diverse in the southernmost part of Illinois (Baker 1939; Hubricht 1985). Their presence serves as an important indicator for the overall health of an ecosystem (Burch and Pearce 1990). Although some historical information about land snail abundance and diversity can be obtained through records of previous collections, plus museum data for this area (F. C. Baker 1939; Hubricht 1985; Hutchison 1989; Field Museum of Natural History Malacology Collections), there remains a need for a quantitative terrestrial gastropod assessment in areas of southern Illinois, because "existing data for land snail species status, distribution, and natural community associations are inadequate to accurately monitor populations" (Critical Trends Assessment Program 2007).

To accompany records of land snail abundance and diversity, it is equally important to collect data on the habitat variables that potentially influence the land snails in an area, as well as factors that could have a negative impact on snail populations. Much of the general habitat data, such as forest type and topography, is obtainable from sources such as the Critical Trends Assessment Program (2007) and the USGS (2007), but field observations also need to be made along with collections of land snails. Similar studies in other areas have commonly collected soil, vegetation, topography and climate data, then compared these variables with the abundance and diversity of snails observed at each site (Burch 1955, 1956; Coney *et al*. 1982; Emberton 1997; Nekola 1999; Tattersfield *et al*. 2001).

The main purpose of this investigation was to quantitatively estimate terrestrial gastropod abundance and diversity and to record data on ecological variables that might influence these parameters. Analyses were then performed to determine which environmental factors were most strongly associated with land snail diversity and abundance. These data in turn can be used to predict snail diversity and abundance in unsurveyed areas, and to monitor and protect land snail habitats.

The value of the proposed study can be outlined as follows:

1) Quantitative data on terrestrial gastropod abundance and diversity in southwest Illinois were obtained for the first time during the course of this study.
2) The works of Baker (1939), Hubricht (1985) Hutchison (1989) – three historically prominent collectors of the area – mainly reflect casual terrestrial gastropod collecting, and thus do not provide quantitative data; however, their combined records indicate there were 104 living and fossil species in the six-county study area and thus provide a baseline list to aid in identification.
3) Several Illinois land snail species have been designated as endangered or threatened in recent years and are therefore of conservation interest. Thirteen species are listed in the Illinois Comprehensive Wildlife Conservation Plan (2007) as threatened or endangered, and six of these species are known to have extant populations in the study area (Hubricht 1985, Nekola and Coles 2001): *Euchemotrema hubrichti* (Pilsbry 1940), *Gastrocopta*

rogersensis Nekola and Coles, 2001, *Megapallifera ragsdalei* (Webb, 1950), *Oxyloma salleanum* (Pfeiffer, 1849), *Paravitrea significans* (Bland, 1866), and *Triodopsis discoidea* (Pilsbry, 1904). The results of the proposed study will promote continued conservation of these critical species in the surveyed areas.

4) Terrestrial gastropods as a group serve as an important indicator for understanding the health of an entire ecosystem. They help to break down and recycle decaying plant material, and in turn serve as a food source for some salamanders, small mammals, birds, and arthropods (Barker 2004). They also play a vital role in the uptake of calcium from the soil and organic matter, and the transfer of this nutrient (and potentially others) to higher trophic levels (Beeby 1991, Adams and Wall 2000).
5) The data generated by this study will be part of inventory that is needed for implementation of the Illinois Comprehensive Wildlife Conservation Plan to protect terrestrial gastropod diversity in southwestern Illinois.

HYPOTHESES

A considerable number of studies have evaluated the associations between particular habitat variables and snail abundance/diversity. Most of these studies investigated obvious requirements of gastropods such as calcium, high pH and soil moisture. Calcium, an essential element for snails, is required for shell growth and repair, as well as egg production (Hyman 1967, Fournié and Chétal 1984, Burch and Pearce 1990, Barker 2001). Snails are known to ingest soil particles and absorb calcium directly from the soil through the foot integument (Fournié and Chétal 1984). Soil calcium content has been shown to be a positive influence on gastropod abundance and distribution (Burch 1955, Coney *et al.* 1982, Nation 2005). Rock type can be intimately related to soil calcium content, and has also been shown to be a significant factor in reflecting high land snail abundance and diversity (Nekola 1999, Nation 2005). Calcium is not always correlated with pH, as Nekola and Smith (1999) showed higher abundances associated with high pH values, but not with calcium. Riggle 1976 found a negative correlation between pH and diversity. Moisture can be a limiting factor to snail populations (Pearce and Örstan 2006). Other ecological factors shown to be positively associated with snail abundance and diversity are slope (Coney *et al*. 1982), vegetation type and richness (Burch 1956, Grime and Blythe 1969, Barker and Mayhill 1999, Nation 2007), and habitat type (Shimek 1930, Coney *et al*. 1982, Nekola 1999).

It is worthwhile to examine relationships between these habitat variables and land snail diversity and abundance, because no data regarding such relationships exist within the study area. Therefore, it is possible that a variety of variables could affect land snail diversity and abundance, and assumptions should be transferred from one geographic region to another with caution.

I intend to test the following hypotheses:

1) Areas of high soil calcium support greater abundances and diversities of terrestrial gastropods.
2) Areas of high pH support greater abundances and diversity of terrestrial gastropods.
3) Habitat and microhabitat affect gastropod abundance and diversity, with areas of greater topographical and vegetative diversity supporting greater snail abundance and diversity.

AREA DESCRIPTION AND CLIMATE

Centrally located in the survey area is Jackson County, Illinois. The elevation of Carbondale (N37.72648, W89.220270 at town center) is 415 ft. (Google Earth). The average summer high temperature is 87 °F and low is 68 °F; the average winter high temperature is 44 °F and low is 26 °F. Average annual precipitation is 43 inches (Illinois Water Supply Planning, http://www.isws.illinois.edu/wsp/).

The area studied comprises 60 sites, with two in each of 30 nature preserves, state parks and fish and wildlife areas, and Shawnee National Forest sites (see Appendix A, Table A1), chosen as representative natural areas in six counties of Illinois, along the eastern shore of the Mississippi River. The sites are state or federally protected areas in the Shawnee National Forest, state parks, or nature preserves within the six counties. In order from north to south, the counties are St. Clair, Monroe, Randolph, Jackson, Union and Alexander (see Figures 1 and 2). This region comprises habitats that are considered to be ideal to support terrestrial gastropods, and it is known to be a species-rich area (Baker 1939, Hubricht 1985, Hutchison 1989).

The area from Carbondale (Jackson County) southward is an extension of the Ozarkian Uplift, the mountainous region of the southeastern part of the state of Missouri. This part of the uplift is known also as the Illinois Ozarks or Shawnee Hills Section, and is part of the Shawnee National Forest. The hills of southern Illinois generally rise between 394 and 655 feet above adjacent valleys. The Shawnee Hills Section is geologically differentiated from the rest of the land in the state of Illinois in that it represents the area that remained unglaciated during the Pleistocene ice age. This resulted in a rough area with diverse elevations, with much of its topography influenced by the bedrock beneath the surface (Willman *et al*. 1975). Within this range, the bedrock geology represents one of the most diverse of the state, comprising Tertiary, Cretaceous, Pennsylvanian, Mississippian, Devonian, Silurian and Ordovician bedrock (Willman *et al*. 1975, Harris *et al*. 1977). The different types of bedrock layers contain several main rock types: sandstone, limestone, dolomite, shale and coal (Willman *et al*. 1975). Some of these bedrocks are exposed in areas, particularly along the eastern border of the Mississippi River. Loess cover forms on top of exposed rock bluffs and in crevices, which, together with the underlying rock type, impacts the general abundance and diversity of life that dwells in this habitat (John Utgaard, SIUC Geology, pers. comm., February 2007).

The dominant vegetative aspects of the area include upland oak-hickory forest, bottomland forest, and lowland or till plains (Voight and Mohlenbrock 1964). Two areas are recognized for having the highest vegetative diversity in the state: Fern Rocks Nature Preserve and La Rue Pine Hills Ecological Area (Jenny Skufca, pers. comm.).

The study area comprises six Illinois Natural Divisions, which are defined by landforms, differences in bedrock type, predominant vegetation and fauna (see Figure 3) (Schwegman 1997, Critical Trends Assessment Program, Illinois Natural History Survey, 2003). These divisions are the Southern Till Plain Division, the Ozark Division, the Lower Mississippi Bottomlands Division, the Shawnee Hills Division and the Illinois Coastal Plain Division.

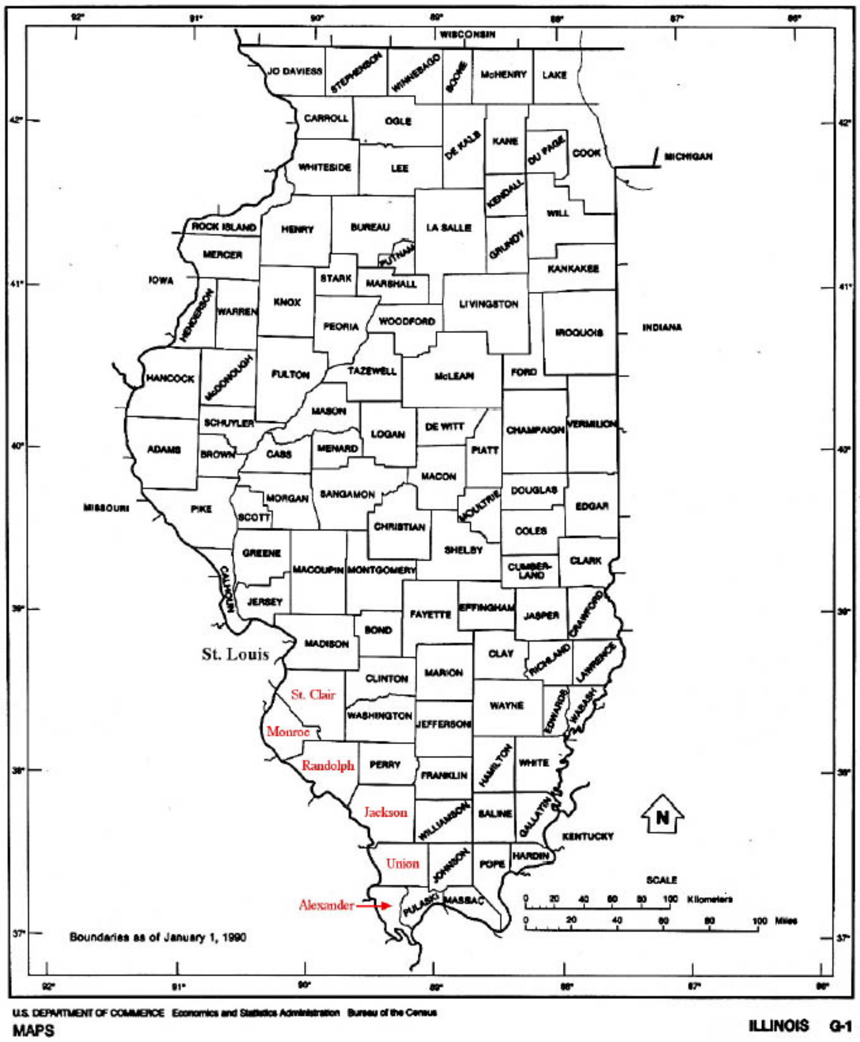

Figure 1. Map of the state of Illinois, showing the six southwestern border counties (St. Clair, Monroe, Randolph, Jackson, Union, Alexander) of the study. (Map source: US Department of Commerce Economics and Statistics Administration, Bureau of the Census).

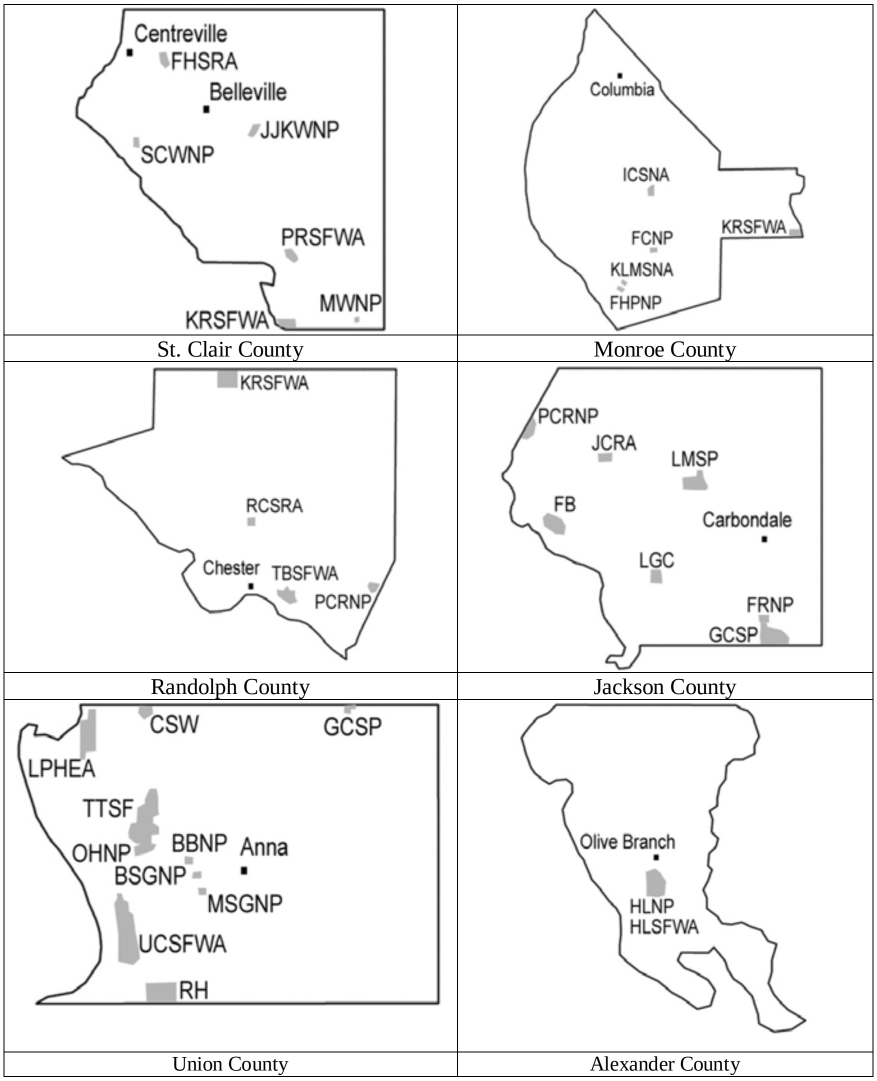

Figure 2. County maps and the general areas surveyed within each, highlighted in grey. See Appendix A, Table A1 for general study area names (abbreviations are given here). Each area contains either 2 or 4 study sites.

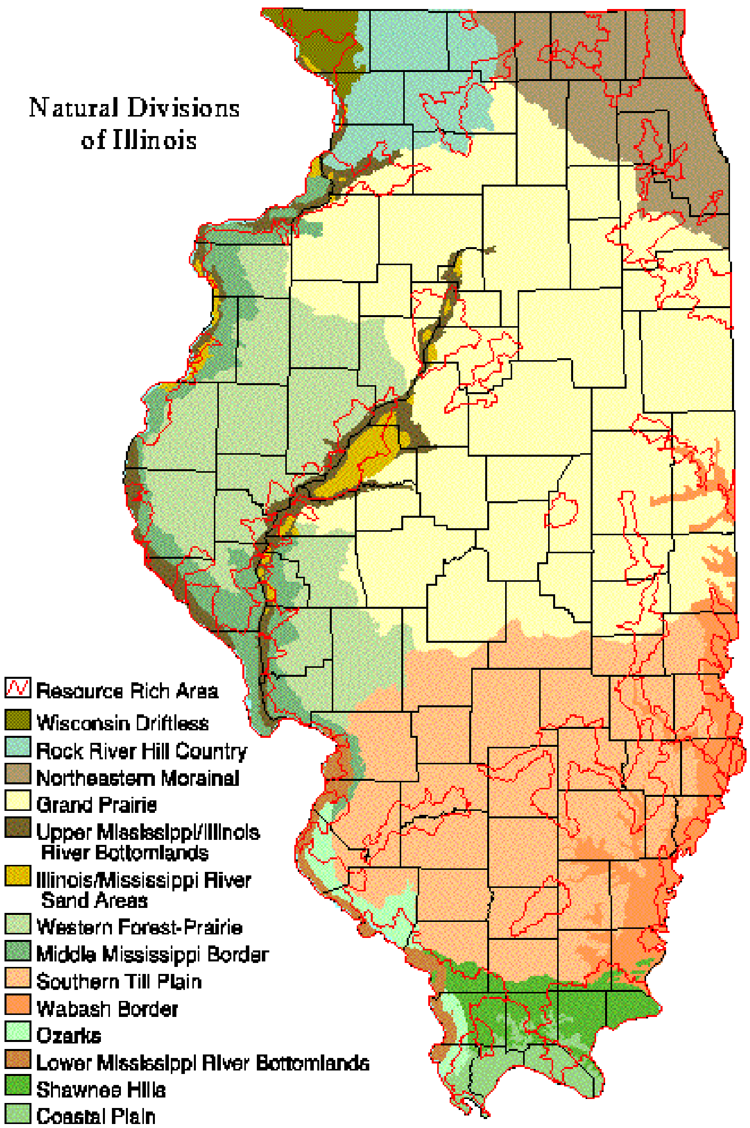

Figure 3. Natural Divisions of Illinois (Illinois Natural History Survey, http://www.inhs.uiuc.edu/cwe/rra/graphics_rra/figure13.gif)

HISTORY OF LAND SNAIL COLLECTING IN SOUTHERN ILLINOIS

Three principal works, by F. C. Baker (1939), L.R. Hubricht (1985) and M.D. Hutchison (1989), represent the existing literature on land snails of the study area. Specimens collected in the study area are housed in the Malacology collections of the Field Museum of Natural History and the Illinois Natural History Survey. The relevant county associations have been extrapolated from the literature and from museum records as baseline data for this study. See Appendix A, Table A7.

Collecting records were further examined at the state level. By integrating data from the Field Museum, Illinois Natural History Survey, and Hubricht (1985), there are approximately 124 extant species of land snails known from the state of Illinois. By comparison, the 6-county study area is known to have 91 species, or 71% of the state's land snail species. This high percentage presumably can be attributed to the relative ecological richness of the study area, as compared with the rest of the state, most of which is dominated by agricultural activity.

BRIEF OVERVIEW OF NORTH AMERICAN LAND SNAIL BIOLOGY AND ECOLOGY

Land snails are terrestrial mollusks, numbering around 1,000 species in North America (north of Mexico) (Pilsbry 1939-1948). They are organisms of low vagility, with populations tending not to spread in observable time. While they have evolved to occupy diverse habitats, their common basic survival needs are moisture, food and shelter (Hyman 1967; Burch and Pearce 1990). Snails generally seek damp, humid microhabitats and tend to be nocturnal in their activities, which helps to retain their bodily moisture content. In dry seasons and in times of drought, snails have remarkable adaptations and abilities to retain moisture and avoid desiccation, such as mucous secretion, epiphragm formation over the aperture of the shell during periods of inactivity, and by lowered metabolic activity (Hyman 1967). The majority of land snails are generalist herbivores, typically feeding upon decaying vegetation and fungi (Baker 1939, Burch and Pearce 1990). Some species are carnivorous, such as *Haplotrema concavum* (Say, 1821), which is equipped with specialized features to feed upon other snails (Baker 1939). Contrary to popular belief, the snail's shell does not offer all the shelter it requires. Snails avoid predation and desiccation by seeking shelter, often under the bark of logs, under rocks and in rock crevices, and in the leaf litter. These areas of shelter can offer food for the snails.

As noted earlier, calcium is of great importance for the growth and physiology of land snails, as it is essential for shell building, egg-laying, and other regulatory functions (Hyman 1967, Burch and Pearce 1990, Barker 2001). It is consumed in the diet and/or uptaken through the foot integument. Soil calcium has been shown by many studies to influence patterns of snail abundance and diversity (Burch 1955, Wäreborn 1970, Coney *et al.* 1982).

There is some evidence in the literature that certain naturally occurring elements are harmful to snails. Elevated levels of iron in the environment, existing in several compounds and chelated forms, have been shown to negatively impact aquatic snail abundance and diversity (Horsák and Hájek 2003). Compounds containing iron are known to have toxic effects on land snails (Henderson and Martin 1990, Triebskorn *et al.* 1999) and aquatic snails (Vuori 1995). Iron phosphate is now commonly used in commercial molluscides for agricultural use as it has proven an effective killer of slugs and snails that are crop pests (Caldwell and Pritts 2000-2001). Likewise, manganese has been shown to interfere with the physiological processes of snails, by breaking down the calcium granules in the snails' digestive gland (or hepatopancreas), which normally function to sequester potentially toxic elements away from the organism's vital processes (Taylor, *et al.* 1988).

Relationships with Other Organisms

Many animal species are important predators of land snails (Barker 2004). Many insects consume land snails, including carabid beetles and the larvae of fireflies (Coleoptera: Lampyridae). Empty snail shells are often used by insects, as they provide a convenient and protected space in which they can lay their eggs, where larvae can develop safely from potential predator attacks (Taylor *et al.* 1977, Örstan 2008).

Land snails are an essential part of the diet of many species of birds (Barker 2004). During periods of egg-laying, female birds that consume snails will increase their consumption of them. For example, female turkeys have been found to ingest 40% more snails in a time span prior to laying eggs (Beasom and Pattee 1978). Birds obtain calcium from the snails, a nutrient that is vital to embryo and egg shell production.

Numerous reptile, amphibian and mammalian species also feed upon snails (Barker 2004).

Environmental Changes Caused by Humans

In today's world of rapid changes due to human impact on natural ecosystems, land snail populations may be in danger of decline. Snails are threatened in areas affected by polluted rainfall, as the soil has become acidic and lacks sufficient calcium for their proper growth and life functions (Dallinger *et al.* 2001). The potentially widespread implications of reduced snail populations are clearly seen when relationships between snails and their predators are considered. For example, one study in Europe documented the decline of forest passerines, which was shown to be caused at least in part by the dwindling populations of their main food, land snails. Due to insufficient dietary calcium, the eggs of these birds were deformed and did not develop properly (Graveland *et al*. 1994).

Other potential human threats to snails include agriculture road, housing and business construction. Furthermore, the common application of salts and chemicals to roads in the winter can have a negative effect on snails (Kay 1995).

Invasive Snails

Over the centuries, some land snail species have been introduced to North America from other lands. Most of the invaders came from Europe in shipments of food or plants. Some do little damage, but others, such as the large slug *Limax maximus*, can damage crops and compete with the native land snails for resources (Robinson 1999).

Land Snail Conservation

The fact that land snails are not sufficiently studied has made it more difficult for conservation specialists to assess the measures that are needed to protect them. Certain events, whether natural or human-induced, can affect abundance and diversity of land snails in both forest and prairie habitats. Studies have demonstrated that fires can adversely impact abundance and diversity of snails (Nekola 2002; Kiss and Magnin 2003; Severns 2005). The same holds true of floods (Boycott 1934; Čejka *et al*. 2008), as land snails cannot protect themselves from over-hydration and will die from drowning. Whether these events are caused intentionally by humans (for example, in prescribed burns or controlled floods) or by natural means, the snail populations are affected, but the extent of these effects has not been thoroughly studied.

OBJECTIVES

The main objectives of this investigation are:

1) To make quantitative estimates of terrestrial gastropod species richness and abundance from 60 representative sites in six southern Illinois counties.
2) To identify relationships and correlations between terrestrial gastropod species diversity/abundance and selected environmental and ecological factors (see below).

PILOT STUDY

The planning, methodology and implementation of this project benefitted greatly from a pilot study, carried out from September to November 2006. Eleven sites at the following areas were surveyed for land snail abundance and diversity during this time: Johnson Creek Recreational Area, Lake Murphysboro State Park, Fountain Bluff, Giant City State Park, Little Grand Canyon, Clear Springs Wilderness, Turkey Bluffs State Fish and Wildlife Area, Randolph County Conservation Area, Trail of Tears State Park, Union County State Fish and Wildlife Area, and Ripple Hollow. The methodology was developed and adjusted for use in the formal study, as described fully in the next section. Aspects of the methods tested in the pilot study and subsequently altered were:

1) Length of search time per quadrat.

   The time originally proposed to search each quadrat was 15 minutes. When tested in the pilot study, this length of time compared to a 10-minute search proved to yield few if any additional snails. The time was shortened to 10 minutes for the formal study.

2) Random quadrat versus random stratified sampled quadrat method.

   At several sites during the pilot study (Giant City State Park, Clear Spring Wilderness, Ripple Hollow) quadrats were chosen randomly within the site. Random quadrats that occurred in areas of little vegetation and not near trees, brush, exposed rock or fallen logs contained very few snails, whereas quadrats placed specifically in areas on or adjacent to these features yielded far greater snail numbers and more species. In the random stratified sampling technique, strata, or specific features within the sampled habitat, are chosen for their likelihood to contain snails. Since the physical distribution of land snails is known to be clumped, the random stratified sampling technique has been shown to be more effective for collecting snails (Bishop 1977, Emberton *et al*. 1996) and was ultimately chosen as the method for the formal study. Similar results were found when comparing leaf litter samples of equal volume taken from selected versus samples taken from randomly chosen areas, hence leaf litter from randomly stratified selected areas were used in the formal study.

3) Use of cardboard sheets

Cardboard sheets have been advocated as useful for attracting land snails (Boag 1982; Hawkins *et al*. 1998). Corrugated cardboard sheets measuring 80 x 100 cm (31.5 x 39.4 inches) were deployed at three sites in the course of the pilot study (Giant City State Park, Randolph County Conservation Area and Trail of Tears State Park) on fairly level ground on top of leaf litter, and held down by rocks and fallen tree limbs. They were checked for any land snails found beneath them two weeks later. As no snails were collected from them, they did not prove to be useful. The cardboard sheet method has been used in several studies (Boag 1982; Hawkins *et al*. 1998) with varied results. Boag (1982) found that cardboard sheets were most useful when the cardboard was wetted the day before inspection for gastropods. In the larger scope of the proposed survey, this method would not be feasible, as there are 60 sites in 6 counties to survey. Therefore the cardboard sheets were not used as part of the methodology for the formal study.

MATERIALS AND METHODS

Two main methods were used for the collection of land snails:

1) Timed quantitative searches in stratified, randomly sampled quadrats.

   Some researchers have suggested that random sampling methods are inappropriate for terrestrial gastropods (Bishop 1977; Cameron and Pokryszko 2005; Emberton *et al*. 1996). Many terrestrial gastropods have very particular microhabitat preferences (Nekola 1999) and are often restricted to small microhabitats, which random sampling methods tend to miss (Emberton *et al*. 1996). Therefore, I used stratified random sampling, which differs in that it will sample chosen microhabitat areas most likely to support snails, because at no site are gastropods completely homogeneous in distribution. In this method, non-overlapping, one-square meter quadrats are selected randomly from the habitat types of interest, i.e., where terrestrial gastropods are most likely to be found. For example, leaf litter, areas of high plant diversity, coarse woody debris, bases of bluffs, bases of trees and rotting logs all represent “snail habitats”, and so quadrat locations were selected from the possibilities present at each site. In addition, abiotic factors related to topography and rock exposure were taken into account and appropriately chosen areas sampled. Quadrats were used to sample twelve 1-m^2 (3.2808 $feet^2$) areas within a 100 x 100 m (328 x 328 feet) area at each site. For 10 minutes, each quadrat was visually searched and the snails were hand-collected, with both live specimens and empty shells placed in numbered vials.

Quadrats were constructed from two one-meter pieces of 1/2 inch PVC pipe, joined at one corner by a PVC elbow joint to form a right angle. At the two free ends of the pipes, a 2-meter fluorescent nylon cord was attached, with a plastic stake tied in the middle of the cord. When in use, the stake is pulled out to form a right angle, and placed into the ground. The design allows the structure to be completely collapsed for portability.

2) Leaf litter collection and search.

Four one-liter (33.8 fl. oz.) bags of leaf litter plus a small amount of topsoil were collected at each site. Searches through these samples allowed recovery of smaller species and juveniles that are not easily found during visual quadrat searches. Leaf litter and the first 2 cm (0.79 inches) of soil were collected using a trowel. Each sample was taken from four different areas of the site. Whenever possible, samples were taken from areas representing different microhabitats (e.g., sites with different altitude, slope, proximity to water, distance from rocks or trees, vegetation). Collections were also concentrated on interface areas, such as leaf litter/fallen log interfaces, leaf litter/rock ledge interfaces, etc., since the greatest abundance and diversity was found in these areas in the pilot study. The collected leaf litter and soil samples were examined in the laboratory under magnification for snails. Specimens were removed, identified, and stored as outlined below. After all the readily seen snails are removed and collected, the leaf litter was put through a series of metal mesh sieves (mesh sizes #5, #10, #60, #230) to recover any remaining snails or identifiable shell fragments.

Other methods

3) Qualitative collections

Due to the patchy habitat preferences of land snails, collection of specimens from substrates that are not measurable quantitatively (*e.g*., under bark of logs, in tree nooks, vertical surfaces, and the undersurfaces of rocky outcroppings) is desirable (Pearce and Örstan 2006). Snails were hand-collected from on or under these surfaces, and samples of mosses or other prevalent vegetation (no more than 1 liter total), were examined for gastropods in the laboratory.

4) Identification and preservation of specimens

Collected snails were identified with the aid of field guides (F.C. Baker 1939; Pilsbry 1939-1948, Burch 1962) and by comparison with specimens from museum collections (Field Museum of Natural History, Carnegie Museum of Natural History, Delaware Museum of Natural History and the Illinois Natural History Survey Collections), and then preserved and labeled. Juveniles and broken specimens that were not identifiable to species were identified to genus or family, or if no identification was possible, they were labeled as "unidentified". Dry empty shells were housed in glass vials with polyfill stoppers; very small (≤2 mm) specimens were housed in archival-quality micromounts. Living specimens were frozen on the same day of collection at -80 ºC then later thawed to remove the shell (if present). Shells were preserved in glass vials with labels. A slice of tissue was taken from the foot of each animal, to be preserved as a voucher for possible future molecular work by others in the Anderson laboratory. The rest of the body was processed as follows: fixed in 5% buffered formalin for 1-3 days (depending upon size of the specimen), removed and rinsed with de-ionized water, then preserved in a vial containing 75-80% ethanol. For specimens not fixed in formalin, the entire body and shell were simply preserved in 80% ethanol. All specimens are stored with archival-quality labels containing collection data and a unique project catalog number (parts of a single specimen, *i.e.*, body and shell, share the same number), and were recorded in a Microsoft Access database.

At completion of the project, all specimens from the pilot study were deposited at the Malacology Section of the Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, and all specimens from the formal study were deposited at the Malacology Section of the Field Museum of Natural History, Chicago, Illinois.

5) Soil collection

Soil samples were taken from each site in the course of both Spring and Fall 2007 field collecting, to obtain a general estimate of the organic and inorganic nutrients, as well as moisture content. A total of twenty soil core samples of 5 cm (~2 inches) depth each were collected with a soil probe from random positions within the sampling area of each site. This depth is most likely to have influence on snails, as Hawkins *et al.* 1998 reported that nearly 90% of snails live within the top 5 cm (~2 inches) of the soil. These twenty samples were then combined and homogenized to make one sample representative of the site. See Analyses section for procedures used to determine the mineral content and other factors of the soil. All homogenized soil samples were sent to the Southern Illinois Soil Laboratory in Hamel, Illinois for processing and analysis of the elements (exchangeable K, exchangeable Ca, P, Mg, Fe, Cu, Mn, Zn, S and B), as well as analysis of water pH, buffer pH, cation exchange capacity (a measure of a soil's ability to hold nutrients) and percentage of organic matter by loss on ignition. A 50 g (1.76 oz.) subsample of each site's sample was analyzed for moisture content at the SIUC College of Agriculture, where I used a gravimetric method to estimate soil water content. The soil sample was weighed and then re-weighed after desiccation in an oven at 105 ºC (221 ºF) for 48 hours. Moisture percentage was then calculated from the weights as (wet soil weight - dry soil weight/ dry soil weight) x 100 (Terry Wyciskalla, SIUC Dept. of Agriculture, pers. comm., December 2006). See Appendix A, Table A4 for a table of soil factors at each site.

6) Habitat complexity

Habitat complexity has been related to species occurrence, abundance and diversity in many studies, based on both terrestrial and aquatic organisms and habitats, though with widely varying approaches that attempt to quantify the habitat variables (Kohn 1967, Heck and Wetstone 1977, Bell *et al*. 1991, Lassau *et al.* 2005). Authors of habitat complexity studies, regardless of the organism considered, advocate that the habitat factors chosen for analysis should relate to the biological needs of the organism. One study that involved terrestrial invertebrates proved to be a useful model. Lassau *et al.* 2005 assessed habitat complexity in relation to forest beetle diversity. The authors used a simple ordinal scale to assign scores between zero and three to describe six different habitat features that are of importance to beetles: tree canopy cover; shrub canopy cover; ground herb cover; soil moisture; amount of leaf litter; and amount of logs, rocks, and debris at each study area. Based on the biotic and abiotic requirements of land snails, I chose to measure four habitat factors at each site: topography, exposed rock, vegetation diversity, and the presence of a body or channel of water. I assigned a simple numerical value (0, 1, or 2) for the level of the habitat feature at each site. Later, all values were summed to serve as a single total value to quantify the level of habitat complexity for the site.

Justification for these four factors is as follows:

Topography: Different land snail species have been observed to occupy landscapes with varying levels of elevation change (Baker 1939). Some are associated with flatter landscape, such as meadows (Baker 1939), whereas others tend to be associated with sloping terrain (Coney *et al*. 1982). Some are associated with terrain comprising many steep elevation changes within a relatively small area, such as *Euchemotrema hubrichti* (Pilsbry, 1940), which lives exclusively in an area characterized by steep bluffs (Anderson and Smith 2005).

Exposed rock: Exposed rock can provide vertical surfaces and crevices that are preferred by some snails. *Euchemotrema hubrichti* (Pilsbry, 1940) again serves as a good example of a species confined to certain habitat, as it is documented as living in rock crevices or under limestone slabs (Anderson and Smith 2005). *E. hubrichti* and some others, such as members of genus *Gastrocopta*, are calciphiles and are often observed crawling directly on limestone surfaces, and rock outcrops in forests are known to be good snail habitat (Örstan and Pearce 2006). Many small snail species, generally measuring less than 5 mm at greatest width, thrive in areas of leaf litter without exposed rock (Boag 1985).

Vegetation diversity: The variety of vegetation types influences snail diversity. Vegetation, in terms of diversity and certain tree species, have been shown to have an effect on the distribution of snails (Shimek 1930, Burch 1956, Karlin 1961, Beyer and Saari 1977, Coney *et al.* 1982, Nation 2007). While most species in southern Illinois inhabit deciduous woodland areas, some, such as *Vallonia* species, are associated with clearings and lighter canopies (Baker 1939; Pearce and Örstan 2007, J. Gerber, pers. comm.). Vegetation was assessed at each site according to lists of plant species obtained from the Illinois Natural Divisions records, in combination with anecdotal evidence at the site, since these lists provide a list of species by Natural Division, not by site.

Body or channel of water: Some snails, such as members of the family Succineidae, along with prosobranch species *Pomatiopsis lapidaria* (Say, 1817) and *Galba obrussa* (Say, 1825), are amphibious and tend to live near some kind of water, sometimes partly or completely submerged (Baker 1939). Others have less tolerance or need for habitat with a body or channel of water in its vicinity, such as most Polygyridae species, which tend to be found on drier ground.

I chose to measure variables on a macro-scale habitat for several reasons. First, these factors are among the most straightforward to quantify at the broad range of four levels I have proposed. I predict that these factors at the macro level could, in turn, translate to more complexity at the microhabitat level. A more complex habitat, and in turn more complex microhabitats, could support more species of snails. Finally, for a person who does not have familiarity with land snails, these macrohabitat factors could offer a basic and immediate way to make some prediction of the snail diversity of an area.

Table 1. Habitat features for habitat complexity index.

Habitat feature	Index
Topography	
-All level ground	0
-Level to 10 m (32.8 feet)	1
-Level to 30 m or more (98.4 feet)	2
Exposed rock	
-None	0
-Some exposed rock, boulders (up to 20% of the site)	1
-Large exposures, rocky outcroppings and escarpments (25% or more of the site)	2
Vegetation	
-Few plant species	0
-Moderate number of plant species	1
-Most diverse plant communities in southern IL	2
Body or channel of water	
-None	0
-Small creek or stream	1
-Major creek or stream, or river, pond or lake	2

7) Other habitat and locality data.

Other main factors of habitat were recorded at each site. General qualitative and quantitative observations included:

- GPS coordinates

- Elevation (measurement from GPS unit and confirmed using Google Earth)

- Type of rock present (limestone, dolomite, sandstone, shale, coal) determined using the Bedrock Geology of Illinois map (Illinois State Geological Survey, Illinois Map 14, 2005)

- Proximity to water body (in meters)

- General description of habitat type (upland oak-hickory forest, bottomland forest, plains, etc.)

Specific habitat or microhabitat variables were also recorded at each quadrat. These factors included:

- Type of ground cover (leaf litter or other)
- Degrees of slope (rounded to the nearest ten degrees) and aspect, measured with a clinometer (Sankey 1958) and compass
- Presence and type of rock, if known
- Presence of coarse woody debris
- Presence and general type of other animals and vegetation

These variables served to further characterize the site and provide additional data to accompany the collected specimens.

Several field guides aided in the identification of the above variables (Voight and Mohlenbrock 1964, Borror and White 1970, Harris *et al*. 1977). Additionally, data from other sources are being included for factors that cannot be analyzed in the fieldwork portion of this survey (*i.e*., Illinois Natural Division Areas information and Bedrock Geology of Illinois map).

ANALYSES

SEASONAL DIFFERENCES

Randomized block ANOVA (SAS 9.1, 2007) was used to check for seasonal (spring and fall) differences in snail abundance. Two sites, both at LaRue Pine Hills (LPH-S07 and LPH-F07), were excluded from this analysis due to unusually high abundances at these site; otherwise they appear as outliers. The abundance data for the remaining 58 sites were normalized via log-transformation.

ESTIMATE OF SPECIES RICHNESS

A jackknife analysis procedure (Manly 1997) was implemented in Microsoft Excel PopTools to estimate species richness. This approach provides for a repeatable estimate of species richness, with the actual number of species found regarded as a lower bound to the number of species in the habitat. This test also provides confidence limits for the estimate.

SHANNON DIVERSITY INDEX

The Shannon Diversity Index provides information about the commonness or rarity of a species, and about the evenness of species across all sites. For a comparison of the ability of the sites to support land snail diversity, I ran a Shannon Diversity Index analysis (Begon *et al.* 2006) using Microsoft Excel. The formula was calculated as follows:

Shannon Diversity Index = $H' = -\sum_{i=1}^{s} P_i \ln P_i$

Where:

S = the number of species

P_i = the relative abundance of each species; proportion of S made up of the ith species

The natural log (ln) of the proportional value for each species (P_i) was used in the equation instead of its log, due to the high number of species.

LINEAR REGRESSION ANALYSES FOR HABITAT COMPLEXITY

I ran linear regression analyses to check for any correlations between habitat complexity (both the total index, as well as its individual components) and species diversity. A regression was also run to examine any correlations between habitat complexity and abundance.

PRINCIPAL COMPONENTS AND MULTIPLE REGRESSION ANALYSES

I ran a combined principal components analysis (PCA) with a multiple regression analysis (SAS 9.1, 2007) of all soil factors (% moisture, pH, organic matter, cation exchange capacity, phosphorus, potassium, calcium, iron, magnesium, copper, manganese, sulfur, zinc, boron) and the habitat complexity index with snail abundance as the dependent variable, and again with snail diversity as the dependent variable, for each site. These analyses were run to observe whether any of the parameters were correlated and could be considered as a component. The individual magnitude of each factor upon abundance and diversity could also be explored using this analysis.

AKAIKE (AIC) AND BAYESIAN (BIC) INFORMATION CRITERA ANALYSES

In order to reduce the number of parameters to avoid spurious correlations, I ran a test of AIC and BIC model comparisons (SAS 9.1, 2007) of all soil variables (% moisture, pH, organic matter, cation exchange capacity, phosphorus, potassium, calcium, iron, magnesium, copper, manganese, sulfur, zinc, boron) and the habitat complexity index with snail abundance, and again with snail diversity, for each site. I compared the resulting top AIC and BIC models, and ultimately chose the best-fit BIC model for the parameters with abundance, and again with diversity. I subsequently ran a multiple regression analysis on the parameters of the BIC-reduced models for abundance and diversity.

RESULTS

GENERAL: LAND SNAIL COLLECTIONS

A total of 5,393 specimens representing 72 species were collected during the course of the study (2,310 in the spring and 3,083 in the fall) from 60 sites at 30 nature preserves, state parks, and US Fish and Wildlife designated areas. 4,689 of the specimens were empty shells, and 704 were live-collected specimens, now preserved in ethanol. 4,579 specimens were identified to the species level, and all remaining specimens were juveniles or fragments of shells identified at best to genus or family, or deemed unidentifiable. The most common species found was *Glyphyalinia* *indentata* (Say, 1823), for which a total of 984 specimens were collected at 58 of the 60 sites and, in terms of percentage of overall abundance, accounts for 18% of all collected specimens. Appendix A, Table A8 provides details on the total counts of each species, shown in rank order from greatest to least in numbers.

From combined species records of this study, and of Baker 1939, Hubricht 1985, Hutchison 1989, and Field Museum and Illinois Natural History Survey collections, a grand total of 108 fossil and living species have been recorded in the 6-county study area, 91 of which have been collected and recorded as living species. Based on Field Museum records, there are 124 living species of land snails in the state of Illinois, thus 71% of all Illinois land snail species are found within the 6-county study area.

At least five of the 91 species are non-native to the study area. These non-native species, all introduced slugs from Europe, are: *Deroceras reticulatum* (Müller, 1774); *Arion intermedius* Normand, 1852; *Arion subfuscus* (Draparnaud, 1805); *Lehmannia valentiana* (Férussac, 1821); and *Limax maximus* Linnaeaus, 1758. They are considered to be agricultural pests. The presence of these slugs has not been officially documented in any publications for the 6-county study area.

Three native North American species that were previously unrecorded in the 6-county area were collected in this study. They are three terrestrial pulmonates, *Ventridens demissus* (A. Binney, 1843), *Vallonia pulchella* (Müller, 1774), and *Gastrocopta cristata* (Pilsbry and Vanatta, 1900). Together with the above-mentioned slug species, a total of 8 species are newly recorded for the study area.

SEASONAL DIFFERENCES

The results of the randomized block ANOVA used to check for seasonal (spring and fall) differences in abundance of the collections were non-significant ($F_{1,56} = 0.03$, $P = 0.8619$), suggesting that the spring and fall collecting seasons yielded similar abundances in this study and that there is no significant effect of spring/fall season on the number of snails collected.

JACKKNIFE ESTIMATE OF SPECIES RICHNESS

The jackknife analysis (Manly 1997) results showed species richness estimate of S* = 83.75 (standard deviation, SD = 35.40833, and standard error, SE = 4.571196). The upper 95% confidence values = 74.60306, and the lower 95% confidence value = 92.89694%.

SHANNON INDEX OF DIVERSITY

The Shannon Index of Diversity values for the 60 sites are reported in Appendix A, Table A5. The top five sites were CSW-S07, LPH-F07, TBSFWA-F07, TBSFWA-S07, and RCCA-S07. The lowest ranking site was UCSFWA-F07, which had a Shannon Index value of zero.

HABITAT COMPLEXITY

The total habitat complexity index values for the 60 sites are shown in Appendix A, Table A6. The total habitat complexity indices were linearly regressed with species diversity and abundance, with results shown in the figures below. The assessment of the 60 sites for all four habitat features combined (elevation, exposed rock, vegetation, body or channel of water) showed a positive trend when compared with species diversity in the linear regression analyses, as seen in the figures below.

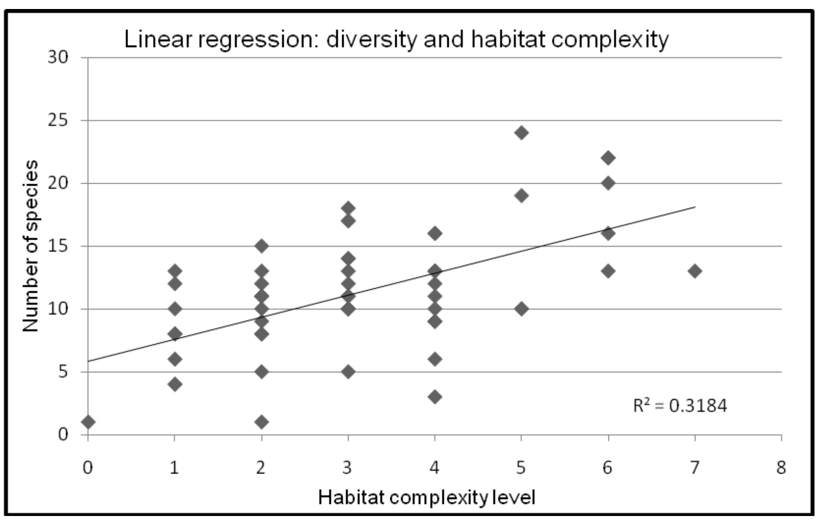

Figure 4. Habitat complexity (combined levels of topography, vegetation, exposed rock, and proximity to water) linearly regressed with number of snail species (diversity).

A positive trend is observed between the diversity and habitat complexity level at the sites ($R^2 = 0.3184$).

However, some difficulties in assigning index values to the sites were encountered in the case of “body or channel of water”. Some sites had obvious creeks or ponds in the spring, but when nearby sites were chosen in the fall, these waters had dried up over the unusually hot and dry summer. Since these bodies of water and waterways are more variable than permanent bodies of water, thus are rather transient features of the sites, they do not lend themselves to a straightforward assessment.

I re-ran the analysis using only the first three variables, and omitted the water factor. The results are shown in the Figure 5. Now a slightly stronger positive trend between diversity and ecological variables is shown ($R^2 = 0.3756$).

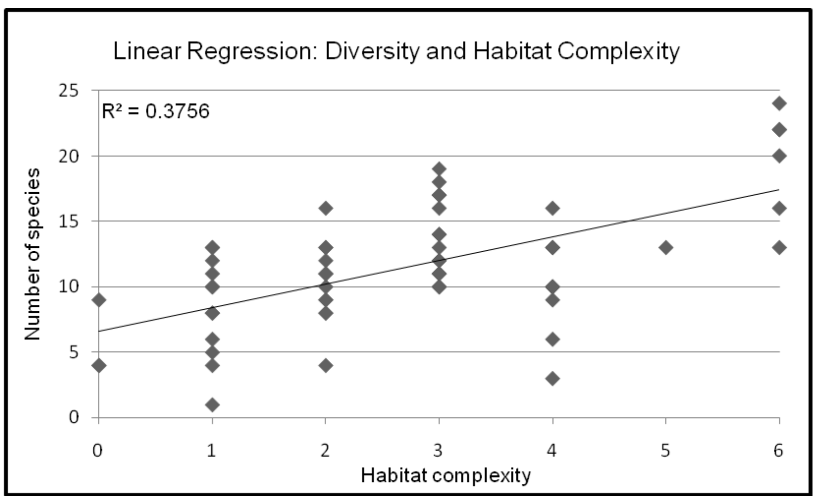

Figure 5. Habitat complexity (combined levels of topography, vegetation, and exposed rock) linearly regressed with number of snail species (diversity).

In order to discern the strength of the individual components of the habitat complexity index, each was run separately with diversity, as shown in Figures 6 through 8 below.

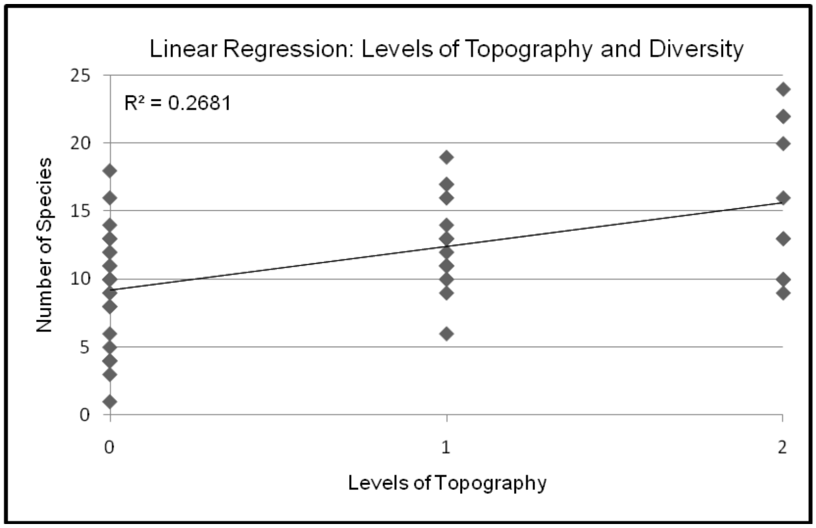

Figure 6. Levels of topography linearly regressed with number of snail species (diversity).

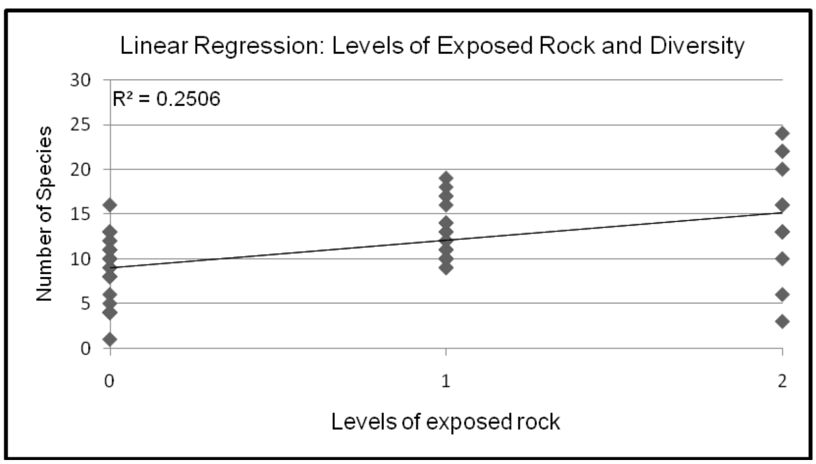

Figure 7. Levels of exposed rock linearly regressed with number of snail species (diversity).

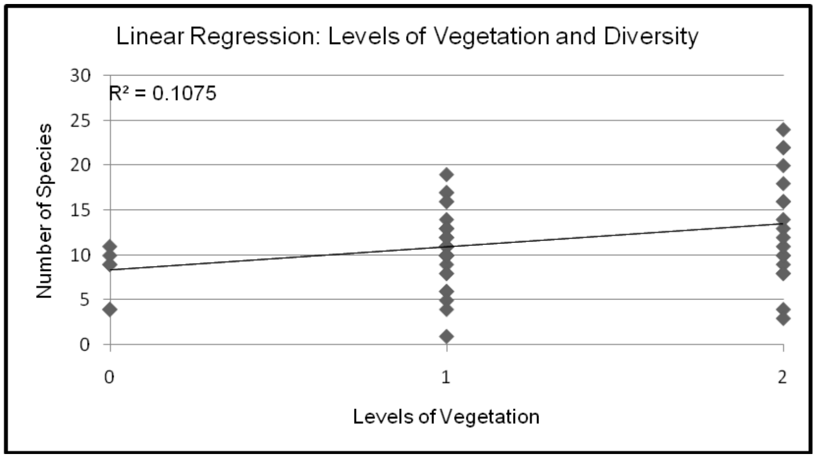

Figure 8. Levels of vegetation linearly regressed with number of snail species (diversity).

Topographical changes within a site showed the strongest trend among the three linear regression tests (R^2=0.2681, as compared with R^2=0.2506 for exposed rock and R^2=0.1075 for vegetation), yet the features measured individually do not present the strengnth of the habitat complexity measured as a combination of all three.

Habitat complexity was also regressed linearly with snail abundance, as shown in Figure 9.

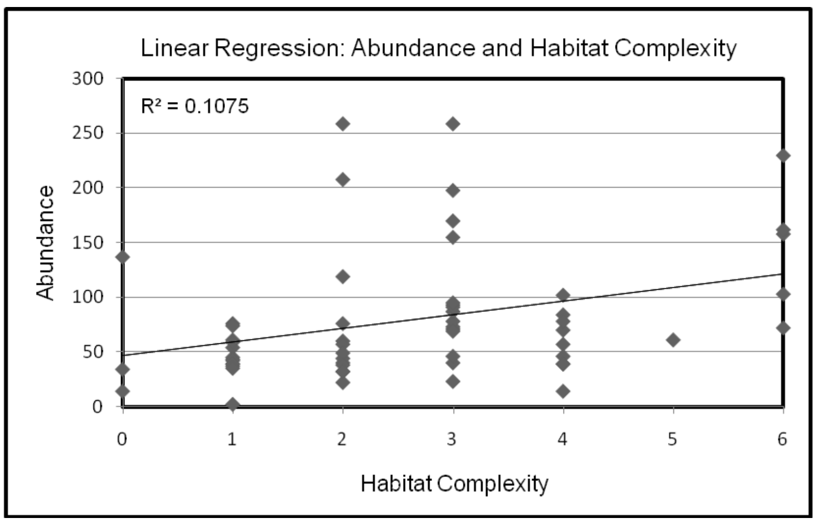

Figure 9. Habitat complexity (combined levels of topography, vegetation, and exposed rock) linearly regressed with snail abundance.

One outlier was removed (LPH-F07), with a habitat complexity index of 6 and 814 specimens collected. The results show a only a very weak trend of abundance increasing with habitat complexity (R^2 = 0.1075).

PRINCIPAL COMPONENTS AND MULTIPLE REGRESSION ANALYSES

Soil Factors, Habitat Complexity and Abundance

The combined principal components analysis (PCA) with a multiple regression analysis of all soil factors (percent moisture, pH, organic matter, cation exchange capacity, phosphorus, potassium, calcium, iron, magnesium, copper, manganese, sulfur, zinc, boron) and the habitat complexity index with snail abundance was overall highly significant ($F_{15, 44} = 4.35$, $P < 0.0001$). Principal component 1 accounted for 40.88% of the variation of the model, and indicated that all soil factors are correlated, with cation exchange capacity and calcium (Eigenvectors were 0.383144 and 0.378706, respectively) as the strongest factors of the component. Manganese was the lowest factor (Eigenvector = 0.004912), followed by iron (Eigenvector = 0.005310), and next by habitat complexity (Eigenvector = 0.006466). The univariate relationships suggest that the soil factors generally have a positive association with land snail abundance, with the exceptions of iron and manganese, which were both shown to have a negative effect on abundance. Overall, this PCA suggests that mineral-rich soils support greater numbers of snails.

Soil Factors, Habitat Complexity and Diversity

The combined principal components analysis (PCA) with a multiple regression analysis of all soil factors (% moisture, pH, organic matter, cation exchange capacity, phosphorus, potassium, calcium, iron, magnesium, copper, manganese, sulfur, zinc, boron) and the habitat complexity index with snail diversity was overall highly significant ($F_{15, 44} = 5.40$, $P < 0.0001$). As with the PCA/multiple regression with abundance, principal component 1 accounted for 40.88% of the variation of the model, and again indicated that all soil factors are correlated.

However, based on the univariate relationships, six parameters were inversely associated with diversity: organic matter, phosphorus, potassium, magnesium, iron and copper.

AKAIKE (AIC) AND BAYESIAN (BIC) INFORMATION CRITERA ANALYSES

Soil Factors, Habitat Complexity and Abundance

The best AIC model for the soil factors, habitat complexity and abundance contained four parameters: pH, cation exchange capacity, sulfur, and habitat complexity. These parameters all appeared within the substantially supportive models having weights within $\text{delta}_i \leq 2$, as recommended by Burnham and Anderson (2002). The top BIC model for the soil factors, habitat complexity and abundance contained three parameters (pH, sulfur and habitat complexity), with an R^2 value of 0.47. Due to the exploratory nature of assessing the effects of a large number of parameters on abundance and diversity, I chose the best BIC model over the best AIC model, in the interest of being more selective and reducing as many parameters as possible. The BIC model was run with abundance as the dependent variable in a multiple regression analysis. The fitted model is represented by abundance = intercept + pH + habitat complexity + S. The overall test was highly significant ($F_{3, 56} = 16.55$, $P < 0.0001$). All individual parameters were highly significant ($P_{\text{pH}} = 0.0002$, $P_{\text{S}} = 0.0005$, $P_{\text{HabCom}} = 0.0016$,). The individual parameter estimates were, in order of magnitude, pH (56.01901), habitat complexity (26.61592) and sulfur (6.77674), all showing a positive relationship with snail abundance.

Soil Factors, Habitat Complexity and Diversity

The best model for the soil factors, habitat complexity and diversity also contained three parameters (calcium, iron and habitat complexity) as calculated by BIC, with an R square value of 0.54. This model was selected and run with abundance as the dependent variable in a multiple regression analysis. The overall test was highly significant ($F_{3, 56} = 22.21$, $P < 0.0001$). All individual parameters were highly significant ($P_{Ca} = 0.0245$, $P_{Fe} = 0.0011$, $P_{HabCom} < 0.0001$). The individual standardized estimates of the parameters were, in order of magnitude, habitat complexity (0.47036), calcium (0.21174), and iron (-0.33636), with iron showing an inverse relationship with snail diversity.

DISCUSSION

COMPARISON OF COLLECTIONS WITH THOSE OF PREVIOUS COLLECTORS

It is worthwhile to look at the collecting history in the species-rich 6-county study area, as it gives some indication of presence/absence data over time. Figure 10 shows a species accumulation curve, depicting the number of species documented in the study area over all years in which any land snail collecting activity occurred.

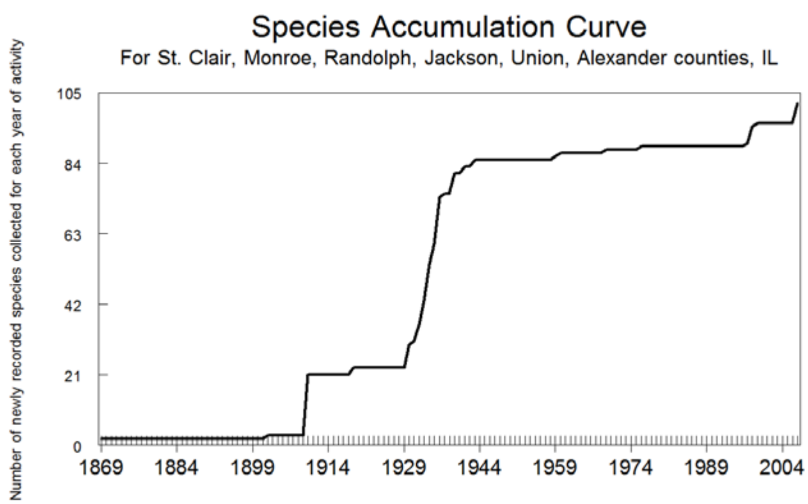

Figure 10. Species accumulation curve depicting the number of species collected in each year of recorded collection activity in the 6-county study area, additive of previous years.

Despite the fact that the greatest number of species was collected within the one-year course of this study, not all snails collected in previous years (by Hubricht, Baker, and others) were recovered (Appendix A, Table A7). Several possible explanations could be inferred. First, previous collectors searched areas that were in different locations from my study sites, although still with the same six counties. In some cases, museum labels were not useful in identifying the exact locality of the collected specimen (*e.g.*, "3.5 miles west of Murphysboro"), so direct comparison by locality cannot be made. Second, with regard to collecting sites that were the same for both a previous collector and my own, the populations of some species may very well have been extirpated from that area. One probable example could be *Rabdotus dealbatus dealbatus* (Say, 1821), which was documented only by Baker at one site, Fountain Bluff. This species was known to be rare in Illinois, and in small numbers it is conceivable that its population may have become extinct. Even by shell morphology alone, this species is distinct and is very unlikely to be confused with another species in southern Illinois, so species identification issues can be ruled out. However, species misidentification *is* likely to be the case to explain other documentations that did not recur. Another factor for non-recovery of previously documented species could be that previous collecting activity spanned for more than a century, compared to my study that covered only one year in two seasons. During the earlier years of collecting, the land was mostly in its natural state. With less human influence, it is probable that more snail populations of greater diversity existed. Still other scenarios could be local extinctions of species due to disturbances to habitat or climatic changes. Finally, the patchy distribution of land snail populations could cause certain species to be harder to collect. Finally, it is probable that neither I nor previous collectors have recovered all the species that inhabit in the six-county area.

NOTES ON SOME GENERA AND SPECIES

The literature base for land snail taxa in North America is in need for further research and updates. Many descriptions are still based on shell morphology alone, and in others that include soft morphological characters, molecular investigations could be applied to better clarify descriptions. Discussed in this section are the land snails documented in the study area that are likely to have been misidentified by past collectors, or continue to be easily confused with other similar species. Some of these species and genera in this discussion are in need of revision.

Anguispira alternata carinata (Pilsbry and Rhoads, 1896) and *Anguispira strongylodes* (Pfeiffer, 1821) were subspecies recognized by Baker and Hubricht, but they are not currently believed to be valid taxa (S. Clutts thesis, 2008).

Mesomphix is believed to contain three species in the study area: *Mesomphix cupreus*, *Mesomphix friabilis* and *Mesomphix vulgatus*, yet some specimen identifications are not completely resolved at the time of this writing. Shell morphology between species tends to be greatly variable, and shells from different locations tend to vary in size and shape. Past collectors often labeled their specimens as *Mesomphix* sp., without further ascertainment of the species designation.

Two species of *Triodopsis* have been found within the study area: *Triodopsis vulgata* and *Triodopsis discoidea*. *T. vulgata* appears to be more common and widespread in its distribution. Both species appear to be habitat generalists, occupying various forested habitats, including upland, lowland and limestone cliff areas. Some of the collected *Triodopsis* specimens could be described as having an intermediate form that bears features of both species. This suggests that the two may be hybridizing in areas where their ranges overlap.

Baker collected and identified one specimen as *Mesodon edentatus* (Sampson, 1889) in Alexander County in 1931. Hubricht (1985) reports its range as mainly in northern Arkansas, plus one county in southern Missouri and two counties in eastern Oklahoma. Baker is likely to have misidentified this specimen, which I examined (INHS Z-33516) and believe it could be a malformed, juvenile specimen of *Inflectarius inflectus* (Say, 1821).

In Baker's collection, housed at INHS, a specimen identified as *Gastrocopta procera mcclungi* (Hanna and Johnson, 1913) was collected by Pilsbry in 1926 in Jackson County. This is considered to be a variant of *Gastrocopta procera* (Gould, 1840) and is not currently recognized as a species.

Baker collected and identified a single, worn specimen as *Glyphyalinia rhoadsi* (Pilsbry, 1899). I examined the specimen from the Illinois Natural History Survey collections (lot number INHS Z-35121) and found it to lack certain distinguishing characters of this species. Hubricht (1985) reports its range to occupy much of the Appalachians, plus some areas of northern Michigan (mainland and the upper peninsula). I believe this specimen should be correctly identified as *Glyphyalinia wheatlyi* (Bland, 1883).

As previously mentioned, Baker collected and labeled one lot (INHS Z-23505) containing 14 specimens of *Rabdotus dealbatus dealbatus* (Say, 1821), a species that has not been found in Illinois since his collections in the 1930s. Upon examination of the lot, some of the specimens had the appearance of being recently alive when collected, strongly suggesting the existence of a living population of this species at the collection locality, the south end of Fountain Bluff. Baker appears to have been the first and the last person to have collected this species in Illinois.

Patera appressa (Say, 1821) was likely misidentified by Baker. According to Hubricht (1985), this species ranges from the mid-Atlantic states to the mid-Appalachian region. Upon examination of the shells of this lot (INHS Z-33280), I believe that these specimens should be correctly identified as *Xolotrema fosteri* (F.C. Baker 1921) which possesses similar shell morphology, but is less broad in width and not as depressed.

One specimen of *Succinea indiana* Pilsbry 1905 was identified by Hubricht and is housed at FMNH. It is likely a misidentification, according to the Field Museum Malacology Collections Manager Jochen Gerber.

Gastrocopta armifera form *affinis* (Sterki) identified by Baker is now a junior synonym of *Gastrocopta similis* (Sterki, 1909).

Polygyra fraudelenta Pilsbry, 1894, *sensu* Baker 1939, is most likely *Triodopsis vulgata* (Pilsbry, 1940).

Polygyra hirsuta (Say, 1817), *sensu* Baker 1939, is most likely *Stenotrema barbatum* (Clapp, 1904).

Polygyra tridentata frisoni Baker, *sensu* Baker 1939, is considered a variant of *Triodopsis tridentata* (Say, 1816).

Polygyra tridentata Say, 1816, *sensu* Baker 1939, is most likely *Triodopsis vulgata* Pilsbry, 1940.

Polygyra tridentata edentilabris, *sensu* Baker 1939, remains a *nomen dubium.*

Polygyra tridentata unidentata Baker, 1898, *sensu* Baker 1939, remains a *nomen dubium*.

Neohelix albolabris (Say, 1817) was likely misidentified. Its range covers the upper Midwest to northeastern United States, though some specimens have been recorded in areas of eastern Illinois.

Zonitoides nitidus (Müller, 1774) was likely misidentified by M. Hutchison. This species ranges in the upper Midwest to northeastern United States. It is most likely *Zonitoides arboreus* (Say, 1816).

Two native North American species in this study are not only new records for the 6-county area, but they are new records for the state, according to data in Hubricht 1985. They are *Ventridens demissus* (A. Binney, 1843) and *Gastrocopta cristata* (Pilsbry and Vanatta, 1900). *V. demissus* was usually found in relatively high abundances in all 6 counties. Its recorded range is along the southeastern Appalachians, and west toward the Gulf-bordering states. The closest record of *V. demissus* to Illinois is in Livingston County, Kentucky, which borders the Ohio River. The new findings of *V. demissus* localities expand the known range northward. *G. cristata*, however, was identified from a single dead specimen, by Dr. Jochen Gerber. This species has disparate ranges in Delaware and Maryland, and in Texas, Oklahoma, and Kansas. Ideally, additional living specimens should be found before *G. cristata* is recognized to have living populations in Illinois.

Finally, of the six species listed by the Illinois Comprehensive Wildlife Conservation Plan (2007) as threatened or endangered, four were found to have extant populations in this study. *Euchemotrema hubrichti* (Pilsbry 1940) is very abundant in the La Rue Pine Hills sites (LPH-S07 and LPH-F07), but nowhere else. Two specimens tentatively identified as *Megapallifera ragsdalei* (Webb, 1950), were collected at one site BSGNP-F07. *Paravitrea significans* (Bland, 1866) was collected at five sites: CSW-S07, CSW-F07, FHPNP-F07, KRSFWA-F07, and LPH-F07. *Triodopsis discoidea* (Pilsbry, 1904) was collected at TBSFWA-S07 only. The other two listed species, *Gastrocopta rogersensis* Nekola and Coles, 2001 and *Oxyloma salleanum* (Pfeiffer, 1849), were not recovered during the course of this study.

HABITAT COMPLEXITY AND ITS EFFECT ON LAND SNAIL ABUNDANCE AND DIVERSITY

Habitat complexity was shown by the analyses to be the strongest factor affecting abundance and diversity, when analyzed together with the soil factors in the Bayesian Information Criteria analyses. It is likely that habitat complexity serves as a proxy for microhabitat complexity, which in turn is associated with higher abundances and diversities. Diversity showed a slightly higher association with habitat complexity than did abundance.

It should be noted here that the use of the habitat complexity index could be inaccurate due to subjectivity. Estimates made by different collectors might not be strictly comparable.

Habitat complexity, measured in the field using this simple method of assigning a score of zero to two to the habitat variables, could serve as a good “primary pass” in performing a prediction assessment of snail abundance and diversity in an area. Without the need for expensive and time-consuming soil tests, habitat complexity on its own can provide a good general estimate of snail abundance and diversity.

However, some sites were assigned a high index of habitat complexity, but had a low abundance and/or diversity of snails, which would not have been expected by use of this prediction method. To illustrate the aberrant results with some examples, two sites scored the highest index of habitat complexity, LPH-S07 and FRNP-S07. The index was 6 for both sites. Collection at LPH-S07 yielded relatively high abundance and diversity (230 and 22, respectively), whereas collection FRNP-S07 yielded only 72 snails of 13 species. These disparate results at sites that otherwise ranked the same habitat complexity index serve to illustrate that parameters in addition to habitat complexity come into play. At these sites, soil factors could exert stronger influences on snail populations than habitat complexity. These possibilities are discussed in the following section.

Soil variables

Because land snails live in intimate contact with the soil and are influenced by soil parameters, the results of the soil analyses could provide useful information, in conjunction with habitat complexity for prediction of abundance and diversity of snails at other sites. Many studies have used similar data to assess how soil features affect land snail abundance and diversity (Burch 1955, Emberton *et al.* 1996, Nekola and Smith 1999, Tattersfield *et al.* 2001). The 14 soil factors analyzed (percent moisture, pH, organic matter, cation exchange capacity, phosphorus, potassium, calcium, iron, magnesium, copper, manganese, sulfur, zinc, boron) were chosen because most have been found in prior studies to be important for shell growth and repair, egg production, or have some influence on snails' physiological functions, for better or for worse (Taylor *et al.* 1988; Vuori 1995; Triebskorn *et al.* 1999; Henderson and Martin 1990; Dallinger *et al.* 2001; Horsák and Hájek 2003). Soil moisture was tested because it has been shown to be positively associated with gastropod presence (Burch 1955). Cation exchange capacity (CEC) is a measure of a soil's ability to retain nutrients, and can be influential in vegetation abundance and diversity (Chapin *et al*, 2002). Organic matter in soil provides essential nutrients for plant growth and influences a soil's ability to retain moisture (Chapin *et al*. 2002), and can also positively influence snail abundance (Burch 1955). It has generally been shown that land snails are more abundant on soils with higher pH levels (Burch 1955, Riggle 1976, Nekola 1999, Nekola and Smith 1999, Tattersfield *et al*. 2001, Hotopp 2002, Millar and Waite 2002). In one study, snails exhibited different behaviors when placed on surfaces of different pH-levels (Wäreborn 1970); snails placed on acidic (low-pH) surfaces crawled on the posterior end of their foot, presumably to prevent tissue damage by the acidic surface.

Iron

The results of the multiple regression analysis with snail diversity show a significant negative correlation between iron and snail diversity. To return to the example FRNP-S07, a site characterized by high habitat complexity, but low abundance and diversity, the negative correlation between iron and diversity could help explain the unexpected result. FRNP-S07 is also characterized by large exposures of sandstone rock, which leaches iron into the surrounding soil (Nation 2005, Willman *et al*. 1975). While the iron level of the soil measured about average among the sites, the bedrock type could be the reason for the unexpectedly low diversity, as it tends to leach iron over time (Nation 2005, Willman *et al*. 1975).

Few field studies exist that show similar associations between snail diversity and iron. However, one study on aquatic snails presents the case where lower snail diversity occurred in water containing high levels of iron (Horsák and Hájek 2003). This result was unexpected, according to the authors, as the other parameters measured in the study, such as calcium, would have predicted higher diversity. These results suggest that iron is not favorable for snails in some way. These unexpected results were supported by Vuori (1995), who presents some evidence that iron can in fact be toxic to aquatic invertebrates, and that high levels of iron can decrease their abundance and diversity.

Some studies used imaging techniques to detect and view the physical traces of iron in slugs. Evans *et al* 1989 used EPR (Electron Paramagnetic Resonance) to locate the presence of iron ions (Fe^{3+}) in the intestine, digestive gland, of reproductive organs of slugs collected from a woodland area at which the iron levels of the soil were also measured. Similarly, Triebskorn *et* *al.* 1999 explored the physical evidence of iron in the organs of slugs after ingestion of iron chelates, by use of EFTEM (Energy-Filtering Transmission Electron Microscopy). Striking images from this work reveal that iron accumulates as encrustations in the digestive gland, and epithelial and mucus-producing cells. The snail's digestive gland, or hepatopancreas, is the most important site for detoxification, as it contains calcium granules, which were discovered to be the mechanism by which excessive amounts of minerals are sequestered from the vital processes (Fournié and Chétail 1984, Taylor and Simkiss 1988, Beeby 1991). When excessive amounts of iron physically blocks these channels of detoxification, it is believed to cause detrimental effects by shutting down vital physiological processes, leading to eventual death of the organism (Taylor and Simkiss 1988, Triebskorn *et al*. 1999).

Agricultural field trials have been conducted to demonstrate the efficacy of iron phosphate ($FePO_3$) as a crop molluscicide, as this compound has been shown to be toxic to terrestrial snails (Caldwell and Pritts 2000-2001, Bolda 2005). Due to its virtual non-toxicity to non-target organisms (other wildlife, humans, and pets), and its ease in spreading over crops, iron phosphate has gained popularity as the active ingredient in several commercial molluscicides over the past 10 years. It is a stable, insoluble, pH-neutral, and non-flammable compound with no adverse environmental effects, since iron phosphate is a naturally occurring compound. According to the manufacturer of Sluggo ®, one of the popular iron phosphate-containing molluscicides, the active ingredient breaks down over time, and as it dissociates it adds a negligible amount of iron ions to the soil compared to naturally occurring levels.

Some additional relevant points can be discussed based upon this result. One, whereas diversity was negatively associated with soil iron levels, abundance was not. This finding suggests that some species could be tolerant of higher environmental iron. For example, *Anguispira alternata* and *Discus patulus*, both of family Discidae, were collected in relatively high abundances at sites with high iron (GCSP-S07 and GCSP-F07) compared to other species. Furthermore, these sites were among the lowest in snail diversity. Since the results of the BIC for individual species demonstrates that different ecological variables show different influence on various species, snail species are thus likely to differ in their physiology and tolerances for ecological variables and have different requirements for their survival.

Another angle to consider is that the levels of habitat complexity and snail diversity are widely disparate at these sites. Based on habitat complexity alone as a predictor of diversity, we could assume a fairly high number of snail species occurs in these areas, but this was not the case. This situation represents one limitation of the use of habitat complexity as a predictor of diversity on its own. As the linear regression results demonstrated, habitat complexity could be used as a first pass to assess diversity, but the multiple regression analysis with the best-fitted BIC model suggests that other ecological parameters are influential in both abundance and diversity levels.

In conclusion, the effect of environmental iron on terrestrial snails is a topic wanting further research.

Sulfur

Sulfur showed an unexpectedly high association with snail abundance, as the BIC analysis included it in the best-fitted model, along with habitat complexity and pH, as a positively correlating variable. Similar studies involving soil chemistry and snail abundance and diversity, have not demonstrated this relationship. One plausible explanation is that organic matter (leaf litter, animal matter, etc.) releases sulfur, along with nitrogen and phosphorus, into the soil as it decomposes (Brady and Weil 2002, Begon *et al* 2006). The vast majority of the snails collected in this study were taken from quadrats containing obvious and often copious amounts of organic matter (leaf litter, woody debris, etc.). This positive association between abundance and sulfur could point towards an association between snail abundance and decomposing organic matter, which would be an expected result. Therefore, while sulfur itself might not be considered directly causal for snail abundance, it does correlate with the type of organic, woodland environment that supports most snail species in southern Illinois.

Interrelatedness of variables

A theme central to ecological studies is the effort to ascertain which of the many influences on a population exerts the greatest impact, while bearing the understanding that is it often difficult, if not impossible, to regard individual influences separately. It is therefore likely that the variables chosen for this study are interrelated in complex ways. One common issue in soil analyses is the fact that different species of trees exert changes in the surrounding soil chemistry (Boettcher and Kalisz 1990; Riggle 1976). Some tree species, such as the flowering dogwood (*Cornus florida*) were shown in one study to increase the soil calcium, thus supporting more species of land snails in its vicinity (Nation 2007). Likewise, underlying and exposed bedrock commonly leach minerals into the surrounding soil, influencing the soil composition (Willman *et al*. 1975).

Equations to predict land snail abundance and diversity

Future assessments on land snail populations of southern Illinois can be estimated by use of the mathematical equations from the multiple regression analyses performed in this study. The advantage of these equations lies in that the user does not need to actually search for snails to arrive at a reasonable estimate of abundance and diversity numbers. The estimates result from equations that utilize the intercept and parameter estimates from the multiple regression models for both abundance and diversity. The user would need to ascertain other variables at the site: the soil pH level, sulfur (in lbs/acre), iron (in lbs/acre), calcium (in lbs/acre) and habitat complexity, as measured according to the index used in this study. These results are then multiplied by the parameter estimates as shown below.

The equation for abundance is:

Abundance = intercept + pH + S + habitat complexity index

Abundance = -515.83931 + 56.01901(pH) + 6.77674(S) + 26.61592(habitat complexity index)

The equation for diversity is:

Diversity = intercept + Ca + Fe + habitat complexity index

Diversity = 10.65151 + 0.00042854(Ca) + -0.06016(Fe) + 1.35402(habitat complexity index)

POTENTIAL THREATS TO LAND SNAILS

As low-vagility organisms, the "survive where you are" life strategy is necessary for the survival of land snails. Although land snails are equipped with multiple adaptations for survival, such as mucus, a shell, an epiphragm, etc. (Hyman 1967), some of the greatest threats to snails are anthropogenically induced. These threats include:

1) Changes in land usage

Major habitat changes, such as the clearing of forested areas for human development (housing, roads, and commercial use) will directly affect the malacofauna in the path of habitat destruction (Kay 1995). Development can also potentially affect adjacent and downstream areas by chemical runoff. Even natural areas that are seemingly safe havens for snail populations might not be as such when used for human recreational activities. McMillan *et al*. 2003 examined differences between land snail abundance and diversity of rock climbing routes versus that of sections that were not trodden, and discovered significantly reduced abundance and diversity in the sections used for climbing. With so many areas not yet surveyed for land snails, this example provides another case where loss of habitat can result in adversely affected snail populations.

2) Fire

Regardless of cause, fire that destroys any snail habitats will most certainly kill snails and reduce their numbers in the area (Nekola 2002, Kiss and Magnin 2003). Land snails have little if any means to remain protected in a fire event; at best it can be speculated that snails inhabiting rock crevices and areas of high moisture might survive. Whereas it can be agreed upon that accidental fires are destructive, land officials must be aware that planned, “controlled” burns, such as those used to clear maple tree saplings, or to burn off underbrush, can be equally devastating to land snail fauna. Controlled burns are performed in southern Illinois to clear maple tree saplings, or to burn off underbrush, which encourages the growth of hardwood trees (Ray Smith, pers. comm.). Snails that live in the understory could be susceptible to such burns. Further studies should be carried out to better ascertain the effects of controlled burns on land snails.

3) Flood

Terrestrial pulmonates drown under water. The effects of a controlled flood were observed at Union County State Fish and Wildlife Area (UCSFWA) during the course of my study. During the pilot study in fall 2006, and in spring 2007, significantly higher abundance and diversity levels of snails were collected before a controlled flood, compared with extremely low numbers collected in the same general area later, in fall 2007. On April 12, 2007, 137 specimens of 9 species were collected. Periodically, U.S. Fish and Wildlife management officials allow dammed waters to flow freely over the parts of the area, for the purpose of attracting game waterfowl. On October 9, 2007, after this controlled flood, merely two shell fragments of specimens were collected, identified as one species (*Anguispira alternata).* No living snails were found at the site, not even on tree trunk or logs. However, many species of freshwater snails and clams (unidentified) were collected in fairly high abundances. The flood waters presumably had sufficient strength to not only wash away the land snails, but also to draw freshwater mollusks out of their normal pond habitats. Site management practices do not include conservation of land snails, but the case of dramatic change to a snail population of the area clearly illustrates the effects caused by flooding.

4) Introduced species

The introduction of non-native snail species can threaten native snail species. According to Turgeon *et al.* 1998, "Invasive species are known to alter population, community, and ecosystem structure and function." Introduced snail species can become a threat to local land snail populations by competing for microhabitat space and food resources, and cause serious damage to the agricultural industry (Robinson 1999). The results of this study recovered several species of invasive slugs. No formal studies have been conducted on introduced slugs in Illinois, but this could provide a worthy topic of research.

5) Vegetation changes

Although there are no virgin forests remaining in the eastern or midwestern USA, the more natural a secondary-growth forest is left, generally the better its chances are of supporting greater abundances and diversities of land snails. Undisturbed forests have different succession levels of vegetation and contain fallen logs, which are favorable habitat for snails. Forests that are managed often have their logs removed, and usually support few snails (Pearce and Örstan

2007). Other disturbances to natural habitat include the removal of rare plants and fungi by poachers (Chris Evans, Invasive Plant Project, pers. comm.). Further research remains to be done to better understand associations between land snails and plants and fungi, thus it is prudent to protect all organisms of a natural area. Finally, non-native plant introductions, which have commonly occurred in southern Illinois, can interfere with native plant survive and could potentially threaten native snail populations as well, by altering the microhabitat and reducing the snails' normal food sources.

CONCLUSIONS

CONSERVATION IMPLICATIONS

Ideally, the work accomplished by this project should represent the beginning of regular land snail surveys in Illinois. Regular monitoring of the sites known to support rare species, such as the study sites highest-ranked by the Shannon Diversity Index, is recommended. The identification of local areas of endemism, such as LaRue Pine Hills, is crucial to understanding where the highest degree of land protection is required.

PRODUCTS

Several valuable products outlined in the grant proposal have resulted from this investigation:

6) A checklist of terrestrial gastropods collected from the proposed counties, including the historical records of F.C. Baker (1939), Hubricht (1985) and Hutchison (1989), as well as records from the Field Museum of Natural History, Chicago, Illinois, USA and the Illinois Natural History Survey (see Appendix A, Table A7).
7) Species lists for each site, to be disseminated to the Illinois Department of Natural Resources and US Forest Service personnel.

8) A web product, consisting of the species checklist, plus an identification key and images of the species collected.
9) A collection of terrestrial gastropods (i.e., dry shells and soft tissue parts preserved in ethanol for both dissection and molecular analysis), to be donated to the Field Museum of Natural History's Malacology collection, upon completion of the research.
10) An educational poster, entitled *Illinois Land Snails and Slugs*, is currently in press for spring 2009 publication, in collaboration with the Illinois Department of Natural Resources Educational Division.

OUTCOME

This research will fill a requirement towards a Master of Science degree in Zoology from Southern Illinois University, Carbondale. Results are being disseminated to the Illinois Department of Natural Resources and at scientific meetings, as well as in peer-reviewed malacological journals and educational publications. The results of this study, along with general information of the biology and ecology of land snails, are being shared with the public through presentations and outreach programs. The products (checklist, key, and website) will be useful to malacologists and non-malacologists alike to gain knowledge of the species that live in the study area.

SIGNIFICANCE AND IMPACT

The results of this research provide a better understanding of the habitat and microhabitat requirements of terrestrial gastropods of the study area, and could guide conservation and management decisions, such as limiting human disturbance to areas known to support high diversity and/or species of limited distribution. Species descriptions and the key provided by this research are intended to be used by IDNR or other biology personnel who are not readily familiar with land snail identification. Predictions can be made about whether an area hosts high or low abundances and diversities of land snails based on the habitat complexity index, and by use of soil analysis. Probably the most valuable aspects of this study are that it raises awareness of the presence and biological importance of land snails in Illinois ecosystems and promotes the possibilities for future studies.

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APPENDIX A

Table A1. General study areas for which collecting permits were obtained. The 60 sites surveyed in this study were located within the following state parks, Fish and Wildlife areas, nature preserves and Shawnee National Forest areas.

General Study Area	Abbreviation	County	Administration
Berryville Shale Glade Nature Preserve	BSGNP	Union	Illinois DNR
Brown Barrens Nature Preserve	BBNP	Union	Illinois DNR
Fern Rocks Nature Preserve	FRNP	Jackson	Illinois DNR
Fogelpole Cave Nature Preserve	FCNP	Monroe	Illinois DNR
Frank Holten State Park	FHSP	St. Clair	Illinois DNR
Fults Hill Prairie Nature Preserve	FHPNP	Monroe	Illinois DNR
Giant City State Park	GCSP	Jackson/ Union	Illinois DNR
Horseshoe Lake Nature Preserve	HLNP	Alexander	Illinois DNR
Horseshoe Lake State Fish and Wildlife Area	HLSFWA	Alexander	Illinois DNR
Illinois Caverns State Natural Area	ICSNA	Monroe	Illinois DNR
Julius J. Knobeloch Woods Nature Preserve	JJKWNP	St. Clair	Illinois DNR
Kaskaskia River State Fish and Wildlife Area	KRSFWA	Monroe/ Randolph/ St. Clair	Illinois DNR
Lake Murphysboro State Park	LMSP	Jackson	Illinois DNR
Marissa Woods Nature Preserve	MWNP	St. Clair	Illinois DNR
McClure Shale Glade Nature Preserve	MSGNP	Union	Illinois DNR
Ozark Hills Nature Preserve	OHNP	Union	Illinois DNR
Peabody River King State Fish and Wildlife Area	PRKSFWA	St. Clair	Illinois DNR
Piney Creek Ravine Nature Preserve	PCRSP	Jackson/ Randolph	Illinois DNR
Randolph County State Recreation Area	RCSRA	Randolph	Illinois DNR
Stemler Cave Woods Nature Preserve	SCWNP	St. Clair	Illinois DNR
Turkey Bluffs State Fish and Wildlife Area	TBSFWA	Randolph	Illinois DNR
Trail of Tears State Forest	TTSF	Union	Illinois DNR
Union County State Fish and Wildlife Area	UCSFA	Union	Illinois DNR
Clear Springs Wilderness	CSW	Jackson	US Forest Service
Fountain Bluff	FB	Jackson	US Forest Service
Johnson Creek Recreation Area	JCRA	Jackson	US Forest Service
Larue-Pine Hills Ecological Area/RNA	LPHEA	Union	US Forest Service
Little Grand Canyon	LGC	Jackson	US Forest Service
Ripple Hollow	RH	Union	US Forest Service

Table A2. Sites, site abbreviations, collection dates, and abundance and diversity counts. Site abbreviations include a suffix to indicate spring (S07) or fall (F07) of the year 2007.

No.	Site name	Site abbreviation	Collection date	Abundance[a]	Diversity[b]
1	Fountain Bluff	FB-S07	20 Feb 2007	61	13
2	Horseshoe Lake Nature Preserve	HLNP-S07	22 Feb 2007	14	4
3	Horseshoe Lake State Fish and Wildlife Area	HLSFWA-S07	22 Feb 2007	61	12
4	Lake Murphysboro State Park	LMSP-S07	27 Feb 2007	40	12
5	Johnson Creek Recreation Area	JCRA-S07	27 Feb 2007	76	13
6	Clear Springs Wilderness	CSW-S07	2 Mar 2007	158	22
7	Little Grand Canyon	LGC-S07	2 Mar 2007	70	10
8	Ripple Hollow	RH-S07	6 Mar 2007	93	14
9	Giant City State Park	GCSP-S07	8 Mar 2007	84	13
10	Fern Rocks Nature Preserve	FRNP-S07	8 Mar 2007	72	13
11	Frank Holten State Park	FHSP-S07	15 Mar 2007	42	6
12	Julius J. Knobeloch Woods Nature Preserve	JJKWNP-S07	15 Mar 2007	45	13
13	Stemler Cave Woods Nature Preserve	SCWNP-S07	15 Mar 2007	71	11
14	Randolph County Conservation Area	RCCA-S07	20 Mar 2007	73	11
15	Turkey Bluffs State Fish and Wildlife Area	TBSFWA-S07	22 Mar 2007	162	20
16	Piney Creek Ravine Nature Preserve	PCRNP-S07	22 Mar 2007	39	10
17	Berryville Shale Glade Nature Preserve	BSGNP-S07	27 Mar 2007	44	13
18	Brown Barrens Nature Preserve	BBNP-S07	27 Mar 2007	78	19
19	Trail of Tears State Forest	TTSF-S07	5 Apr 2007	40	10
20	Ozark Hills Nature Preserve	OHNP-S07	5 Apr 2007	87	16
21	Fults Hill Prairie Nature Preserve	FHPNP-S07	6 Apr 2007	103	16
22	Fogelpole Cave Nature Preserve	FCNP-S07	6 Apr 2007	60	11
23	Union County State Fish and Wildlife Area	UCSFWA-S07	12 Apr 2007	137	9
24	McClure Shale Glade Nature Preserve	MSGNP-S07	20 Apr 2007	57	6
25	Illinois Caverns State Natural Area	ICSNA-S07	3 May 2007	91	17

Table A2. Continued.

No.	Site name	Site abbreviation	Date collected	Abundance[a]	Diversity[b]
26	Kaskaskia River State Fish and Wildlife Area	KRSFWA-S07	3 May 2007	34	4
27	Peabody River King State Fish and Wildlife Area– North	PRKSFWA-N-S07	16 May 2007	76	9
28	Peabody River King State Fish and Wildlife Area – South	PRKSFWA-S-S07	16 May 2007	170	13
29	Marissa Woods Nature Preserve	MWNP-S07	16 May 2007	54	11
30	LaRue Pine Hills Natural Area	LPH-S07	18 May 2007	230	22
31	Fountain Bluff	FB-F07	06 Nov 2007	102	16
32	Horseshoe Lake Nature Preserve	HLNP-F07	13 Sep 2007	37	10
33	Horseshoe Lake State Fish and Wildlife Area	HLSFWA-F07	13 Sep 2007	59	10
34	Lake Murphysboro State Park	LMSP-F07	11 Sep 2007	43	5
35	Johnson Creek Recreation Area	JCRA-F07	11 Sep 2007	32	9
36	Clear Springs Wilderness	CSW-F07	25 Sep 2007	208	13
37	Little Grand Canyon	LGC-F07	25 Sep 2007	57	11
38	Ripple Hollow	RH-F07	09 Oct 2007	95	10
39	Giant City State Park	GCSP-F07	30 Oct 2007	78	13
40	Fern Rocks Nature Preserve	FRNP-F07	30 Oct 2007	46	10
41	Frank Holten State Park	FHSP-F07	23 Oct 2007	259	8
42	Julius J. Knobeloch Woods Nature Preserve	JJKWNP-F07	23 Oct 2007	22	4
43	Stemler Cave Woods Nature Preserve	SCWNP-F07	23 Oct 2007	23	10
44	Randolph County Conservation Area	RCCA-F07	04 Oct 2007	39	8
45	Turkey Bluffs State Fish and Wildlife Area	TBSFWA-F07	02 Oct 2007	39	9
46	Piney Creek Ravine Nature Preserve	PCRNP-F07	04 Oct 2007	74	10
47	Berryville Shale Glade Nature Preserve	BSGNP-F07	01 Nov 2007	49	11
48	Brown Barrens Nature Preserve	BBNP-F07	20 Sep 2007	46	12

Table A2. Continued.

No.	Site name	Site abbreviation	Date collected	Abundance[a]	Diversity[b]
49	Trail of Tears State Forest	TTSF-F07	27 Sep 2007	69	12
50	Ozark Hills Nature Preserve	OHNP-F07	27 Sep 2007	155	14
51	Fults Hill Prairie Nature Preserve	FHPNP-F07	18 Sep 2007	198	17
52	Fogelpole Cave Nature Preserve	FCNP-F07	18 Sep 2007	14	3
53	Union County State Fish and Wildlife Area	UCSFWA-F07	09 Oct 2007	2	1
54	McClure Shale Glade Nature Preserve	MSGNP-F07	20 Oct 2007	119	16
55	Illinois Caverns State Natural Area	ICSNA-F07	11 Oct 2007	38	10
56	Kaskaskia River State Fish and Wildlife Area	KRSFWA-F07	11 Oct 2007	32	8
57	Peabody River King State Fish and Wildlife Area – North	PRKSFWA-N-F07	16 Oct 2007	39	4
58	Peabody River King State Fish and Wildlife Area – South	PRKSFWA-S-F07	16 Oct 2007	259	18
59	Marissa Woods Nature Preserve	MWNP-F07	16 Oct 2007	35	8
60	LaRue Pine Hills Natural Area	LPH-F07	13 Nov 2007	814	24

a: Abundance numbers represent quantitative measures (quadrat plus leaf litter data combined).
b: Diversity numbers represent quantitative plus qualitative collections.

Table A3. Sites, coordinates, quadrangle data, county, elevation, IDNR Natural Division and prevalent underlying rock type. Site abbreviations are as shown in Appendix A, but with a suffix to indicate spring (S07) or fall (F07) of the year 2007.

No.	Site abbreviation	Coordinates	Quadrangle, township, range	County	Elevation	IDNR Natural Division	Prevalent underlying rock type
1	FB-S07	N37.7008, W89.4970	Altenburg, Section 13 (center), T10S, R14E	Jackson	131 m (429.8 ft)	Shawnee Hills Division, Greater Shawnee Hills Section	Sandstone, limestone
2	HLNP-S07	N37.1316, W89.3259	Tamms, Section 4 (SW quarter of SE quarter), T16S, R2W	Alexander	101 m (331.4 ft)	Coastal Plain Division, Bottomlands section	Dolomite
3	HLSFWA-S07	N37.1127, W89.3302	Cache, Section 21 (SW quarter of NE quarter), T16S, R2W	Alexander	99 m (324.8 ft)	Coastal Plain Division, Bottomlands section	Limestone
4	LMSP-S07	N37.7773, W89.3857	Oraville, Section 36 (NW quarter of SE quarter), T8S, R3W	Jackson	134 m (429.6 ft)	Southern Till Plain Division, Mt. Vernon Hill Country Section	Sandstone
5	JCRA-S07	N37.8347, W89.5208	Raddle, Section 11 (SW quarter of SE quarter), T8S, R4W	Jackson	190 m (623.4 ft)	Southern Till Plain Division, Mt. Vernon Hill Country Section	Sandstone
6	CSW-S07	N37.6046, W89.4385	Wolf Lake, Section 33 (SE quarter of NE quarter), T10S, R3W	Union	133 m (436.3 ft)	Lower Mississippi River Bottomlands Division, Southern Section	Sandstone
7	LGC-S07	N37.6839, W89.3917	Gorham, Section 1 (NW quarter of SW quarter), T10S, R3W	Union	166 m (544.6 ft)	Shawnee Hills Division, Lesser Shawnee Hills Section	Sandstone
8	RH-S07	N37.3278, W89.3333	Mill Creek, Section 4 (SE quarter of NW quarter), T14S, R2W	Alexander	227 m (744.7 ft)	Ozark Division, Southern Section	Limestone, sandstone

Table A3. Continued.

No.	Site abbreviation	Coordinates	Quadrangle, township, range	County	Elevation	IDNR Natural Division	Prevalent underlying rock type
9	GCSP-S07	N37.5948, W89.1903	Makanda, Section 2 (W of NW quarter), T11S, R1W	Union	187 m (613.5 ft)	Shawnee Hills Division, Greater Shawnee Hills Section	Sandstone, shale
10	FRNP-S07	N37.6242, W89.1999	Makanda, Section 27 (SW quarter of NE quarter), T10S, R1W	Jackson	158 m (518.4 ft)	Shawnee Hills Division, Greater Shawnee Hills Section	Sandstone
11	FHSP-S07	N38.5854, W90.0983	French Village, Section 27 (W of SW quarter), T2N, R9W	St. Clair	126 m (413.4 ft)	Lower Mississippi River Bottomlands Division, Northern Section	Limestone
12	JJKWNP-S07	N38.4764, W89.8847	Freeburg, Section 4 (center of NW quarter), T1S, R7W	St. Clair	164 m (538.1 ft)	Southern Till Plain Division, Effingham Plain Section	-
13	SCWNP-S07	N38.4667, W90.1667	Columbia, Section 12 (NW quarter of NW quarter), T1S, R10W	St. Clair	189 m (620.1 ft)	Ozark Division, Northern Section	Limestone
14	RCCA-S07	N37.9667, W89.8167	Chester, Section 30 (SW quarter of SE quarter), T6S, R6W	Randolph	144 m (472.4 ft)	Ozark Division, Central Section	Sandstone
15	TBSFWA-S07	N37.8671, W89.7536	Belgique, Section 3 (NW quarter of NW quarter), T8S, R6W	Randolph	166 m (544.6 ft)	Ozark Division, Northern Section	Limestone, Sandstone
16	PCRNP-S07	N37.8917, W89.6333	Welge, Section 22 (SW quarter of SE quarter, T7S, R5W	Randolph	174 m (570.9 ft)	Ozark Division, Central Section	Sandstone

Table A3. Continued.

No.	Site abbreviation	Coordinates	Quadrangle, township, range	County	Elevation	IDNR Natural Division	Prevalent underlying rock type
17	BSGNP-S07	N37.4422, W89.3037	Jonesboro, Section 26 (NE Quarter), T12S, R2W	Union	129 m (423.2 ft)	Ozark Division, Southern Section	Shale
18	BBNP-S07	N37.4490, W89.2962	Jonesboro, Section 23 (N of NE quarter), T12S, R2W	Union	145 m (475.7 ft)	Ozark Division, Southern Section	Shale
19	TTSF-S07	N37.4837, W89.3578	Jonesboro, Section 8 (SW quarter of SE quarter), T12S, R2W	Union	154 m (505.2 ft)	Ozark Division, Southern Section	Sandstone
20	OHNP-S07	N37.4851, W89.3527	Jonesboro, Section 17 (center of NW quarter), T12S, R2W	Union	157 m (515.1 ft)	Ozark Division, Southern Section	Sandstone
21	FHPNP-S07	N38.1632, W90.2014	Renault, (unnamed) Section, T4S, R10W	Monroe	140 m (459.3 ft)	Ozark Division, Northern Section	Limestone
22	FCNP-S07	N38.2038, W90.1313	Renault, Section 7 (SE quarter), T4S, R9W	Monroe	177 m (580.7 ft)	Ozark Division, Northern Section	Sandstone
23	UCSFWA-S07	N37.4083, W89.3500	Jonesboro, Section 6 (SE quarter of SE quarter), T13S, R2W	Union	100 m (328.1 ft)	Lower Mississippi River Bottomlands Division, Southern Section	Sandstone
24	MSGNP-S07	N37.4359, W89.2942	Jonesboro, Sections 26 (SE quarter) and 35 (NE quarter), T12S, R2W	Union	153 m (502.0 ft)	Ozark Division, Southern Section	Shale
25	ICSNA-S07	N38.2354, W90.1369	Renault, Section 31 (SW quarter of NE quarter), T3S, R9W	Monroe	206 m (675.8 ft)	Ozark Division, Northern Section	Limestone, dolomite
26	KRSFWA-S07	N38.2127, W89.8501	Redbud, Section 33 (NE quarter of NE quarter), T3S, R7W	St. Clair	130 m (426.5 ft)	Southern Till Plain Division, Mt. Vernon Hill Country Section	-

Table A3. Continued.

No.	Site abbreviation	Coordinates	Quadrangle, township, range	County	Elevation	IDNR Natural Division	Prevalent underlying rock type
27	PRKSFWA-N-S07	N38.3333, W89.8167	New Athens East, Section 24 (SW quarter of SE quarter), T2S, R6W	St. Clair	127 m (416.7 ft)	Southern Till Plain Division, Effingham Plain Section	Limestone, sandstone, shale, coal
28	PRKSFWA-S-S07	N38.3202, W89.8603	New Athens East, Section 34 (NW quarter of NE quarter), T2S, R7W	St. Clair	130 m (426.5 ft)	Southern Till Plain Division, Effingham Plain Section	Limestone, sandstone, shale, coal
29	MWNP-S07	N38.2266, W89.7510	Baldwin, Section 34 (center), T3S, R6W	St. Clair	142 m (465.9 ft)	Southern Till Plain Division, Mt. Vernon Hill Country Section	-
30	LPH-S07	N37.5613, W89.4406	Wolf Lake, Section 16 (NW quarter of SE quarter), T11S, R3W	Union	160 m (524.9 ft)	Ozark Division, Southern Section	Limestone
31	FB-F07	N37.6565, W89.5034	Gorham, Section 36 (center), T9S, R4W	Jackson	131 m (429.8 ft)	Shawnee Hills Division, Greater Shawnee Hills Section	Sandstone
32	HLNP-F07	N37.1350, W89.3219	Tamms, Section 4 (SW quarter of SE quarter), T16S, R2W	Alexander	101 m (331.4 ft)	Coastal Plain Division, Bottomlands section	Dolomite
33	HLSFWA-F07	N37.1206, W89.3329	Cache, Section 21 (N center of NE quarter), T16S, R2W	Alexander	102 m (334.6 ft)	Coastal Plain Division, Bottomlands section	Limestone
34	LMSP-F07	N37.7828, W89.3878	Oraville, Section 36 (SW quarter of SE quarter), T8S, R3W	Jackson	127 m (416.7 ft)	Southern Till Plain Division, Mt. Vernon Hill Country Section	Sandstone
35	JCRA-F07	N37.8400, W89.5125	Raddle, Section 14 (NW quarter of NE quarter), T8S, R4W	Jackson	146 m (479.0 ft)	Lower Mississippi River Bottomlands Division, Southern Section	Sandstone

Table A3. Continued.

No.	Site abbreviation	Coordinates	Quadrangle, township, range	County	Elevation	IDNR Natural Division	Prevalent underlying rock type
36	CSW-F07	N37.6104, W89.4317	Wolf Lake, Section 34 (NE quarter of NW quarter), T10S, R3W	Union	151 m (495.4 ft)	Lower Mississippi River Bottomlands Division, Southern Section	Sandstone
37	LGC-F07	N37.6801, W89.3955	Gorham, Section 1 (NW quarter of SW quarter), T10S, R3W	Union	220 m (721.8 ft)	Shawnee Hills Division, Lesser Shawnee Hills Section	Sandstone
38	RH-F07	N37.3303, W89.3352	Mill Creek, Section 4 (W center of NW quarter), T14S, R2W	Alexander	230 m (754.6 ft)	Ozark Division, Southern Section	Limestone, sandstone
39	GCSP-F07	N37.5956, W89.1909	Makanda, Section 2 (NW of NW quarter), T11S, R1W	Union	189 m (620.1 ft)	Shawnee Hills Division, Greater Shawnee Hills Section	Sandstone, shale
40	FRNP-F07	N37.6207, W89.1926	Makanda, Section 27 (SW quarter of NE quarter), T10S, R1W	Jackson	148 m (485.6 ft)	Shawnee Hills Division, Greater Shawnee Hills Section	Sandstone
41	FHSP-F07	N38.5862, W90.0913	French Village, Section 27 (W of SW quarter), T2N, R9W	St. Clair	125 m (410.1 ft)	Lower Mississippi River Bottomlands Division, Northern Section	Limestone
42	JJKWNP-F07	N38.4774, W89.8869	Freeburg, Section 4 (center of NW quarter), T1S, R7W	St. Clair	182 m (597.1 ft)	Southern Till Plain Division, Effingham Plain Section	-
43	SCWNP-F07	N38.4609, W90.1529	Columbia, Section 12 (NW quarter of NW quarter), T1S, R10W	St. Clair	188 m (616.8 ft)	Ozark Division, Northern Section	Limestone
44	RCCA-F07	N37.9754, W89.8034	Chester, Section 30 (SW quarter of SE quarter), T6S, R6W	Randolph	140 m (459.3 ft)	Ozark Division, Central Section	Sandstone

Table A3. Continued.

No.	Site abbreviation	Coordinates	Quadrangle, township, range	County	Elevation	IDNR Natural Division	Prevalent underlying rock type
45	TBSFWA-F07	N37.8805, W89.7608	Rockwood, Section 34 (SE quarter of SE quarter), T7S, R6W	Randolph	156 m (511.8 ft)	Ozark Division, Northern Section	Limestone, Sandstone
46	PCRNP-F07	N37.8950, W89.6355	Welge, Section 22 (center of SE quarter, T7S, R5W	Randolph	157 m (515.1 ft)	Ozark Division, Central Section	Sandstone
47	BSGNP-F07	N37.4516, W89.2955	Jonesboro, Section 26 (SW of NE Quarter), T12S, R2W	Union	150 m (492.1 ft)	Ozark Division, Southern Section	Shale
48	BBNP-F07	N37.4646, W89.2939	Jonesboro, Section 26 (SW of NE Quarter), T12S, R2W	Union	151 m (495.4 ft)	Ozark Division, Southern Section	Shale
49	TTSF-F07	N37.4822, W89.3577	Jonesboro, Section 8 (NW quarter of SE quarter), T12S, R2W	Union	139 m (456.0 ft)	Ozark Division, Southern Section	Sandstone
50	OHNP-F07	N37.4838, W89.3540	Jonesboro, Section 17 (NW quarter of NW quarter), T12S, R2W	Union	135 m (442.9 ft)	Ozark Division, Southern Section	Sandstone
51	FHPNP-F07	N38.1562, W90.1899	Renault, (unnamed) Section, T4S, R10W	Monroe	124 m (406.8 ft)	Ozark Division, Northern Section	Limestone
52	FCNP-F07	N38.1972, W90.1280	Renault, Section 7 (SE quarter), T4S, R9W	Monroe	193 m (633.2 ft)	Ozark Division, Northern Section	
53	UCSFWA-F07	N37.4088, W89.3582	Jonesboro, Section 6 (N center of SE quarter), T13S, R2W	Union	104 m (341.2 ft)	Lower Mississippi River Bottomlands Division, Southern Section	Sandstone
54	MSGNP-F07	N37.4373, W89.2957	Jonesboro, Section 25 (center of SW quarter), T12S, R2W	Union	130 m (456.5 ft)	Ozark Division, Southern Section	Shale

Table A3. Continued.

No.	Site abbreviation	Coordinates	Quadrangle, township, range	County	Elevation	IDNR Natural Division	Prevalent underlying rock type
55	ICSNA-F07	N38.2359, W90.1376	Renault, Section 31 (NW quarter of NE quarter), T3S, R9W	Monroe	206 m (475.8 ft)	Ozark Division, Northern Section	Sandstone
56	KRSFWA-F07	N38.2317, W89.8813	Redbud, Section 4 (center of N half), T4S, R7W	St. Clair	128 m (419.9 ft)	Southern Till Plain Division, Mt. Vernon Hill Country Section	-
57	PRKSFWA-N-F07	N38.3366, W89.8255	New Athens East, Section 24 (SW quarter of SE quarter), T2S, R6W	St. Clair	123 m (403.5 ft)	Southern Till Plain Division, Effingham Plain Section	Limestone, sandstone, shale, coal
58	PRKSFWA-S-F07	N38.3202, W89.8600	New Athens East, Section 34 (NW quarter of NE quarter), T2S, R7W	St. Clair	129 m (423.2 ft)	Southern Till Plain Division, Effingham Plain Section	Limestone, sandstone, shale, coal
59	MWNP-F07	N38.22606, W89.7536	Baldwin, Section 34 (center), T3S, R6W	St. Clair	140 m (459.3 ft)	Southern Till Plain Division, Mt. Vernon Hill Country Section	-
60	LPH-F07	N37.5732, W89.4382	Wolf Lake, Section 9 (center of SE quarter), T11S, R3W	Union	143 m (469.2 ft)	Ozark Division, Southern Section	Limestone

Table A4. Soil analyses results. OM = organic matter, CEC = cation exchange capacity, lbs/a = pounds per acre.

No.	Site abbreviation	% Moisture	wpH	BpH	OM lbs/a	P lbs/a	K lbs/a	Ca lbs/a	Mg lbs/a	CEC	S lbs/a	Zn lbs/a	Fe lbs/a	Mn lbs/a	Cu lbs/a	B lbs/a
1	FB-S07	28.9	6.6	6.8	53	90	233	3499	316	11.6	24	17.8	69	53	1.5	2.4
2	HLNP-S07	59.4	5.7	5.7	146	89	430	2443	1015	13.2	24	24.1	110	109	1.6	1.8
3	HLSFWA-S07	49.4	6.7	6.7	125	130	589	7540	963	25.2	22	24.4	136	36	2.5	3.4
4	LMSP-S07	34	5.7	5.9	60	31	277	1619	345	8.0	32	17.8	80	140	0.7	1.4
5	JCRA-S07	40.6	6.8	6.8	84	53	347	4234	549	14.5	22	20.7	53	130	1.6	2.6
6	CSW-S07	41.2	6.7	6.9	60	68	325	4429	385	14.3	24	20.9	61	80	1.9	3.4
7	LGC-S07	33.5	6.1	6.3	74	85	261	3945	620	14.5	22	19.4	72	59	1.4	2.6
8	RH-S07	32.8	6.9	6.9	126	46	392	5846	730	19.3	22	19.2	55	67	1.5	3.2
9	GCSP-S07	48	6.1	6.2	122	22	286	3328	408	12.2	26	16.0	52	138	1.2	1.6
10	FRNP-S07	36.2	5.9	6.1	79	22	282	2422	392	10.0	22	17.8	68	117	1.7	2.0
11	FHSP-S07	40.9	7.2	7.1	71	153	504	5479	1043	19.6	22	38.0	117	46	4.1	7.2
12	JJKWNP-S07	36.9	6.8	6.8	71	95	435	4174	316	13.6	22	28.7	66	191	2.0	3.8
13	SCWNP-S07	44.8	6.2	6.3	72	20	278	3441	331	12.0	22	27.2	72	96	2.1	2.8
14	RCCA-S07	35.5	5.5	5.8	66	12	238	1434	362	7.7	28	21.8	88	106	1.3	1.6
15	TBSFWA-S07	45.8	6.9	6.9	170	59	427	7770	600	23.6	30	25.3	81	69	2.2	6.2
16	PCRNP-S07	39.6	5.4	5.8	79	16	190	1498	294	7.6	22	23.3	78	64	1.1	1.0
17	BSGNP-S07	27.2	5.0	5.2	109	19	264	966	201	6.4	26	14.3	69	80	1.2	1.0
18	BBNP-S07	40.1	6.2	6.2	169	41	386	5613	586	18.8	26	27.4	86	60	1.8	3.0
19	TTSF-S07	35.3	5.3	5.6	70	37	198	1330	353	7.5	22	11.2	72	42	1.3	1.2
20	OHNP-S07	38.7	4.8	5.3	84	42	248	884	261	6.6	26	12.7	78	63	1.2	1.0
21	FHPNP-S07	39.3	6.9	6.9	104	141	588	8480	667	26.1	26	24.0	43	149	2.6	7.2
22	FCNP-S07	32.1	6.2	6.3	80	24	310	4690	479	15.8	24	22.6	82	71	1.7	2.8
23	UCSFWA-S07	64.3	6.6	6.6	164	81	781	8510	845	27.7	26	18.7	74	64	2.6	5.4
24	MSGNP-S07	36.6	5.7	5.9	110	22	362	1943	271	8.7	26	13.0	57	175	1.0	1.4
25	ICSNA-S07	37.4	6.7	6.7	86	52	410	4547	490	15.3	24	28.3	43	214	1.9	3.6
26	KRSFWA-S07	37.2	6.6	6.6	60	299	528	3367	379	12.3	20	24.8	117	77	1.4	2.4
27	PRKSFWA-N-S07	33.5	6.7	6.7	121	68	526	8600	1581	30.2	42	20.6	109	56	2.5	3.4

Table A4. Continued.

No.	Site abbreviation	% Moisture	wpH	BpH	OM lbs/a	P lbs/a	K lbs/a	Ca lbs/a	Mg lbs/a	CEC	S lbs/a	Zn lbs/a	Fe lbs/a	Mn lbs/a	Cu lbs/a	B lbs/a
28	PRKSFWA-S-S07	39.1	7.5	7.3	72	30	448	8510	1344	28.0	32	22.1	38	79	2.1	4.2
29	MWNP-S07	41.5	6.5	6.5	127	37	438	4360	521	15.2	28	33.5	41	212	2.0	3.4
30	LPH-S07	41.2	7.0	7.0	186	129	588	10750	560	31.2	32	28.8	44	120	2.5	10.6
31	FB-F07	27.3	6.9	6.9	79	64	379	5516	669	18.1	28	12.9	84	47	2.2	3.4
32	HLNP-F07	13.3	6.1	6.4	79	85	468	2784	481	11.6	26	5.8	103	92	1.9	1.4
33	HLSFWA-F07	10.4	7.1	7.1	127	71	461	5024	482	16.2	30	8.2	51	113	2.5	2.8
34	LMSP-F07	17.0	5.4	5.8	62	42	199	1663	354	8.2	26	5.5	85	70	1.9	0.8
35	JCRA-F07	18.1	5.8	6.2	81	11	217	2080	482	9.5	28	5.3	67	100	1.8	1.2
36	CSW-F07	11.6	6.9	7.0	91	31	290	4753	439	15.1	26	5.4	51	60	2.1	3.0
37	LGC-F07	10.4	6.5	6.8	98	63	386	4443	711	16.1	26	11.1	78	46	1.8	2.0
38	RH-F07	10.5	6.0	6.2	106	43	322	2631	504	11.0	26	6.6	75	52	1.6	1.0
39	GCSP-F07	26.8	5.4	6.2	67	18	197	1204	247	6.6	30	4.9	78	77	1.7	0.8
40	FRNP-F07	31.0	5.2	5.8	70	14	243	1077	262	6.7	28	4.3	58	55	1.4	0.6
41	FHSP-F07	24.7	7.4	7.3	91	104	460	4822	831	16.8	34	22.1	136	47	3.8	5.0
42	JJKWNP-F07	25.2	6.8	7.0	80	84	382	3634	345	12.2	24	13.8	72	117	2.5	2.6
43	SCWNP-F07	24.7	5.9	6.4	70	22	228	2931	483	11.5	26	7.0	85	48	2.4	1.2
44	RCCA-F07	9.6	6.0	6.3	105	26	247	2764	393	10.7	26	5.1	72	78	1.9	1.4
45	TBSFWA-F07	10.7	6.1	6.4	106	38	266	3684	445	13.1	30	9.3	91	59	1.6	1.8
46	PCRNP-F07	7.1	5.2	5.9	86	17	198	1206	226	6.8	30	4.7	96	78	1.4	0.6
47	BSGNP-F07	30.9	5.2	5.9	81	18	220	1178	325	7.2	32	4.1	113	55	1.9	0.6
48	BBNP-F07	11.4	5.2	5.8	81	24	186	1115	259	6.6	30	5.6	98	60	1.9	0.8
49	TTSF-F07	15.8	4.8	5.3	94	26	178	912	219	6.3	32	4.0	82	41	1.6	0.4
50	OHNP-F07	27.9	6.5	6.8	79	16	169	3149	332	10.7	26	5.4	47	81	2.0	1.6
51	FHPNP-F07	16.7	7.7	7.4	128	119	664	7392	574	22.4	38	20.8	16	58	3.2	9.2

Table A4. Continued.

No.	Site abbreviation	% Moisture	wpH	BpH	OM lbs/a	P lbs/a	K lbs/a	Ca lbs/a	Mg lbs/a	CEC	S lbs/a	Zn lbs/a	Fe lbs/a	Mn lbs/a	Cu lbs/a	B lbs/a
52	FCNP-F07	11.8	6.3	6.4	90	51	407	4115	702	15.5	24	5.3	112	20	2.3	1.8
53	UCSFWA-F07	35.8	5.7	5.7	318	76	852	6627	801	23.9	38	13.3	153	18	3.1	2.8
54	MSGNP-F07	16.1	6.2	6.6	92	15	305	3261	517	12.4	24	4.8	69	72	2.2	1.4
55	ICSNA-F07	7.6	5.8	6.1	103	22	266	2817	474	11.4	26	8.3	65	60	2.0	1.0
56	KRSFWA-F07	4.7	6.7	6.8	95	57	478	3251	424	11.9	16	6.9	49	102	1.8	0.8
57	PRKSFWA-N-F07	22.0	5.5	5.9	177	36	542	2897	1062	15.1	36	9.5	99	95	3.2	2.0
58	PRKSFWA-S-F07	20.9	7.7	7.5	62	50	503	7430	1007	23.9	42	7.5	54	52	3.5	2.8
59	MWNP-F07	25.5	6.3	6.4	148	43	388	3641	493	13.4	36	14.7	58	126	2.7	3.2
60	LPH-F07	28.1	7.2	7.2	149	44	514	5133	488	16.5	38	13.0	43	87	2.7	5.6

Table A5. Shannon index of diversity (in rank order from greatest to least value)

Site Abbreviation	Shannon Index of Diversity
CSW-S07	2.775322
LPH-F07	2.611756
TBSFWA-F07	2.397836
TBSFWA-S07	2.397836
RCCA-S07	2.385786
PCRNP-S07	2.351829
JCRA-S07	2.348463
RH-S07	2.293249
FRNP-S07	2.285405
LPH-S07	2.264142
FB-F07	2.2583
CSW-F07	2.243218
FCNP-S07	2.220377
SCWNP-S07	2.214224
MSGNP-F07	2.184297
MWNP-S07	2.153144
OHNP-S07	2.117497
LGC-S07	2.097496
BBNP-S07	2.079173
FHPNP-F07	2.046594
BBNP-F07	2.01878
GCSP-F07	1.995836
OHNP-F07	1.978695
LGC-F07	1.977225
FB-S07	1.965669
FHPNP-S07	1.960303
TTSF-S07	1.955861
ICSNA-S07	1.942704
UCSFWA-S07	1.927245
PRKSFWA-N-S07	1.926136
RH-F07	1.913061
BSGNP-F07	1.896129
SCWNP-F07	1.882039
PRKSFWA-S-S07	1.880633
JJKWNP-S07	1.879299
MWNP-F07	1.867719

Table A5. Continued.

Site Abbreviation	Shannon Index of Diversity
HLSFWA-S07	1.849162
MSGNP-S07	1.84428
PRKSFWA-S-F07	1.835166
PCRNP-F07	1.790168
GCSP-S07	1.774912
LMSP-S07	1.765097
HLNP-F07	1.750285
FRNP-F07	1.742863
JCRA-F07	1.734765
ICSNA-F07	1.734433
HLSFWA-F07	1.714231
HLNP-S07	1.711845
TTSF-F07	1.680634
FHSP-S07	1.677053
BSGNP-S07	1.592415
RCCA-F07	1.567181
KRSFWA-F07	1.523959
JJKWNP-F07	1.512137
PRKSFWA-N-F07	1.35403
FHSP-F07	1.179199
LMSP-F07	1.115609
KRSFWA-S07	0.926038
FCNP-F07	0.562335
UCSFWA-F07	0

Table A6. Habitat complexity.

Site abbreviation	Topography	Exposed rock	Vegetation	Body or channel of water	TOTAL Habitat complexity index with water variable	TOTAL Habitat complexity index without water variable
FB-S07	2	2	1	1	6	5
HLNP-S07	0	0	0	1	1	0
HLSFWA-S07	0	0	1	0	1	1
LMSP-S07	1	0	1	0	2	2
JCRA-S07	0	0	1	2	3	1
CSW-S07	2	2	2	0	6	6
LGC-S07	2	1	1	0	4	4
RH-S07	1	1	1	0	3	3
GCSP-S07	1	2	1	0	4	4
FRNP-S07	2	2	2	1	7	6
FHSP-S07	0	0	1	0	1	1
JJKWNP-S07	0	0	1	0	1	1
SCWNP-S07	1	1	1	0	3	3
RCCA-S07	1	1	1	1	4	3
TBSFWA-S07	2	2	2	0	6	6
PCRNP-S07	2	1	1	1	5	4
BSGNP-S07	1	0	1	0	2	2
BBNP-S07	1	1	1	2	5	3
TTSF-S07	2	0	1	0	3	3
OHNP-S07	1	0	2	1	4	3
FHPNP-S07	2	2	2	0	6	6
FCNP-S07	1	1	0	1	3	2
UCSFWA-S07	0	0	0	2	2	0

Table A6. Continued.

Site abbreviation	Topography	Exposed rock	Vegetation	Body or channel of water	TOTAL Habitat complexity index with water variable	TOTAL Habitat complexity index without water variable
MSGNP-S07	1	2	1	0	4	4
ICSNA-S07	1	1	1	0	3	3
KRSFWA-S07	0	0	0	0	0	0
PRKSFWA-N-S07	0	0	2	2	4	2
PRKSFWA-S-S07	1	1	1	1	4	3
MWNP-S07	0	0	1	1	2	1
LPH-S07	2	2	2	0	6	6
FB-F07	1	2	1	0	4	4
HLNP-F07	0	0	1	2	3	1
HLSFWA-F07	0	0	1	2	3	1
LMSP-F07	0	0	1	2	3	1
JCRA-F07	1	1	0	2	4	2
CSW-F07	0	1	1	0 (dry creek bed)	2	2
LGC-F07	1	0	1	0	2	2
RH-F07	1	0	2	0	3	3
GCSP-F07	1	2	1	0	4	4
FRNP-F07	0	2	2	1	5	4
FHSP-F07	0	0	2	0 (dry creek)	2	2
JJKWNP-F07	0	0	2	0	2	2
SCWNP-F07	1	1	1	0	3	3

Table A6. Continued.

Site abbreviation	Topography	Exposed rock	Vegetation	Body or channel of water	TOTAL Habitat complexity index with water variable	TOTAL Habitat complexity index without water variable
RCCA-F07	0	0	1	0	1	1
TBSFWA-F07	2	1	1	0	4	4
PCRNP-F07	0	1	0	0 (dry creek)	1	1
BSGNP-F07	0	0	2	0 (dry creek)	2	2
BBNP-F07	1	1	1	1	4	3
TTSF-F07	0	1	2	0	3	3
OHNP-F07	0	1	2	0 (dry creek)	3	3
FHPNP-F07	1	1	1	0	3	3
FCNP-F07	0	2	2	0 (dry creek)	4	4
UCSFWA-F07	0	0	1	1	2	1
MSGNP-F07	0	1	1	0 (dry creek)	2	2
ICSNA-F07	0	1	1	0	2	2
KRSFWA-F07	0	0	2	0	2	2
PRKSFWA-N-F07	0	0	1	0 (dry creek)	1	1
PRKSFWA-S-F07	0	1	2	0 (dry creek)	3	3
MWNP-F07	0	0	1	0	1	1
LPH-F07	2	2	2	0	6	6

Table A7. Checklist of species.

The checklist below provides a summary of recorded specimens from the 6 counties of this study. All identified species collected in the course of this research effort are incorporated into the checklist (Coppolino 2007). Other sources of species data are from a combination of the literature (Baker, 1939; Hubricht, 1985, Hutchison, 1989) and/or museum holdings: Field Museum of Natural History (FMNH) and the Illinois Natural History Survey (INHS), which houses Baker's collections. The Field Museum now houses all of Hubricht's collections, which comprise not only his own but specimens from other collectors as well.

Distribution records are represented by county initials: St. Clair (S), Monroe (M), Randolph (R), Jackson (J), Union (U), and Alexander (A). An "X" indicates that the species was most likely collected within the six-county region (recorded in the literature or on specimen labels as "southwest Illinois"), but no specific county or other locality information was recorded. A dash indicates that no records for that species exist in any of the 6 counties. Notations of "misidentified", "invalid", and "introduced" species are indicated following the indicated species' name. Species that are recorded from fossil or river drift specimens are noted as such after the relevant county abbreviations.

Living and fossil species are arranged systematically by family, with genera and species arranged alphabetically within each family.

At present, there are 127 fossil and living species recorded in the six-county area; however some of these records remain to be verified. Incompletely identified species records from this study will be retained as tools for future research work.

Family	Species	Coppolino (2007)	INHS/ Baker (1939)	Hubricht (1985)	Hutchison (1989)	FMNH (1869-2007)
Helicinidae	*Hendersonia occulta* (Say, 1831)	-	U (fossil)	SMJR (fossil)	-	SM (fossil)
Pomatiopsidae	*Pomatiopsis lapidaria* (Say, 1817)	JU	-	SU (fossil)	-	SJU
Lymnaeidae	*Galba obrussa* (Say, 1825) (mostly aquatic and not normally recorded as a terrestrial species)	U	-	-	-	-
Ellobiidae	*Carychium exiguum* (Say, 1822)	-	X (fossil?)	S (fossil)	-	-
Ellobiidae	*Carychium exile* Lea, 1842	SMJU	X	JMS	-	SMJUA
Succineidae	*Catinella vermeta* (Say, 1824)	SMRUA	JUA	SM	-	SMUA
Succineidae	*Catinella gelida* (Baker, 1927)	-	-	SR (fossil)	-	SM (fossil)
Succineidae	*Catinella vagans* (Pilsbry, 1900) (misidentified)	-	-	-	-	U
Succineidae	*Novisuccinea ovalis* (Say, 1817)	U	X	S	-	S
Succineidae	*Oxyloma retusum* (Lea, 1834)	-	-	-	-	SUA
Succineidae	*Oxyloma peoriensis* (Wolf, 1894)	-	-	-	-	S
Succineidae	*Oxyloma salleanum* (Pfeiffer, 1849)	-	SM	SM	-	SM
Succineidae	*Succinea bakeri* Hubricht, 1963	-	-	SA (fossil)	-	S (fossil)
Succineidae	*Succinea chittangoensis* Pilsbry, 1908	-	-	SU (fossil)	-	SM (fossil)
Succineidae	*Succinea grosvenori* Lea, 1864	-	-	-	-	S
Succineidae	*Succinea indiana* Pilsbry, 1905 (misidentified)	-	-	-	-	S
Cochlicopidae	*Cochlicopa lubrica* (Müller, 1774)	U	U	J	-	U
Cochlicopidae	*Cochlicopa lubricella* (Porro, 1838)	-	-	S (fossil)	-	S (fossil)
Cochlicopidae	*Cochlicopa morseana* (Doherty, 1878)	U	-	-	-	J
Pupillidae	*Pupoides albolabris* (Adams, 1841)	SU	MRU	SMRJU	-	SMU
Strobilopsidae	*Strobilops aeneus* Pilsbry, 1926	SMRJU	RJ	RJU	-	U
Strobilopsidae	*Strobilops labyrinthicus* (Say, 1817)	SMRJ	MRJ	SMRJ, A (fossil)	-	SMJU
Valloniidae	*Vallonia gracilicosta* Reinhardt, 1883	-	-	SMA (fossil)	-	SM (fossil)
Valloniidae	*Vallonia perspectiva* Sterki, 1893	U	-	SU (fossil)	-	SJU
Valloniidae	*Vallonia parvula* Sterki, 1893	-	X (fossil?)	S (fossil), U	-	U (fossil)

Table A7. Continued.

Family	Species	Coppolino (2007)	INHS/ Baker (1939)	Hubricht (1985)	Hutchison (1989)	FMNH (1869-2007)
Valloniidae	*Vallonia pulchella* (Müller, 1774)	S	-	-	-	-
Vertiginidae	*Columella columella alticola* (Ingersoll, 1875)	S	-	S (fossil)	-	S (fossil)
Vertiginidae	*Columella simplex* (Gould, 1841)	S	-	-	-	-
Vertiginidae	*Gastrocopta abbreviata* (Sterki, 1909)	-	J	J	-	MRJ
Vertiginidae	*Gastrocopta armifera* (Say, 1821)	SMUA	MRU	SMRJU	-	SMJU
Vertiginidae	*Gastrocopta armifera affinis* Sterki (invalid name; currently recognized as *Gastrocopta similis*)	-	M	-	-	-
Vertiginidae	*Gastrocopta contracta* (Say, 1822)	SMRJUA	MJ	MJ	-	MJU
Vertiginidae	*Gastrocopta corticaria* (Say, 1816)	S	X	J (river drift)	U	J
Vertiginidae	*Gastrocopta cristata* (Pilsbry and Vanatta, 1900)	U	-	-	-	-
Vertiginidae	*Gastrocopta holzingeri* (Sterki, 1889)	-	J	J	-	JU
Vertiginidae	*Gastrocopta pentodon* (Say, 1822)	SRJU	JU	JU	-	JU
Vertiginidae	*Gastrocopta procera* (Gould, 1840)	SU	U	JU	-	JU
Vertiginidae	*Gastrocopta procera mcclungi* (Hanna and Johnson, 1913) (variant; invalid species)	-	J	-	-	-
Vertiginidae	*Gastrocopta rogersensis* Nekola and Coles, 2001	-	-	-	-	M
Vertiginidae	*Gastrocopta similis* (Sterki, 1909)	M	-	SM (fossil)	-	SJU (fossil)
Vertiginidae	*Gastrocopta tappaniana* (C.B. Adams, 1842)	SMJUA	X	SJU	-	SJ
Vertiginidae	*Vertigo brierensis* Leonard, 1972	-	-	J (fossil)	-	-
Vertiginidae	*Vertigo elatior* Sterki, 1894	-	X (fossil?)	SJ (fossil)	-	S (fossil)
Vertiginidae	*Vertigo gouldi* (A. Binney, 1843)	U	-	-	-	J
Vertiginidae	*Vertigo hubrichti* Pilsbry, 1934	-	-	SMJA (fossil)	-	SM (fossil)
Vertiginidae	*Vertigo milium* (Gould, 1840)	SJUA	X	J	-	J
Vertiginidae	*Vertigo modesta* (Say, 1824)	-	-	SMJA (fossil)	-	SM (fossil)
Vertiginidae	*Vertigo ovata* Say, 1822	-	J	J	-	J

Table A7. Continued.

Family	Species	Coppolino (2007)	INHS/ Baker (1939)	Hubricht (1985)	Hutchison (1989)	FMNH (1869-2007)
Vertiginidae	*Vertigo teskeyae* Hubricht, 1961	A	-	-	-	A
Vertiginidae	*Vertigo tridentata* Wolf, 1870	SJA	-	-	-	J
Orthalicidae	*Rabdotus dealbatus dealbatus* (Say, 1821)	-	J	-	J	-
Haplotrematidae	*Haplotrema concavum* (Say, 1821)	MRJUA	MJU	SMJUA	JU	SMJUA
Punctidae	*Punctum minutissimum* (Lea, 1841)	SMRUA	-	SMJU	-	SMJU
Punctidae	*Punctum vitreum* (H.B. Baker, 1830)	RJUA	-	M	-	MJUA
Discidae	*Anguispira alternata* (Say, 1816)	SMRJUA	MRJUA	SMRJUA	-	SMUA
Discidae	*Anguispira alternata carinata* (Pilsbry and Rhoads, 1896) (invalid species)	-	U	-	JU	-
Discidae	*Anguispira kochi* (Pfeiffer, 1845)	-	MJ	MJR	-	SMJ
Discidae	*Anguispira strongylodes* (Pfeiffer, 1821) (invalid species)	-	-	SMA	-	SMJ
Discidae	*Discus patulus* (Deshayes, 1830)	JU	MJUA	SMJUA	J	SMJU
Discidae	*Discus macclintocki* (Baker, 1928)	-	-	SMA (fossil)	-	SMU (fossil)
Discidae	*Discus shimeki* (Pilsbry, 1890)	-	-	S (fossil)	-	SM (fossil)
Discidae	*Discus whitneyi* (Newcomb, 1864)	-	-	-	-	SM
Helicodiscidae	*Helicodiscus notius notius* Hubricht, 1962	SMRJU	-	SMU	-	SMU
Helicodiscidae	*Helicodiscus parallelus* (Say, 1817)	SMJUA	SMRJU	SU	-	JU
Helicodiscidae	*Lucilla inermis* H.B. Baker, 1929	-	J	S (fossil), J (river drift)	-	S
Helicodiscidae	*Lucilla singleyana* (Pilsbry, 1889)	-	-	JU (fossil, river drift)	-	U
Gastrodontidae	*Striatura milium* (Morse, 1859)	-	-	S (fossil)	-	S (fossil)
Gastrodontidae	*Striatura meridionalis* (Pilsbry and Ferriss, 1906)	SMRJUA	M	M	-	MJUA
Gastrodontidae	*Ventridens demissus* (A. Binney, 1843)	SMRJUA	-	-	-	-

Table A7. Continued.

Family	Species	Coppolino (2007)	INHS/ Baker (1939)	Hubricht (1985)	Hutchison (1989)	FMNH (1869-2007)
Gastrodontidae	*Ventridens ligera* (Say, 1821)	SJUA	UA	SMJU	J	SMUA
Gastrodontidae	*Zonitoides arboreus* (Say, 1816)	SMRJUA	SMRJU	SMRJUA	JU	SMJU
Gastrodontidae	*Zonitoides nitidus* (Müller, 1774) (misidentified)	-	-	-	U	-
Euconulidae	*Euconulus chersinus* (Say, 1821)	MJUA	SM	-	-	-
Euconulidae	*Euconulus fulvus* (Müller, 1774)	SRJUA	U	SMJA (fossil)	-	SMJ
Euconulidae	*Euconulus trochulus* (Reinhardt, 1883)	SJA	-	SM	-	-
Euconulidae	*Guppya sterkii* (Dall, 1888)	SMJUA	-	U	-	JU
Oxychilidae	*Glyphyalinia indentata* (Say, 1823)	SMRJUA	SMRJUA	SMRJUA	-	SMJUA
Oxychilidae	*Glyphyalinia rhoadsi* (Pilsbry, 1899) (misidentified)	-	J	-	-	-
Oxychilidae	*Glyphyalinia wheatleyi* (Bland, 1883)	SMRJUA	JU	JUA	-	U
Oxychilidae	*Mesomphix cupreus* (Rafinesque, 1831)	MUJA	X	-	-	U
Oxychilidae	*Mesomphix friabilis* (W.G. Binney, 1857)	RU	-	M(fossil), SJU	-	MJUA
Oxychilidae	*Mesomphix vulgatus* H.B. Baker, 1933	-	X	-	JU	-
Oxychilidae	*Nesovitrea electrina* (Gould, 1841)	-	-	SMRJUA (fossil)	-	SMUA(fossil)
Oxychilidae	*Paravitrea capsella* (Gould, 1851)	MRJU	M	MJU	-	JU
Oxychilidae	*Paravitrea significans* (Bland, 1866)	MU	R	M	-	-
Pristilomatidae	*Hawaiia alachuana* (Dall, 1885)	-	-	S (fossil)	-	SU (fossil)
Pristilomatidae	*Hawaiia minuscula* (Binney, 1841)	SMRJUA	JU	SMJU	U	JU
Limacidae	*Lehmannia valentiana* (Férussac, 1821) (introduced)	J	-	-	-	-
Limacidae	*Limax maximus* Linnaeaus, 1758 (introduced)	U	X	-	-	U
Agriolimacidae	*Deroceras laeve* (Müller, 1774)	RJ	X	S (fossil), J	J	SU

Table A7. Continued.

Family	Species	Coppolino (2007)	INHS/ Baker (1939)	Hubricht (1985)	Hutchison (1989)	FMNH (1869-2007)
Agriolimacidae	*Deroceras reticulatum* (Müller, 1774) (introduced)	RJUA	X	-	-	UA
Arionidae	*Arion intermedius* Normand, 1852 (introduced)	S	-	-	-	-
Arionidae	*Arion subfuscus* (Draparnaud, 1805) (introduced)	J	-	-	-	-
Philomycidae	*Megapallifera mutabilis* (Hubricht, 1951)	R	-	SJU	-	JU
Philomycidae	*Megapallifera ragsdalei* (Webb, 1950)	U	-	J	-	-
Philomycidae	*Megapallifera wetherbyi* (W.G. Binney, 1874)	-	-	-	-	S
Philomycidae	*Pallifera fosteri* F.C. Baker, 1939	-	M	SM	-	SM
Philomycidae	*Philomycus carolinianus* (Bosc, 1802)	MRJU	X	SMRJUA	-	SMJUA
Polygyridae	*Allogona profunda* (Say, 1821)	-	J (fossil)	SMRJA (fossil)	JA (fossil)	SM (fossil)
Polygyridae	*Daedalochila leporina* (Gould, 1848)	RJUA	RJU	RJU	-	-
Polygyridae	*Euchemotrema fraternum fraternum* (Say, 1824)	SMRJUA	SMRJU	SMRJU	J	SMJ
Polygyridae	*Euchemotrema hubrichti* (Pilsbry, 1940)	U	-	U	-	JU
Polygyridae	*Euchemotrema leai aliciae* (Pilsbry, 1893)	SRU	-	S (fossil), MJ	-	M
Polygyridae	*Euchemotrema leai leai* (A. Binney, 1841)	-	-	S (fossil)	-	S (fossil)
Polygyridae	*Inflectarius inflectus* (Say, 1821)	SMRJUA	SMJUA	SMJUA	JU	SMJUA
Polygyridae	*Mesodon clausus* (Say, 1821)	SMRJUA	MRJ	SMRJA	J	SM
Polygyridae	*Mesodon edentatus* (Sampson, 1889)	-	A	-	-	-
Polygyridae	*Mesodon elevatus* (Say, 1821)	JU	JA	SJA		SA
Polygyridae	*Mesodon thyroidus* (Say, 1816)	SMRJUA	JUA	SMJUA	UA	SMJUA
Polygyridae	*Mesodon zaletus* (Binney, 1837)	JUA	MRJUA	SMRJUA	-	SMJUA
Polygyridae	*Millerelix dorfeuilliana* (Lea, 1838)	M	MJ	MRJ	-	M

Table A7. Continued.

Family	Species	Coppolino (2007)	INHS/ Baker	Hubricht (1985)	Hutchison (1989)	FMNH (1869-2007)

			(1939)			
Polygyridae	*Neohelix albolabris* (Say, 1817) (misidentified)	-	-	-	UA	U
Polygyridae	*Neohelix alleni* (Weatherby in Sampson, 1883)	-	MJ	SMJA	U	SM
Polygyridae	*Patera appressa* (Say, 1821) (misidentified)	-	MJUA	-	-	-
Polygyridae	*Patera pennsylvanica* (Green, 1827)	-	R	SM (fossil), RJ (live)	-	SM (fossil)
Polygyridae	*Polygyra fraudulenta* Pilsbry 1894 (misidentified)	-	U	-	-	-
Polygyridae	*Polygyra hirsuta* (Say, 1817) (misidentified)	-	MJU	-	-	-
Polygyridae	*Polygyra tridentata* (Say 1816) (misidentified)	-	J	-	-	-
Polygyridae	*Polygyra tridentata frisoni* (misidentified)		RJ	-	-	-
Polygyridae	*Polygyra tridentata unidentata* Baker, 1898 (variant; invalid species)	-	J	-	-	-
Polygyridae	*Stenotrema barbatum* (Clapp, 1904)	SRJU	-	SMJU	-	SMU
Polygyridae	*Triodopsis discoidea* (Pilsbry, 1904)	RU	-	RJUA	-	MRUA
Polygyridae	*Triodopsis tridentata* (Say, 1816) (misidentified)	-	-	-	JU	JU
Polygyridae	*Triodopsis vulgata* Pilsbry, 1940	JUA	-	JU	-	JU
Polygyridae	*Webbhelix multilineata* (Say, 1821)	U	A	SMA	-	SM
Polygyridae	*Xolotrema denotatum* (Férussac, 1821)	-	-	-	-	J
Polygyridae	*Xolotrema fosteri* (F.C. Baker, 1921)	SMRJU	MRJUA	SMRJUA	AJMR	SMJUA

Living spp documented in southern IL = 88
Living spp in Illinois (based on records from FMNH, INHS, own collections) = 124
Percentage of Illinois' land snails in the 6-county area = 71%

Table A8. Total numbers of each species collected in this study, in order of rank from most to least numerous.

Species	Total numbers for 6-county area
Glyphyalinia indentata (Say, 1823)	984
Carychium exile exile Lea, 1842	297
Anguispira alternata (Say, 1816)	274
Triodopsis vulgata (Pilsbry, 1940)	251
Glyphyalinia wheatleyi (Bland, 1883)	245
Striatura meridionalis (Pilsbry & Ferriss, 1906)	182
Inflectarius inflectus (Say, 1821)	173
Hawaiia minuscula (Binney, 1841)	168
Ventridens demissus (A. Binney, 1843)	154
Gastrocopta armifera (Say, 1821)	153
Paravitrea capsella (Gould, 1851)	153
Xolotrema fosteri (Baker, 1921)	146
Ventridens ligera (Say, 1821)	125
Stenotrema barbatum (Clapp, 1904)	104
Zonitoides arboreus (Say, 1816)	97
Haplotrema concavum (Say, 1821)	92
Euchemotrema hubrichti (Pilsbry, 1940)	74
Euchemotrema fraternum fraternum (Say, 1824)	73
Gastrocopta contracta (Say, 1822)	66
Catinella vermeta (Say, 1824)	53
Punctum vitreum (H.B. Baker, 1930)	50
Euconulus fulvus (Muller, 1774)	49
Mesomphix cupreus (Rafinesque, 1831)	47
Helicodiscus parallelus (Say, 1817)	45
Helicodiscus notius notius (Hubricht, 1962)	43
Mesodon zaletus (A. Binney, 1837)	39
Gastrocopta pentodon (Say, 1822)	36
Strobilops labyrinthicus (Say, 1817)	35
Paravitrea significans (Bland, 1866)	31
Punctum minutissimum (Lea, 1841)	30
Discus patulus (Deshayes, 1830)	25

Table A8. Continued.

Species	Total count for 6-county area
Guppya sterkii (Dall, 1888)	25
Mesodon clausus clausus (Say, 1821)	25
Gastrocopta tappaniana (C.B. Adams, 1842)	22
Strobilops aenus (Pilsbry, 1926)	22
Euchemotrema leai aliciae (Pilsbry, 1893)	19
Daedalochila leporina (Gould, 1848)	17
Euconulus chersinus (Say, 1821)	14
Philomycus carolinianus (Bosc, 1802)	14
Mesodon thyroidus Say, 1816	12
Triodopsis discoidea (Pilsbry, 1904)	12
Vertigo milium (Gould, 1840)	10
Galba obrussa (Say, 1825)	9
Mesodon elevatus (Say, 1821)	8
Mesomphix friabilis (W.G. Binney, 1857)	8
Pomatiopsis lapidaria (Say, 1817)	8
Arion intermedius (Normand, 1852)	7
Vertigo tridentata Wolf, 1870	6
Cionella morseana (Doherty, 1878)	5
Vallonia perspectiva Sterki, 1893	5
Deroceras reticulatum (Muller, 1774)	4
Gastrocopta corticaria (Say, 1816)	4
Cionella lubrica (Muller, 1774)	3
Gastrocopta procera (Gould, 1840)	3
Megapallifera mutabilis (Hubricht, 1951)	3
Pupoides albilabris (Adams, 1841)	3
Vertigo gouldi (A. Binney, 1843)	3
Euconulus trochulus (Reinhardt, 1883)	2
Millerelix dorfeuiliana (Lea, 1838)	2
Vertigo tappaniana (C.B. Adams, 1842)	2
Columella simplex (Gould, 1841)	1
Deroceras laeve (Muller, 1774)	1
Gastrocopta cristata (Pilsbry and Vanatta, 1900)	1

Table A8. Continued.

Species	Total numbers for 6-county area
Gastrocopta similis (Sterki, 1909)	1
Limax maximus Linnaeus, 1758	1
Lucilla inermis (H.B. Baker, 1929)	1
Megapallifera ragsdalei (Webb, 1950)	1
Vallonia pulchella (Muller, 1774)	1
Total specimens identified to species	4,579