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Urbanization Impacts on Land Snail Community Composition

Mackenzie N. Hodges
University of Tennessee - Knoxville, mhodges8@vols.utk.edu

To the Graduate Council:

I am submitting herewith a thesis written by Mackenzie N. Hodges entitled "Urbanization Impacts on Land Snail Community Composition." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Geology.

Michael L. McKinney, Major Professor

We have read this thesis and recommend its acceptance:

Colin Sumrall, Charles Kwit

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

Urbanization Impacts on Land Snail Community Composition

A Thesis Presented for the

Master of Science

Degree

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Mackenzie N. Hodges

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DEDICATION

I dedicate this research to my late grandmother, Shirley Boling, who introduced me to snails in the garden in very young age. I believe her love and constant presence in my early years has changed my life in unknowable ways.

I also dedicate this to Philip Moore, my partner in love, life, and happiness. His support and rationale throughout this process has been nothing short of life-saving.

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I would like to sincerely thank Dr. Michael McKinney for his constant support and all the knowledge he has imparted upon me, which started on my first day of college when I sat in the front row of his biodiversity class. I credit him for developing my love of nature and understanding of the environment, which includes the tiniest snails and the most beautiful phenomenon.

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ABSTRACT

Urbanization has tremendous impacts on most native species. Urban ecosystems are becoming increasingly prevalent, while urban ecology is a relatively underdeveloped field. This is especially true for terrestrial mollusks, which are a surprisingly understudied organism. Due to their low mobility and dispersal potential, land snails are valuable indicators of ecosystem disturbance. For this study, land snails were collected in 54 city parks along an urban gradient to understand influences of urbanization on snail communities. Sampled parks include small extensively landscaped downtown parks, neighborhood and community parks, district parks, and large nature parks, each with variable vegetation, soil characteristics, disturbance regimes, and human activities. Sampling recovered 12,153 individual snails, representing 20 families, 43 genera, and 95 species. Seven new Tennessee state and 87 new county occurrences were recorded for Davidson, Knox, Hamilton, and Marion counties. Five non-native and one extra-limital invasive species were found, four of which are new Tennessee state records. Results show that urbanization greatly alters land snail community structure. Nature and district parks have significantly greater species richness, species diversity and species evenness than community, neighborhood, and downtown parks. Degradation of parks, distance from the park to the city center and percent of coarse woody debris explained most of the variation between park types. Non-metric multidimensional scaling shows that downtown snail communities are similar across all three cities, whereas snail communities in nature parks are distinct. This suggests that urbanization promotes homogenization among land snail communities in Tennessee.

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CHAPTER 1
INTRODUCTION

Urbanization Impacts on Biodiversity and Community Similarity

Urbanization of previously rural or natural land has led to a dramatic change in ecosystems all over the world. Urban development in the United States endangers more species than any other human activity (Czech et al., 2000). As a result of urbanization, vast areas of land are devegetated, paved over, and modified in a way that they cannot longer function in their original capacity (McKinney, 2006). Alig and others (2004) predicted that the amount of developed land would increase by 79% in the next 25 years. In the United States, over 80% of the population already lives in or near cities, a number that is expected to continue growing (McKinney, 2006).

The effects of urbanization with regard to native plant and animal species have been widely studied and reviewed (McKinney, 2008). Studies indicate that urbanization can either increase or decrease species richness depending on variables like intensity of urbanization, scale of analysis, and taxonomic group (McKinney, 2008). Organisms with low dispersal capabilities, like snails, are particularly susceptible to anthropogenic activities, like urbanization (Strom et al., 2009). Micro-snails (<5mm in diameter) were found to be more vulnerable to disturbance because they have very limited dispersal, and because of their high dependence on microhabitats (Baur and Baur, 1988).

In 2008, McKinney compiled all available urban gradient studies on invertebrate species, and concluded that there was a 30% increase in species richness in moderately urbanized areas (areas with 20-50% impervious surface), though this includes non-native species. Urban areas are known to have a larger percentage of non-native species than more rural surroundings (Roy et al., 1999; Kühn & Klotz, 2006; Pyšek et al., 2010). Interestingly, some studies have found that the diversity of urban habitats can also harbor threatened taxa (Gilbert, 1989; Wang et al., 2007). An increasing proportion of non-native species can be found with increasing urbanization, meaning that non-native species will likely be found in higher numbers in the urban core versus the periphery (McKinney, 2006). McKinney (2004), found that similar non-native species tend to become established in cities due to the uniform nature of urban areas, and thereby causing biotic homogenization.

Introduction to Terrestrial Gastropods

Terrestrial gastropods, or land snails, belong to the phylum Mollusca, the second most diverse animal phylum on the planet in terms of described species (Lydeard et al., 2004). Globally, there are descriptions of approximately 24,000 species of terrestrial snails, with 12,000 occurring in North America (Lydeard et al.; 2004; Barker, 2001; Pilsbry, 1948). There are an estimated 11,000-40,000 species of undescribed land snails in the world, resulting in a potential global diversity of between 35,000-65,000 terrestrial gastropods (Figure 1).

Species estimates remain varied partly because the low number of molluscan taxonomists have not been able to survey vast areas of the world (Lydeard et al., 2004). Land snails are highly dependent on microhabitat. Therefore, thorough surveys of a given habitat are necessary to account for all diversity in a given area (Coney et al., 1982). Estimates also vary due to widely unsettled gastropod taxonomy. Many attribute this to “a long evolutionary history, rapid radiations, and the adaptation to many habitats by members of the same evolutionary line and to the same habitat by distantly related forms” (Bieler, 1992). The morphological variation within a single species can lead to misidentifications in a field where most identifications are based solely on morphological characteristics. The Polygyridae, one of the most commonly encountered snail families in North America, was recently found to have 61% of species identified as not being monophyletic (Perez et al., 2014).

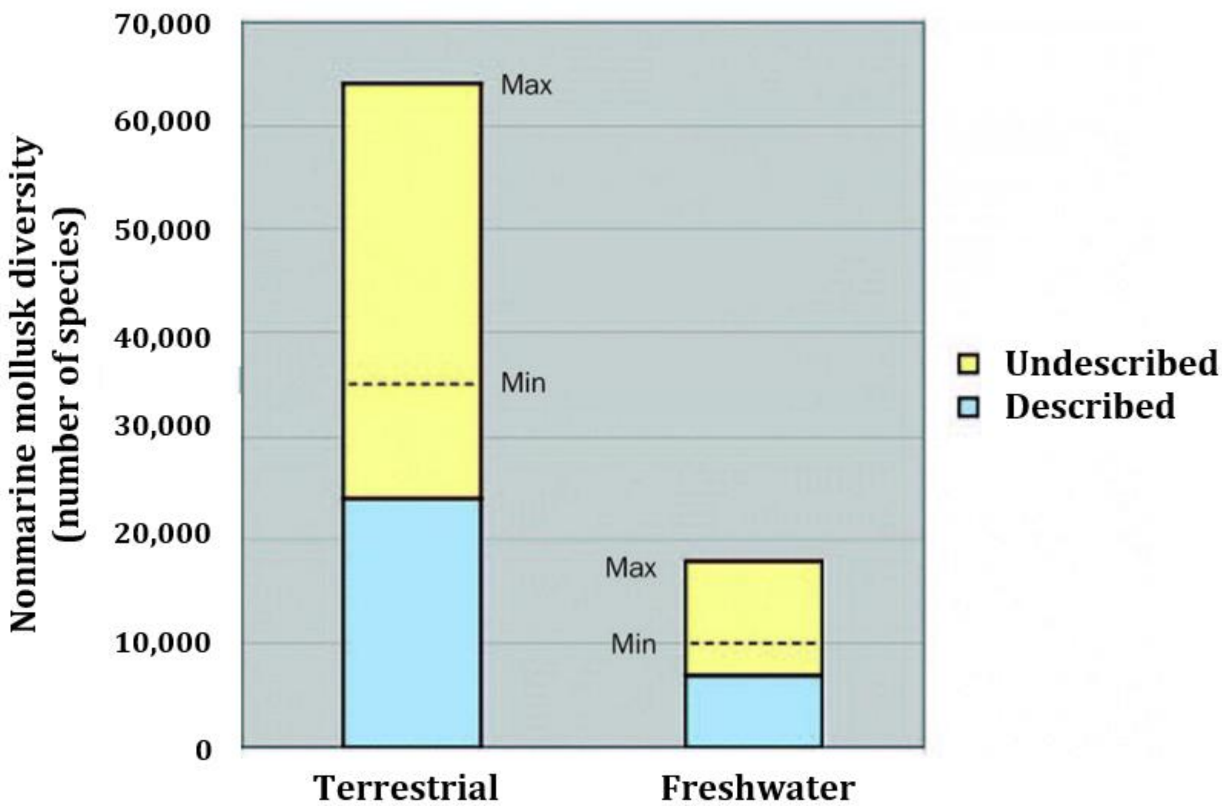

Figure 1: Global estimations of described and undescribed mollusks (Lydeard et al., 2004).

The Mollusca have the highest number of recorded extinctions. Since the year 1500 through the early 2000's, 37% of the documented 693 animal extinctions have been gastropods (Lydeard et al., 2004). As of 2015, there are 1,772 gastropods listed as threatened on the International Union for Conservation of Nature (IUCN) red list (Figure 2). Even with the critical rate of imperilment, gastropods are currently one of the most understudied groups of animals. Snails receive far less attention than their vertebrate counterparts, with relatively few researchers studying them today (Lydeard, 2004).

The Importance of Terrestrial Gastropods

Terrestrial gastropods can be found in almost every habitat on Earth ranging from deserts, to high mountains, to tropics and rainforests, the only exception being the polar regions (Abbott, 1989). The role snails play in these diverse ecosystems varies, but in general they are significant cyclers of nutrients through the environment and an important source of food, notably calcium, for several animal groups (Caldwell, 1993). The snail body and the calcium-rich shell serve as a food source for nearly every systematic group of animals, including ants, fireflies, flies, beetles, carnivorous snails, salamanders, turtles, frogs, snakes, small mammals, numerous species of birds, bats, and humans (Dourson, 2010). Snail shells are thought to be the main source of calcium for forest birds while forming egg-shells (Schifferli, 1973; Graveland et al., 1994; Perrins, 1996). A decrease in snail abundance in acidified and calcium poor areas can cause a calcium deficiency in birds which results in thinner eggs that are susceptible to breaking resulting in reduced reproductive success (Graveland et al., 1994; Graveland, 1996).

Land snails are critical in cycling nutrients through the forest environment. One study suggests that land snails play a relatively small role in the actual litter consumption of forests, ingesting about 1 percent of the annual litter in an English forest, compared to millipedes ingesting 1.7 to 10 percent. It was concluded that their main role was promoting fungal and microbial growth through the alteration of leaf litter (Mason, 1970b). Snails also

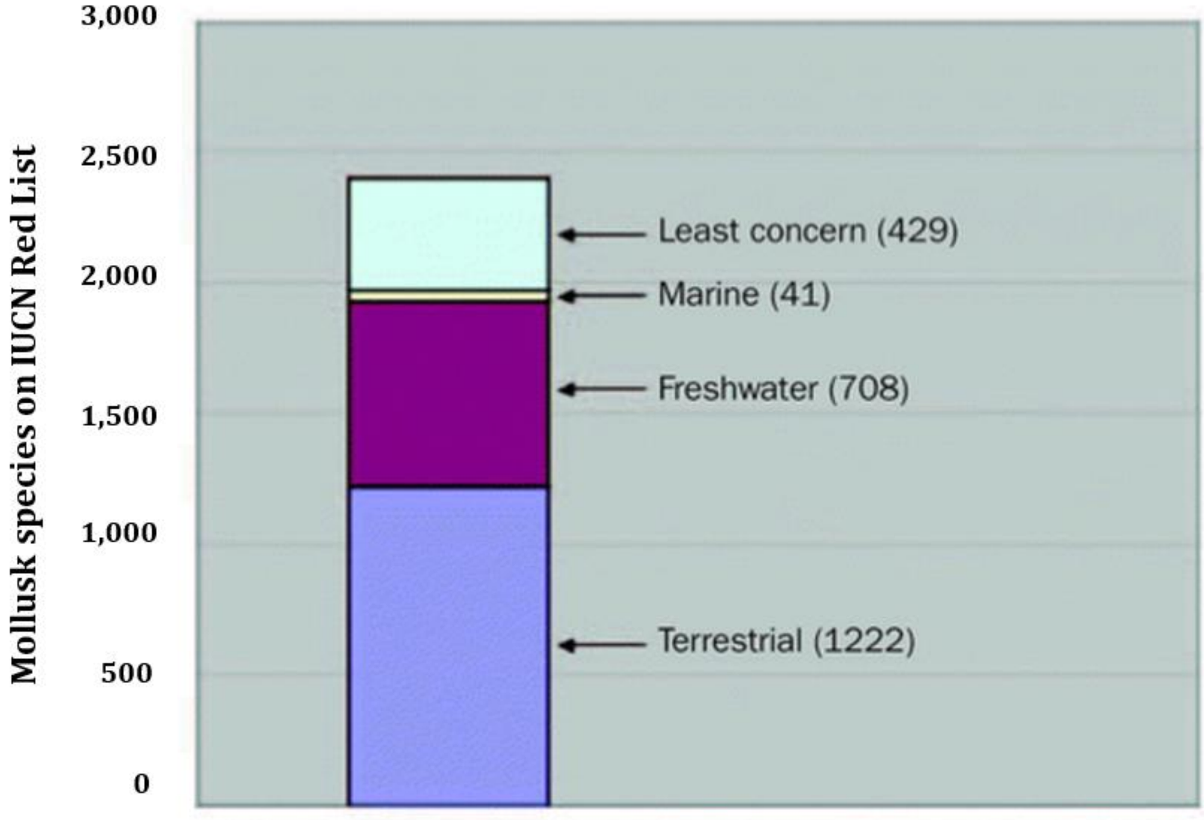

Figure 2: Total number of threatened mollusks on the 2002 IUCN Red List (Lydeard et al., 2004)

act as a reservoir of calcium in an ecosystem. On a percent weight basis, snails store more calcium in the shell and soft tissue than any other soil fauna (Caldwell, 1993).

Land snails may also serve as biological indicators of soil quality and chemistry. Snails are efficient accumulators of heavy metals due to their dual uptake of toxins cutaneously and through their diet. They have been identified as useful indicators for cadmium, lead, copper, and zinc soil pollution (Dallinger, 1994). The presence of certain species can serve as indicators of the overall health of the ecosystem (Burch and Pearce, 1990). Due to their ubiquitous nature, limited mobility, and increased vulnerability to habitat change, land snails, especially micro-snails (< 5 mm diameter), are a practical choice when assessing the overall health of an ecosystem (Frest and Johannes, 1995; Frest, 2002).

Habitat Factors that Influence Terrestrial Gastropod Communities

The diversity of land snail habitat has made it difficult to say which environmental factors most affect snail diversity and abundance. Much research has gone into determining how moisture, pH, calcium, leaf litter depth and composition, coarse woody debris (CWD), geology, vegetation, gradient, elevation, and other factors influence land snail communities (Bishop, 1977; Getz & Uetz, 1994; Locasciulli & Boag, 1987; Millar & Waite, 1999; Nekola & Smith, 1999; Hotopp, 2002; Graveland & van der Wal, 1996; Loranger et al., 2001; Berry, 1973; Wardhaugh, 1995; Wäreborn, 1969). Analyzed together, soil Ca, soil pH (mostly as a function of Ca), and soil moisture were found to be the most important abiotic factors that influence snail diversity (Martin & Sommer, 2004). Most researchers have found a positive relationship between soil pH and calcium and snail species richness and snail abundance. A study in Finland found pH was positively correlated with land snail abundance and richness, with a minor decline in abundance above pH 6.5 (Valovirta, 1968). Wareborn (1992) found a positive correlation between Ca and land snail abundance and richness, while a Wisconsin study found no correlation between Ca and land snail richness, but did find a positive correlation between pH (pH 7-8) and richness and abundance (Nekola & Smith, 1999).

Urbanization Impacts on Land Snails

Urbanization and anthropogenic impacts on land snails have been well studied on islands and some European countries (Goodfriend et al., 1994; Cowie and Robinson, 2003; Chiba and Roy, 2011; Cowie, 2001, 2002; Chiba et al., 2009; Chiba, 2010; Douglas et al., 2013; Horsák et al., 2013, 2009). A review of these studies by Yanes (2012) concludes that three main anthropogenic factors are impacting land snails: habitat loss through urban and agricultural development, introduction of non-native predators, and introduction of non-native snail species. Horsák and others (2013) found that homogenization of land snails is also a problem, due to the introduction of non-native species to Europe. Habitat loss and alteration is thought to be the leading cause in land snail extinction. Using the fossil record, Goodfriend (1994) determined that the majority of all land snail extinctions that have occurred on the Madeiran Islands happened recently from habitat destruction.

There have been over 57 urban gradient studies on invertebrate species. (McKinney, 2008). However, until now, no studies have been done on urban snails in the U.S. Of the few studies that look at land snail communities along an urban gradient, the general finding was an increase in gastropod diversity from the city center radiating out (Horsák et al., 2009). Horsák and others (2009) conducted the most thorough and extensive study of land snails along an urban gradient in three Czech cities. Results confirmed that species richness, as well as rare and habitat-sensitive (anthrophobic) species decreased with increased habitat degradation. Results were independent of the site location within the city, indicating that higher snail diversity could be reached with better habitat protection and maintenance (Figure 3).

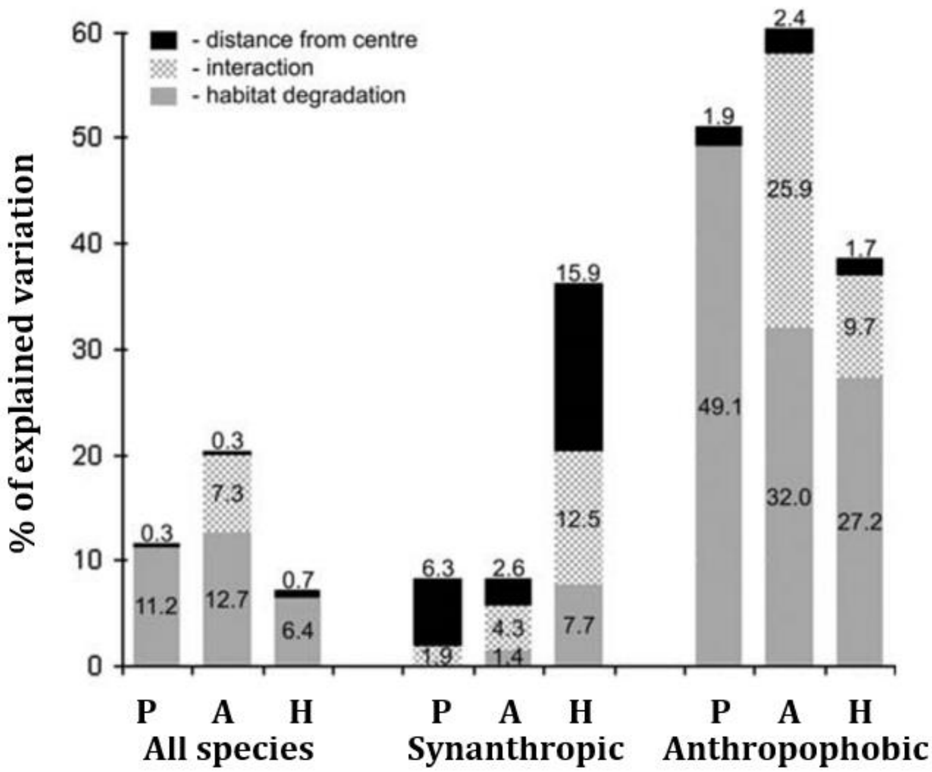

Figure 3: Percent of variation explained by habitat degradation and distance from city center by species category and city (R 2.6.1 Software). P=Pilsen, A=Prague, H=Hradec Kra'love' (Horsák et al., 2009)

Study Goals

This study analyzes the effects of urbanization on land snail communities in Tennessee across an urban gradient. Land snails were surveyed in 54 parks in three major Tennessee cities. Snail abundance and species diversity were measured, along with several abiotic and biotic factors to determine differences among cities and across the urban gradient. My null hypothesis is that urbanization will have no effect on land snail communities, regardless of degree of urbanization. Expected outcomes are that communities of snails will differ across the urban gradient, and that some degree of homogenization will be seen in communities closer to the urban core. I also expect to see a decrease in species richness and diversity in more urbanized habitats. I will determine if synanthropic species, (non-native species, and native species whose habitat preferences include: urban areas, parking lots, gardens, lawns, greenhouses, and waste cities) are dominating in different parks types, which could later be used to determine the relative health of an urban environment. Habitat preferences for snails designated as synanthropic were compiled based on accepted habitat descriptions made by experts in the field, including Burch (1962), Dourson (2010), Pearce & Hotopp (2013).

CHAPTER 2
MATERIALS AND METHODS

City and Site Selection

Snails were investigated in three Tennessee cities (Figure 4). Nashville (764.6 km^2; 644,014 population, settled in 1779) is located in the Central basin of Middle Tennessee and is the second largest city in the state (U.S. Census Bureau, 2015). Nashville is situated on the Cumberland River, which runs east-west through the city. The topography of the area is known as rolling, with elevation ranging from 400-700 feet above sea level. The Central Basin is defined by the Hudson River and Trenton limestone groups of the Ordovician limestone and Lower Silurian, shale, and dolomite. Knoxville (255.1 km^2; 184,281 population; settled in 1792) is located in eastern Tennessee in the Southern Appalachian Ridges and Valleys area (U.S. Census Bureau, 2015). Knoxville is established on the Tennessee River, which flows southwest through the city. The topography is defined as rolling, to hilly, with steep rugged ridges. The elevation ranges from 740 feet to 2128 feet. The bedrock is made of Cambrian, Ordovician, and some Silurian age limestone, dolomite, shale, and siltstone (USDA, NRCS, 2000). Chattanooga, (354.8 km^2; 173,779 population; settled in 1819) in the southeastern part of Tennessee, lies in the Cumberland Plateau and the Southern Appalachian Ridges and Valleys (U.S. Census Bureau, 2015). The bedrock is made up of Ordovician-Cambrian, Ordovician, Mississippian, and Pennsylvanian sandstone, shale, limestone, chert, dolomite, claystone, and siltstone. Chattanooga is located on the Tennessee River, which enters the city from the southwest. The topography is similar to Knoxville, with rolling hills and rocky ridges. The elevation ranges from 210 meters in downtown to 728 m at Lookout Mountain (USDA, NRCS, 1982).

Figure 4: Tennessee cities chosen for sampling: Nashville, Knoxville, and Chattanooga

All parks were chosen from a compiled list based off of each city's Parks & Recreation Department website, with the exception of Prentice Cooperr State Forest in Chattanooga. Parks were sorted into categories based on the cities' description of the park and using Google Earth to determine forest cover. Categories were: nature parks (larger, mostly forested parks with minimal degradation), district parks (mid-size parks with large open spaces with ample forested space), community parks (small mainly recreational parks with mostly open space, pavilions and sports fields, with some forested area), neighborhood parks (very small parks, situated in suburbs for human use), and downtown parks (located directly downtown, typically less than one acre, and very urban).

In each city, three nature parks, three district parks, three community parks, six neighborhood parks, and three downtown parks were chosen using a random number generator, for a total of 54 parks (Figures 5, 6, and 7). Neighborhood parks made up the majority of every city's park system, and therefore required a greater degree of sampling. Because Chattanooga lacks nature parks on its park directory, Prentice Cooperr State Forest, was used as a proxy.

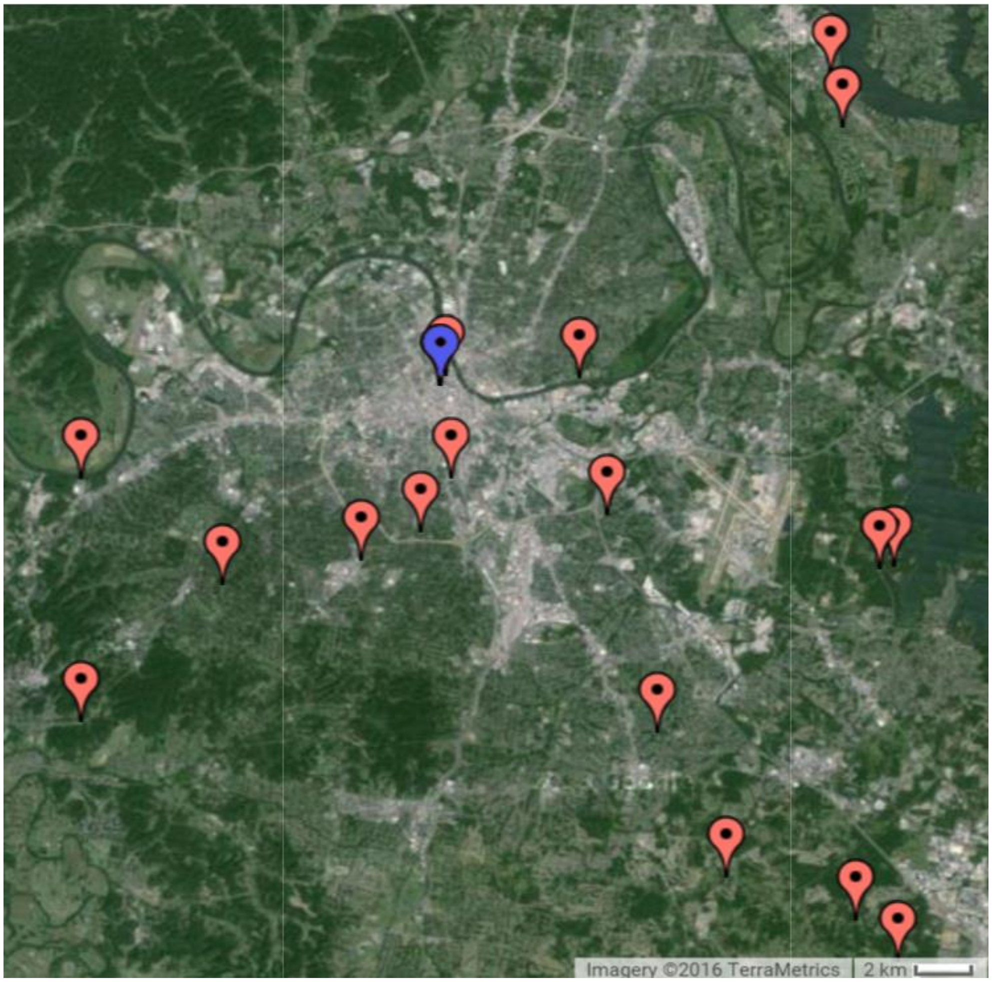

Figure 5: Nashville, TN. Parks sampled are represented by red markers, city center is represented by the blue marker

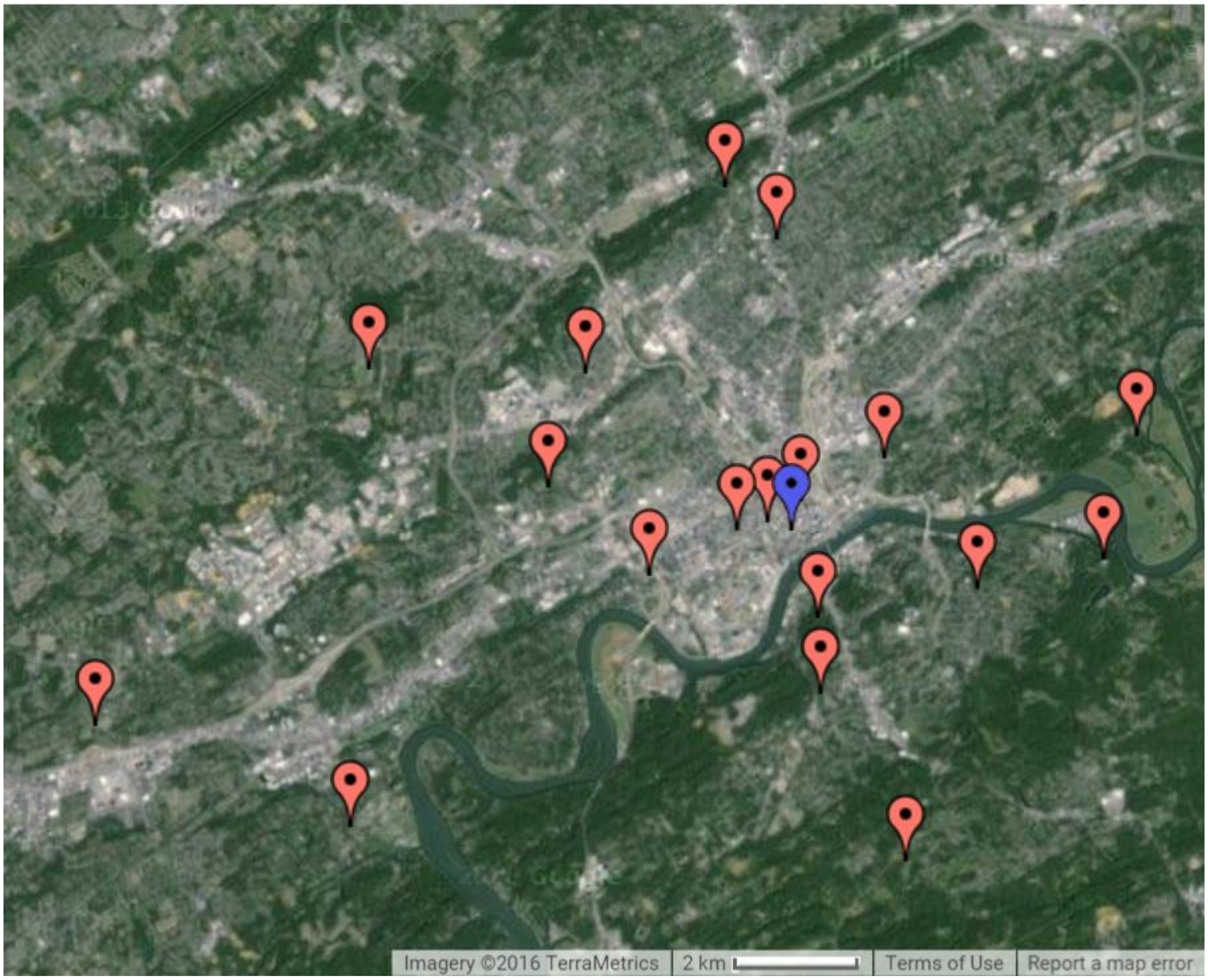

Figure 6: Knoxville, TN. Parks sampled are represented by red markers, city center is represented by the blue marker

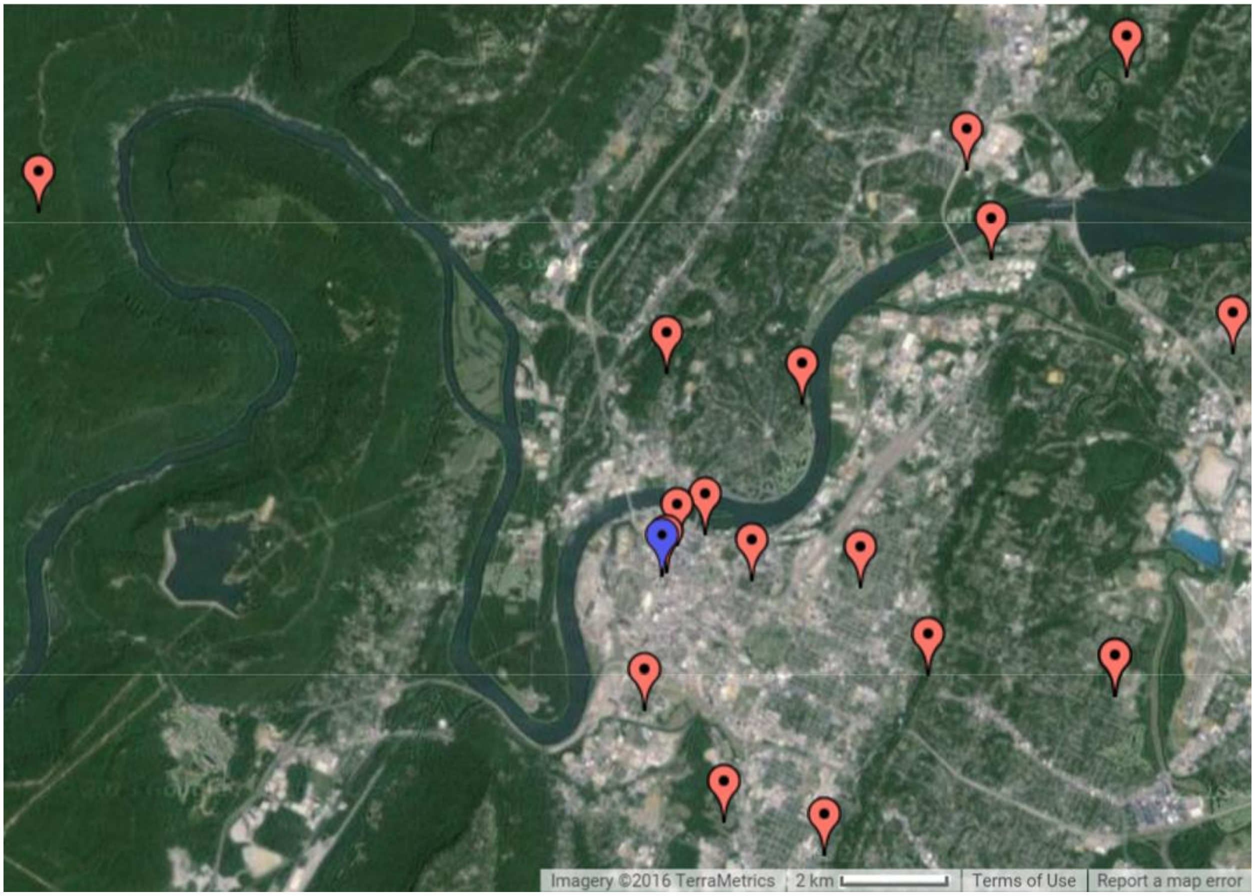

Figure 7: Chattanooga, TN. Parks sampled are represented by red markers, city center is represented by the blue marker

Sampling Overview

Snails (living and shells) were collected between May and September, 2015 between the hours of 9 A.M. and 4 P.M. Because snails are most active at night and after rainfall, surveys only occurred following a period of 48 hours without rain to control for snail activity. (Barker, 2001). Two standard terrestrial gastropod sampling methods were used in this study; visual searches of plots and soil collection of the same plot. Visual surveying for land snail is very effective at locating macro-snails (>5mm maximum width), but often misses micro-snails (<5mm maximum width) (Hotopp, 2002). Soil collection is recommended to account for the micro-snail population at a given site (Clergeau, 2011). Clergeau (2011) determined that using only these two methods in urban gastropod sampling was effective in obtaining 55%-61.5% (visual search) and 92%-100% (soil search) of snails. The number of plots per park was determined by the variety of habitat and acreage of each park. Variety of habitat was determined by a visual walkthrough when feasible, conversations with park officials, and virtual tours. If a park had one habitat type, one plot was surveyed. In contrast, when a park had more than one habitat type, one plot was surveyed in each habitat. One plot was used for most downtown and neighborhood parks because they had one habitat type, typically invasive plant species, landscaping, or open lawn, and an average of four acres.

Visual Survey and Processing

At each habitat type within a park, plots were selected based on higher likelihood of increased snail abundance based on the researcher's knowledge of snail habitat. (Figure 8). Two $9m^2$ plots within 30 meters of each other were sampled in the same habitat type to account for microhabitat variation (the two plots are considered a "double plot" and are average to equal one plot for all analysis) . Each plot was thoroughly searched for snails by two people. Habitat searched within each plot included: leaf litter, under leaf litter, on vegetation, under rocks, on and under downed wood, tree crevices, and moss (Figure 9). Timed searches were not used due to the wide range in ground cover in each plot. Plots with greater ground cover were more time intensive to search than plot with little to no

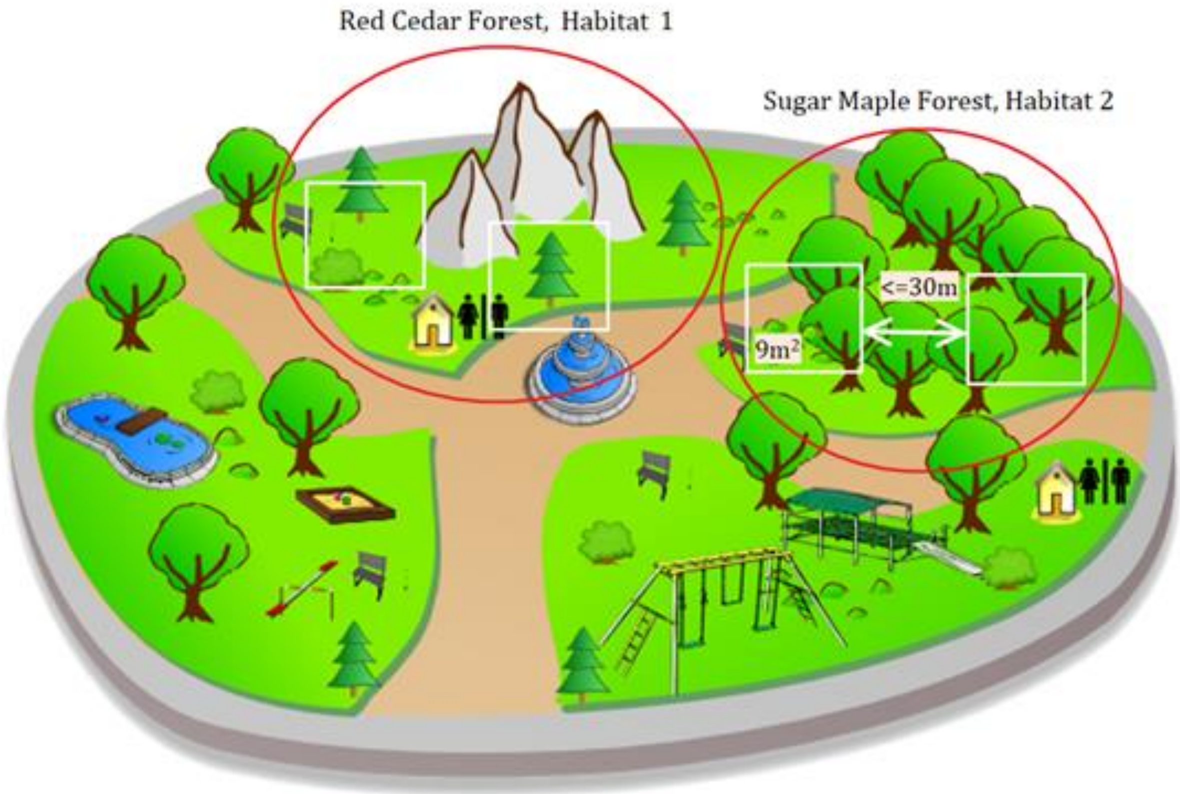

Figure 8: Example illustration of a park. Red circles indicate the different types of habitat in a park. White squares represent plots visually and soil sampled within each habitat

Figure 9: A 3 x 3 meter plot outlined in yellow tape at Cane Ridge Park in Nashville, TN

ground cover. On average, each search lasted 30 minutes, but plots with dense (>12 inches) leaf litter or heavy ground cover lasted an hour or more. Every living snail and relatively whole shells encountered were placed into a plastic vial and labeled with the park's name and plot number. When possible (i.e., species identity was obvious), living snails were identified in the field and released.

To remove soft bodies of live snails for identification, vials were filled with tap water and left overnight, boiled for one minute, and extracted with forceps. Shells were then placed in a 3% hydrogen peroxide solution for 24 hours to clean both the inside and the outside of the shell and rinsed with water. No apparent dissolution or abrasion of the shell occurred from this process.

Soil and Litter Collection and Processing

After the visual survey of a plot, one half liter of soil and detritus was collected to a depth of three cm in multiple locations throughout the plot. Each bag was labeled and stored at room temperature until processed for micro-snails.

Traditional soil processing involves allowing the soil to dry for a 2-4 week period and then sorted using multiple soil sieves. All collected soil must then be visually searched under magnification for micro-snails. This process can be tedious and time consuming. A new method of processing the soil was used, which expedited the process with no loss of precision (personal comm., Sumrall, 2015).

Soil was emptied into a container where rocks, twigs, leaves, and other large matter was removed. Soil was then placed into flexible plastic mesh screen with openings of 0.5 mm (Figure 10). This size was chosen because the smallest known terrestrial snail is 0.7 mm; most researchers agree that a 0.6 mm sieve will catch all adult snails (Fontaine et al., 2007; Tattersfield, 1998 Vermeulen et al., 2015). Bags were secured with zip ties and repeatedly dunked in a 3% hydrogen peroxide solution to remove soil matter that was less than

Figure 10: Plastic mesh bag used for washing in hydrogen peroxide.

0.5 mm. The bags were then thoroughly rinsed with tap water until the water coming out of the bag ran clear. Bags were placed in a sunny window where they were dried for 2-3 days. This process significantly reduces the amount of soil matter and therefore the amount of time it takes to sort through the remaining soil. Once dry, the soil was carefully examined under a stereo microscope or using a head-mounted optical magnifier. All snails were removed and placed into a labelled vial for later identification.

Snail Identification

Nearly all specimens (95.5%) were identified to species based on morphological features according to Burch (1962), Dourson (2010), Pearce & Hotopp (2013), Pilsbry (1940, 1946, 1948). In addition, some difficult specimens were identified by consultation with snail taxonomists, Amy and Wayne Van Devender, Ron Caldwell, Tim Pierce, Daniel Douglas, and Franciso Borreo. Those remaining were identified to genus or not identified (juveniles and broken shells).

Habitat Data Collection

Abiotic and biotic factors known to influence land snails were recorded or collected at each plot. These factors included percent of invasive plant species and coarse woody debris (CWD) in a plot, leaf litter depth, tree species present, and soil samples to be tested for pH and calcium (Ca). Before each plot was searched, dominant vegetation within the plot was identified and calculated into a percentage of area covered by invasive plant species. CWD, which includes rotting wood or bark was visually estimated in each plot. Leaf litter depth was measured in three locations within the plot. A composite soil sample was taken from each plot and stored in a sealed plastic bag at 4° Celsius. Those samples were later analyzed by the Soil, Plant, and Pest Center at the University of Tennessee, Nashville TN, to determine pH, calcium, magnesium, phosphorus, and potassium content.

Degradation at each site was approximated based on three explanatory variables, based on similar work done by Horsák et al. (2009). These three variables are: human alteration of the habitat, isolation of the park, and percent of invasive species present (Table 1). The three variables are summed together to produce a degradation rank. As an example, Krutch Park is a small downtown park in Knoxville, TN. On the degradation scale it receives a three out of three for human alteration of the habitat, because the entire park has been influenced by humans through heavy landscaping, and little forest. For the second part, isolation of the park, Krutch Park receives a two out of two for being completely surrounded by the city. For percent of invasive species present, Krutch Park receives a three out of three, because in the plots sampled 100% of the plant species were invasive. These three parts add up to give Krutch Park a degradation rank of eight, the highest degradation rank.

Data analysis

Analysis of Variation

To account for variation in number of plots searched in each park, plots were average together to produce species diversity, richness, abundance, and evenness. Shannon-Weiner species diversity and evenness were calculated for every plot and an average species diversity and evenness for the whole park was produced based on number of plots searched. Snail abundance and richness for each plot were also averaged to together to produce one average number for each plot that accounted for variation in plot numbers. Differences in species diversity, richness, abundance, and evenness among park types in each city and among park types irrespective of city were tested using a factorial analysis of variance (ANOVA), (PROC MMAOV; Saxton, 1998) in SAS ver. 9.3 (SAS Insitute, Cary, NC). Fisher's least significant difference (LSD) mean separation at the 5% significance level was used to compare means.

Table 1: Habitat degradation scale; park rank based on sum total of the three parts: (A) Human alteration of the habitat (B) Isolation of park (C) Average percent of invasive plant species. Modified from Horsák et al. (2009).

A.	**HUMAN ALTERATION OF THE HABITAT**
0	mostly natural habitats, no landscaping, 90%> of land is forested
1	naturalized habitats modified by humans, with little management; may include tarmac, some open space, and minimal landscaping (invasive plant removal, herbicide use); 70% > is forested
2	managed green space, used for human recreation; light to moderate landscaping (use of chemical inputs and non-native planting), mowed open spaces, paved trails, and moderate forested areas (<40%)
3	heavily disturbed sites; mostly mowed open space, little or no forested area, heavy landscaping (chemical input, and non-native planting)
B.	**Isolation of park**
0	fully connected with surrounding non-built up habitat
1	partially connected with surrounding habitats
2	totally connected with buildings and tarmac
C.	**Average percent invasive vegetation**
0	no invasive vegetation present in sample area
1	<20% of vegetation is invasive in sample area
2	50% of vegetation is invasive in sample area
3	100% of vegetation is invasive in sample area

Regression Models

Variable selection (PROC REG; Saxton, 1998), performed in SAS, was used to determine the best regression model for species diversity, richness, abundance, and evenness for all three cities combined and separately. Model variables were chosen from: acreage, calcium, CWD, degradation, distance, litter, and pH. Best fits were chosen based on the R-square, Akaike's information criterion (AIC), and Mallow's Cp in the following conditions: AIC measures the fit of the model, but penalizes for the number of parameters. Models within two AIC of each other are considered nearly equally good. All models chosen were within two AIC of the lowest AIC of all the models. Mallow's Cp measures the fit and prediction, the standard error, and bias and the precision of the model. The best Cp is lower than how many variables are in the model, plus one (Saxton, 2015).

Regressions were run in SAS (PROC REG; Saxton, 1998) based on the variable selection. Final variables in the regression models are different than what was chosen in variable selection due to collinearity and low significance (P. 0.05) of some variables. All simple linear regressions were first run as a 4^{th} degree polynomial and simplified based on the P-values for each degree.

Indicator species analysis

An indicator species analysis was performed using PC ORD 6.19 to detect if certain species are associated with different park types, and could, therefore, be used as an indicator of that park type (McCune and Medford, 2006; Dufrene and Legendre, 1997). A proportional abundance for every species in each park type relative to the abundance of that species in all park types was calculated. Then, the proportional frequency (how reliably a species will be present in a park type), of every species found in a park type was calculated. The two proportions are then multiplied together to yield the indicator value (IV), which ranges from zero (no indication), to 100 (perfect indication). A Monte Carlo test was run with 4,999 randomizations to calculate the significance of each species as an indicator for a park type.

Nonmetric multidimensional scaling

Nonmetric multidimensional scaling (NMDS) was performed using PC ORD 6.19 to obtain a graphical representation of snail community relationships among park types (Kruskal, 1964). NMS is an ordination method used for non-normal data common in ecological data sets. It is an iterative search that finds the best position of *n* entities on *k* dimensions, with the lowest stress of the *k*-dimensional configuration. Low stress for ecological community data is considered to be less than 15, while stress values approaching 20 are of concern (McCune, 2002). Bray-Curtis dissimilarity was used for running the NMDS with 250 iterations. This analysis was conducted on all parks types using park data, on nature parks and downtown parks to determine if homogenization is occurring, and on degradation ranks using plot data. Degradation ranks were rounded to the nearest whole number to create degradation ranks 1-9.

CHAPTER 3
RESULTS

Descriptive Statistics

Snail sampling recovered 12,153 individual snails, representing 20 families, 43 genera, and 95 species (Table 2). Species found at each plot and the plots coordinates can be found in Appendix Table 1. Seven new state and 87 new county occurrences were recorded for Davidson, Knox, Hamilton, and Marion counties. I also found five non-native and one extra-limital (native to US but located outside its native range) invasive, four of which are new Tennessee state records.

The most abundant snail family encountered was Zonitidae, which accounts for 64% of all snails found in this study, followed by Polygyridae with 20% (Figure 11). *Ventridens* was the most abundant genus found in all three cities accounting for almost half of all indiviuals at 46.3% (Figure 12). *Ventridens demissus,* representing 21% of all snails, followed by *Ventridens ligera* which accounted for 15% of all snails were the two most abundant snails species recovered (Figure 13). *Ventridens demissus* and *V. ligera* were both found in all three cities. *Ventridens demissus* had not previously been reported from Knox or Hamilton county, and *V. ligera* represents a county record for Knox county.

Synanthropic snail species (species adapted to urban habitats, McKinney, 2002) were found in all parks with an inverse species richness and snail abundance relationship to increasingly urbanized park types. Nature parks had 22% synanthropic individuals collected. District parks had 38% synanthropic individuals. Community and neighborhood parks each contained 48% synanthropic individuals, where downtown parks had 59% synanthropic individuals.

Table 2: Snail species collected in Nashville (Davidson county), Knoxville (Knox county), and Chattanooga (Hamilton & Marion county) Tennessee in city parks in 2015. Species with an asterisk are non-native or extra-limital invasive. Species with a cross (†) are synanthropic. Numbers and species in red are county and state records respectively according to Hubricht. DA=Davidson, KN=Knox, HA=Hamilton, MA=Marion.

Family	**Species**	**DA**	**KN**	**HA**	**MA**	**Total**
Carychiidae	*Carychium exile* (I. Lea, 1842)	12	10	70		92
Cionellidae	*Cochlicopa lubrichella** † (Porro, 1838)	3	25	4		32
Discidae	*Anguispira alternata* † (Say, 1816)	179		22	1	202
	Anguispira strongylodes (Pfeiffer, 1854)				1	1
	Discus patulus (Deshayes, 1830)		5	48	7	60
	Discus whitneyi † (Newcomb, 1864)		1			1
Gastrodontidae	*Gastrodonta interna* (Say, 1822)			181	59	240
Haplotrematidae	*Haplotrema concavum* (Say, 1821)	41	41	55	48	185
Helicarionidae	*Euconulus chersinus* (Say, 1821)	6	19			25
	Euconulus trochulus (Reinhardt, 1883)	9		6		15
Helicidae	*Cepaea nemoralis** † (Linnaeus, 1758)			5		5
Helicinidae	*Oligyra orbiculata* (Say, 1818)	149		3		152
Helicodiscidae	*Helicodiscus parallelus* † (Say, 1817)	6	14	12		32
	Heliodiscus notius (Hubricht, 1962)	19	14	13		46
Orthalicidae	*Rabdotus dealbatus* (Say, 1821)	26				26
Oxychilidae	*Oxychilus cellarius** † (Muller, 1774)		26			26
Polygyridae	*Euchemotrema fraternum* (Say, 1824)	1				1
	Euchemotrema leai † (A. Binney, 1841)	32				32
	Inflectarius inflectus † (Say, 1821)	201	58	189	6	454
	Inflectarius rugeli † (Shuttleworth, 1852)	43	96	1		140
	Mesodon clausus † (Say, 18210	2		3		5

Table 2. (Continued)						
Family	**Species**	**DA**	**KN**	**HA**	**MA**	**Total**
	Mesodon elevatus (Say, 1821)		9			9
	Mesodon normalis (Pilsbry, 1900)			5		5
	Mesodon thyroidus (Say, 1816)	59	8	27		94
	Mesodon zaletus (A. Binney, 1837)	33	5	1	1	40
	Millerelix plicata (Say, 1821)			7		7
	Millerelix troostiana (I. Lea, 1839)	118				118
	Neohelix albolabris (Say, 1817)				1	1
	Patera appressa † (Say, 1821)	45	161	12		218
	Patera perigrapta (Pilsbry, 1894)				7	7
	*Polygyra cereolus** † (Muhlfeld, 1816)	2	1			3
	Stenotrema barbatum (G.H. Clapp, 1904_	1		6		7
	Stenotrema calvescens (Hubricht, 1961)		1			1
	Stenotrema hirsutum (Say, 1817)	3			4	7
	Stenotrema spinosum (Lea, 1830)		6			6
	Stenotrema stenotrema † (Pfeiffer, 1842)	63	135	87	14	299
	Stenotrema stenotrema nudum (Rafinesque, 1815)	1				1
	Triodopsis alabamensis (Pilsbry, 1902)			3		3
	Triodopsis complanata (Pilsbry, 1898)		26		5	31
	Triodopsis hopetonensis † (Shuttleworth, 1852)	281	489	67		837
	Triodopsis tridentata † (Say, 1816)			24	4	28
	Triodopsis vulgata (Pilsbry, 1940)	30		25		55
	Xolotrema denotatum (Ferussac, 1821)			3		3
	Xolotrema obstrictum (Say, 1821)	20				20

Table 2. (Continued)						
Family	**Species**	**DA**	**KN**	**HA**	**MA**	**Total**
Pomatiopsidae	*Pomatiopsis lapidaria* (Say, 1817)	2		16		18
Punctidae	*Paralaoma servilis** † (Shuttleworth, 1852)	5				5
	Punctum minutissimum (I. Lea, 1841)			4		4
	Punctum vitreum (H.B. Baker, 1930)		6			6
Pupillidae	*Columella simplex* (Gould, 1840)	1	4			5
	Gastrocopta armifera † (Say, 1821)	130	24	29		183
	Gastrocopta contracta † (Say, 1822)	46	58	13	2	119
	Gastrocopta corticaria (Say, 1816)	3	1			4
	Gastrocopta pentadon (Say, 1822)	15	5	9		29
	Gastrocopta procera (Gould, 1840)	1	8	1		10
	Gastrocopta tappaniana (C.B. Adams, 1842)	4	5	15		24
	Pupoides albilabris † (C.B. Adams, 1841)	39	9	18		66
	Vertigo gouldii (A. Binney, 1843)		1			1
	Vertigo milium (Gould, 1840)	2				2
	Vertigo tridentata (Wolf, 1870)	3				3
Strobilopsidae	*Strobilops aeneus* (Pilsbry, 1926)	3	2	1		6
	Strobilops labyrinthicus (Say, 1817)	78	19	2		99
Subulinidae	*Opeas pyrgula** † (Schmacker & Boettger, 1891)	40	13	27		80
Succineidae	*Catinella oklahomarum* (Webb, 1953)	4				4
	Catinella vermeta (Say, 1829)	6	1			7
	Novisuccinea ovalis (Say, 1817)	23		6		29
	Oxyloma retusum (I. Lea, 1834)	4				4
Valloniidae	*Vallonia excentrica* † (Sterki, 1893)		3	1		4

Table 2. (Continued)						
Family	**Species**	**DA**	**KN**	**HA**	**MA**	**Total**
	Vallonia pulchella † (Muller, 1774)	28	3			31
Zonitidae	*Glyphyalinia caroliniensis* (Cockerell, 1890)			71		71
	Glyphyalinia cryptomphala (G.H. Clapp, 1915)	59			10	69
	Glyphyalinia indentata † (Say, 1823)	103	248	435	37	823
	Glyphyalinia praecox (H. B. Baker, 1930)				14	14
	Glyphyalinia solida (H.B. Baker, 1930)	222		33	57	312
	Glyphyalnia wheatleyi (Bland, 1883)	17	6	4		27
	Hawaiia minuscula † (A. Binney, 1841)	82	27	20		130
	Lucilla scintilla † (R. T. Lowe, 1852)	6		16	1	23
	Lucilla singleyanus † (Pilsbry, 1889)		5			5
	Mesomphix capnodes (W.G. Binney, 1857)	11				11
	Mesomphix cupreus (Rafinesque, 1831)	3				3
	Mesomphix perlaevis (Pilsbry, 1900)			2	23	25
	Mesomphix vulgatus (H.B. Baker, 1933)	162		55		217
	Paravitrea capsella (Gould, 1851)	2		16		18
	Paravitrea lamellidens (Pilsbry, 1898)				1	1
	Paravitrea petrophila (Bland, 1883)		6			6
	Striatura meridionalis (Pilsbry & Feriss, 1906)	6	7	5	1	19
	Ventridens acerra (J. Lewis, 1870)	11	59	10		80
	Ventridens collisella (Pilsbry, 1896)		52			52
	Ventridens demissus † (A. Binney, 1843)	961	893	732		2596
	Ventridens intertextus (A. Binney, 1841)		1	99	11	101
	Ventridens lasmadon (Phillips, 1841)		33			33

Table 2. (Continued)						
Family	**Species**	**DA**	**KN**	**HA**	**MA**	**Total**
	Ventridens lawae (W.G. Binney, 1892)	8			139	147
	Ventridens ligera † (Say, 1821)	113	1163	577		1853
	Ventridens percallosus † (Pilsbry, 1898)	654				654
	Ventridens pilsbryi (Hubricht, 1964)	3	48	36	32	119
	Zonitoides arboreus (Say, 1816)	136	125	126	43	450
Total		4,381	3,985	3,528	529	12,154

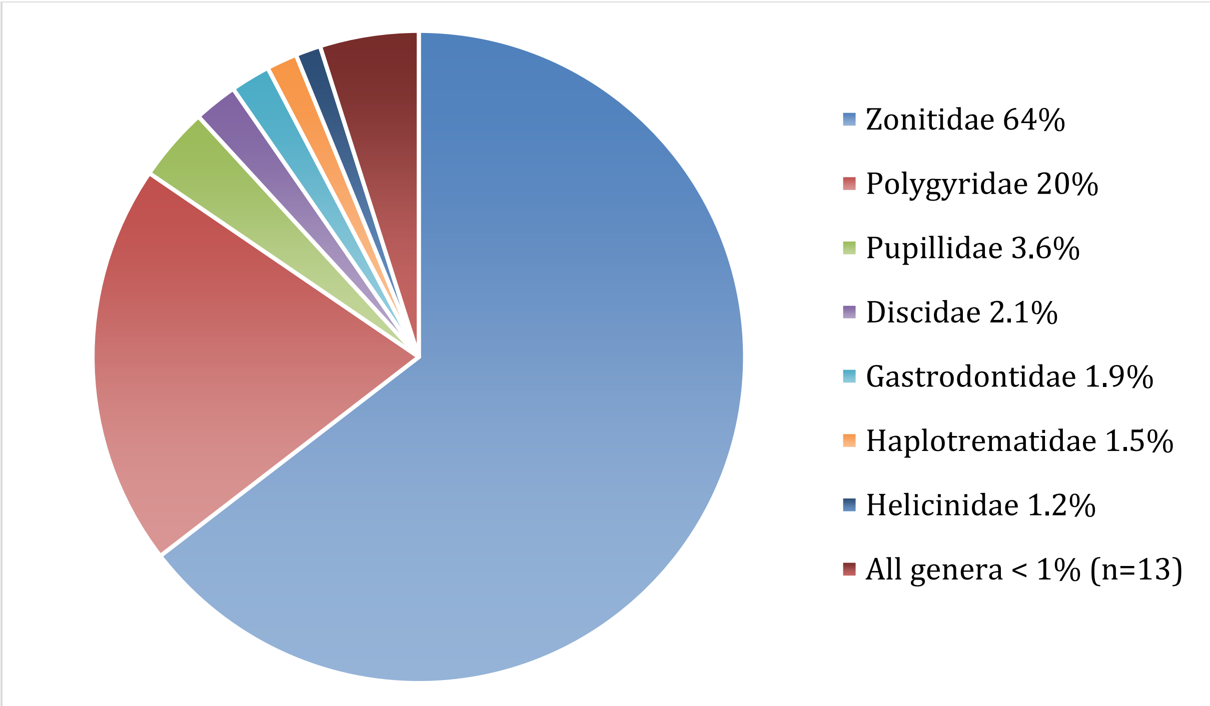

Figure 11: Most encountered snail families from parks in Nashville, Knoxville, and Chattanooga TN in 2015. Over three times more individuals in the Zonitidae family were found than Polygyridae, which is thought to be the most commonly encountered family in North America (Perez et al., 2014).

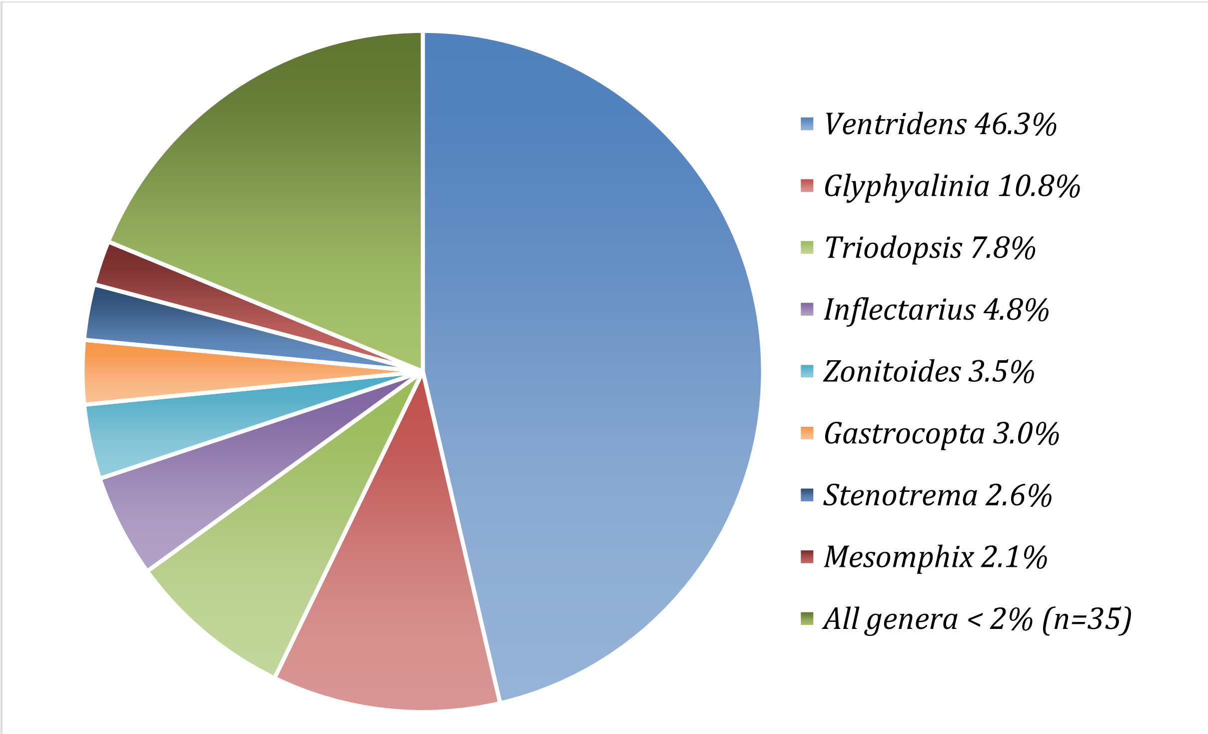

Figure 12: Most encountered snail genera from parks in Nashville, Knoxville, and Chattanooga TN in 2015. The genus *Ventridens* and *Glyphyalinia* account for over half of all collected individuals.

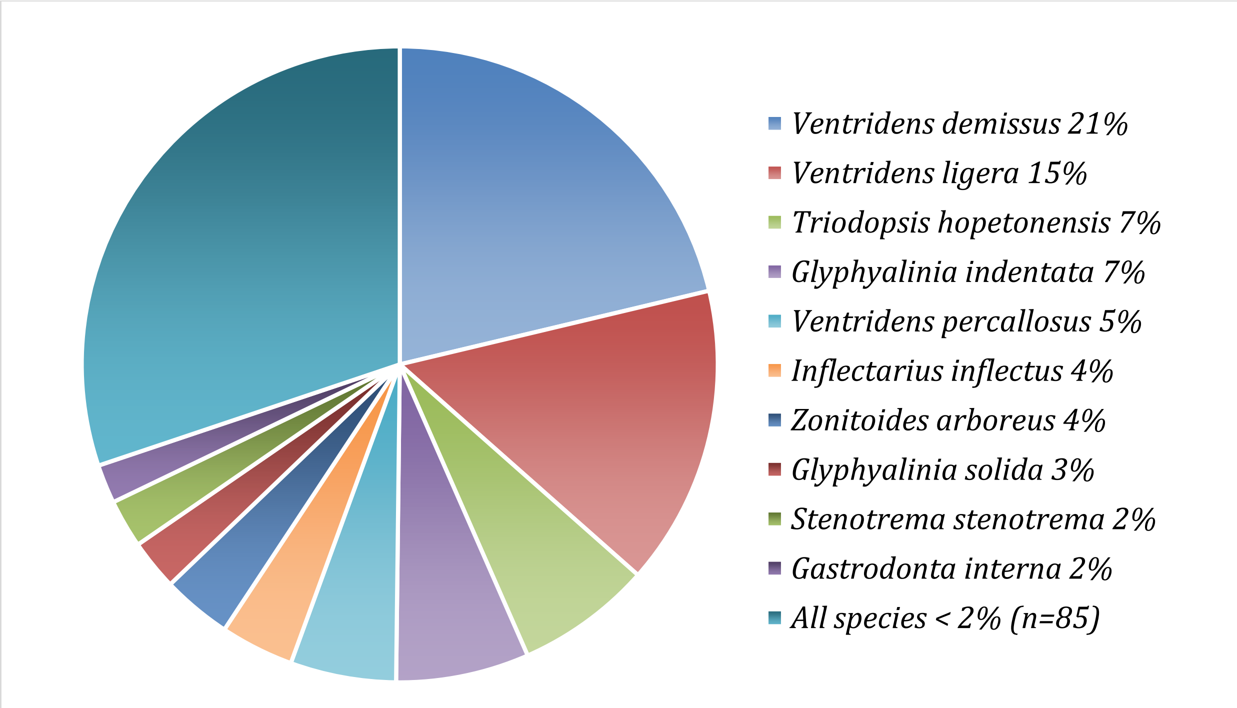

Figure 13: Most abundant snail species collected from parks in Nashville, Knoxville, and Chattanooga TN in 2015. Two *Ventridens* species account for 36% of all individuals.

Analysis of Snail Communities across Park Types and Cities

Cities did not differ in species diversity as measured by using a factorial ANOVA ($P > 0.05$). However, significant differences were observed in Shannon-Weiner diversity among park types ($P= 0.0001$, $F_{4,49} = 9.77$, Figure 14). Nature Parks (M= 1.41, SE±= 0.11) had the highest mean species diversity and were not different from district parks (M= 1.33, SE±= 0.11). Downtown parks (M= 0.71, SE±= 0.11), had the lowest mean species diversity and were not different from community parks (M= 0.81, SE±= 0.11) or neighborhood parks (M= 0.79, SE±= 0.07).

Cities did not differ in species richness ($P > 0.05$), but differences were observed in species richness among park types ($P = 0.0005$, $F_{4,49} = 5.96$, Figure 15). District parks had the highest mean species richness (M= 7.8, SE±= 0.66) and were not different from nature parks (M= 7.03, SE±= 0.66). Mean species richness in community, neighborhood, and downtown parks were not different (M= 5.11, 4.58, and 3.94, SE±= 0.66, 0.49, 0.66 respectively). Community parks, neighborhood parks and downtown parks had similar mean Shannon species evenness (M= 0.52, 0.55, 0.54, SE±= 0.04, 0.03, 0.04 respectively, $P= 0.0028$, $F_{4,49} = 4.68$ Figure X). Nature parks and district parks had greater mean species evenness (M= 0.72, 0.67, SE±= 0.04 respectively, Figure 16).

Snail abundance was greatest in district parks (M= 78.44, SE= 14.18, $P = 0.028$, $F_{4,49} = 2.98$, Figure 17) but this was not different from nature, community, or downtown parks (M= 63.66, 73.22, 65.88, SE= 14.18, 14.18, 10.02 respectively). While neighborhood parks exhibited the lowest snail abundance (M= 37.33, SE±= 10.02), these were not different from community parks.

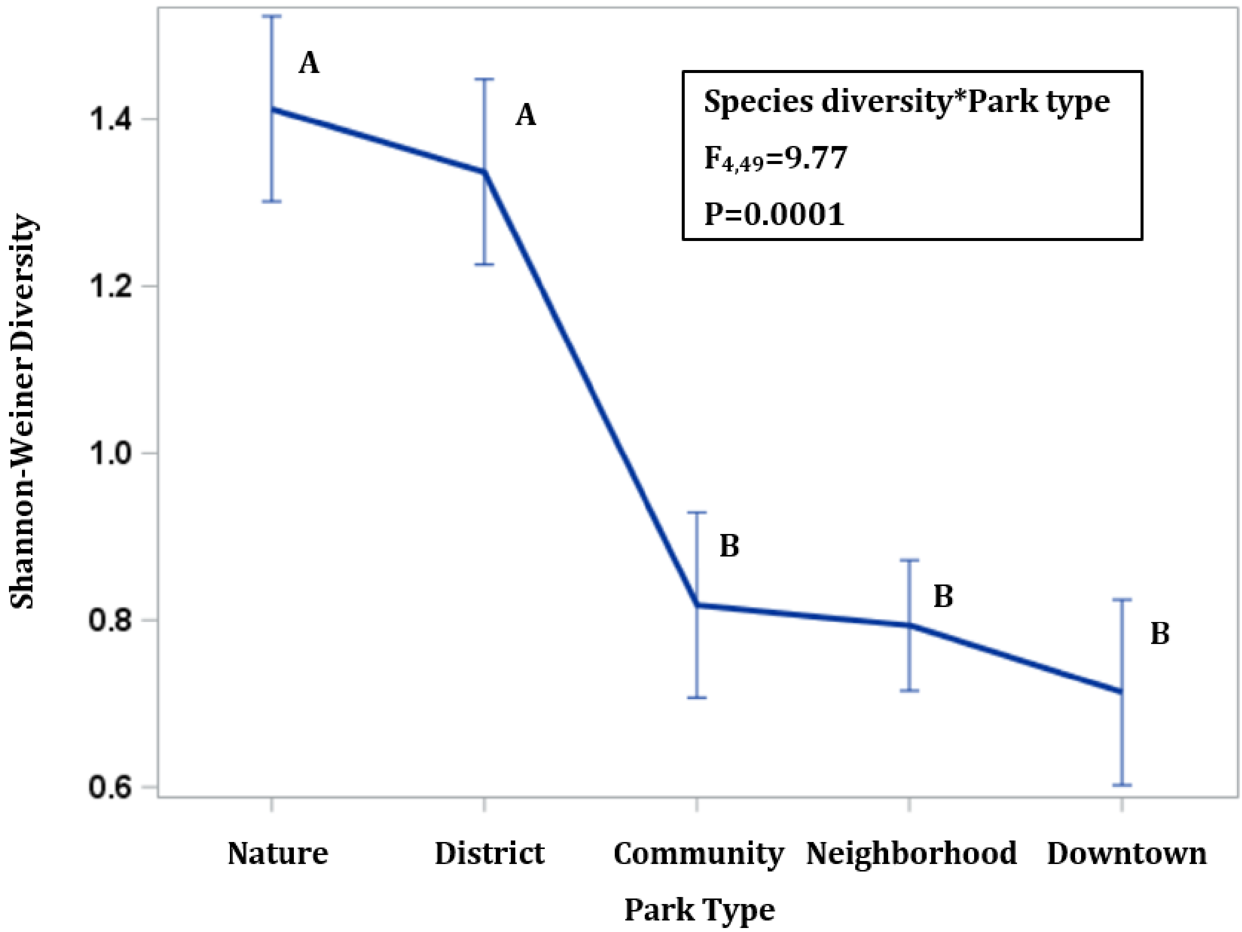

Figure 14: Mean species diversity ± SE among park type. Average species diversity for each park was summed and averaged with standard error for each park type in SAS v. 9.3 with ANOVA and Fisher's LSD for mean separation at the 5% significance level; P= 0.0001, N= 54

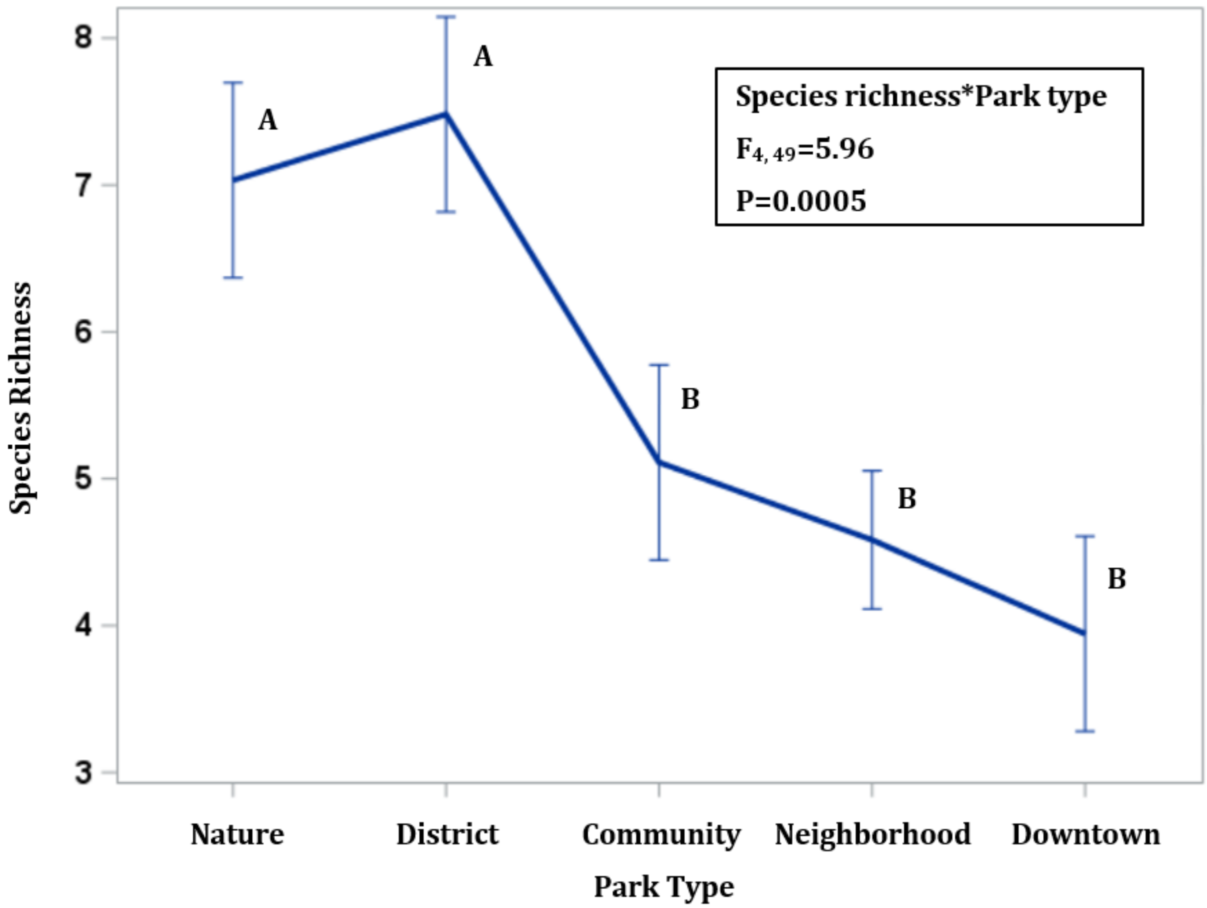

Figure 15: Mean species richness ± SE among park type. Average species richness for each park was summed and averaged with standard error for each park type in SAS v. 9.3 with ANOVA and Fisher's LSD for mean separation at the 5% significance level; $P<0.0001$, N= 54

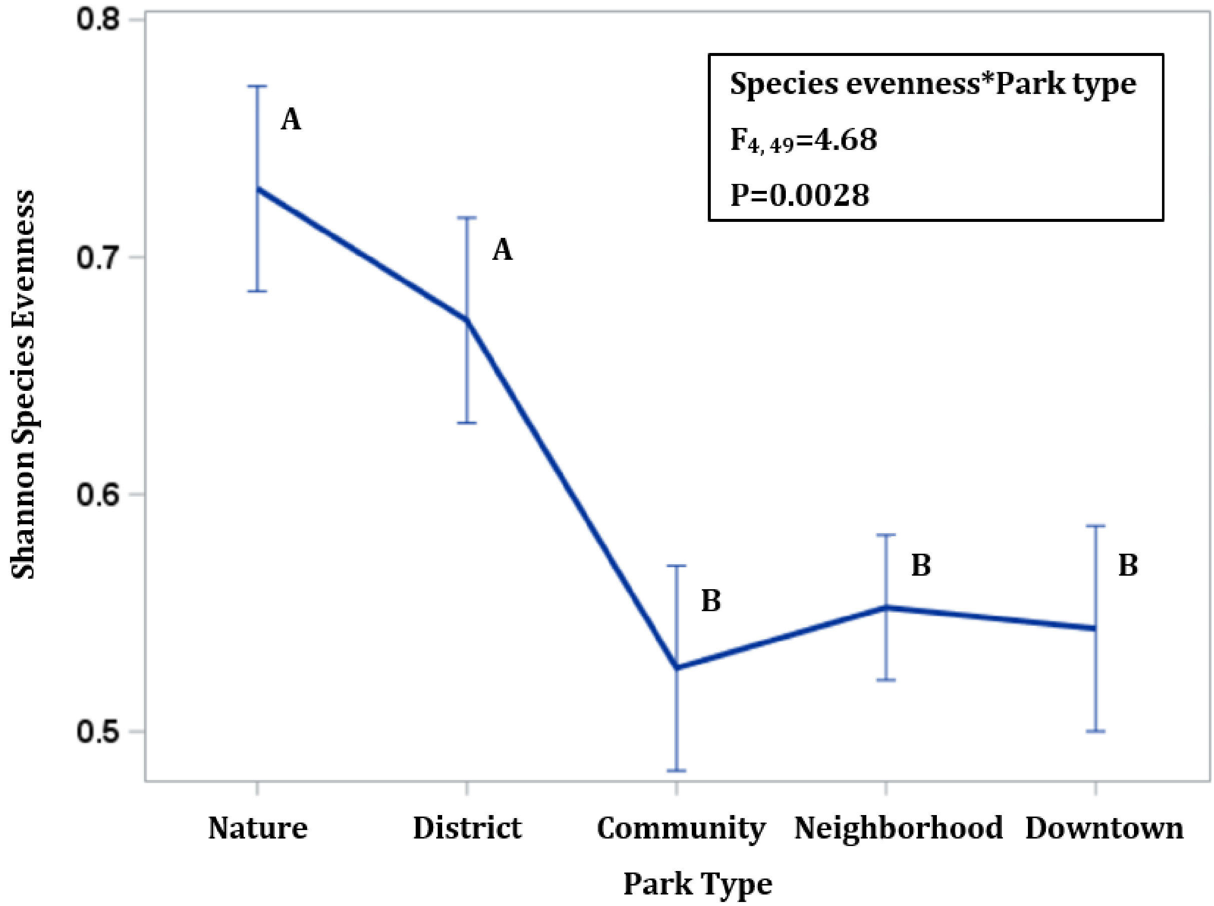

Figure 16: Mean Shannon species evenness ± SE of parks. Average species evenness for every park were summed and averaged with standard error for each park type in SAS v. 9.3 with ANOVA and Fisher's LSD for mean separation at the 5% significance level; P= 0.0028, N= 54

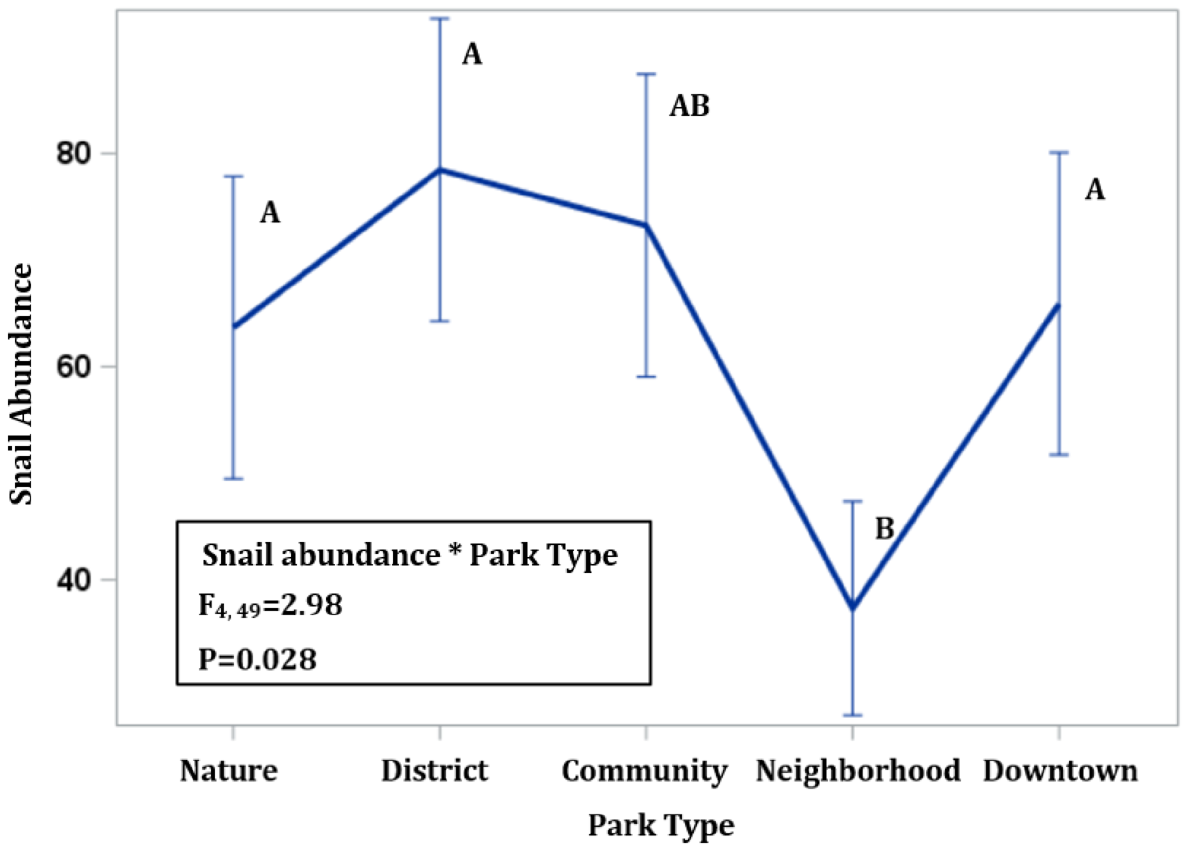

Figure 17: Mean snail abundance ± SE of parks. Average snail abundance for every park were summed and averaged with standard error for each park type in SAS v. 9.3 with ANOVA and Fisher's LSD for mean separation at the 5% significance level; P<0.0001, N= 54

Abiotic and Biotic Factors Influencing Snail Communities

Degradation rank was the most common predictor variable chosen across all sixteen categories, with eight models selecting with degradation as the most important model variable (Table 3). Park acreage was also influential; it was found to be the most important factor in five models. Calcium was a common secondary factor in seven models, while CWD and distance were secondary factors in six models. Litter and pH were the least important variables, only appearing secondarily in four and three models respectively.

A multiple regression model of species diversity in all parks indicated degradation, distance, and CWD as the most influential variables (partial R-square= 0.17, 0.08, 0.08 respectively, P= 0.0001, Table 4). In a multiple regression model of Nashville and a simple linear model for Knoxville park species diversity, distance was influential (partial R-square= 0.37, P<0.002 and R-square= 0.18, P=0.071, respectively). Nashville park species diversity was also strongly influenced by acreage (partial R-square= 0.28, P<0.002). CWD and degradation were each related to Chattanooga park species diversity (Partial R-square= 0.42 and 0.39 respectively, P=0.0001).

The best fit multiple regression model of species richness in all parks indicated CWD, calcium, degradation, and distance as significant factors (partial R-square= 0.14, 0.11, 0.08, 0.07, respectively, P<0.0001, Table 5). Nashville parks species richness was related to distance in a simple linear model (R-square= 0.27, P=0.027). Chattanooga parks species richness was most influenced by CWD in a simple linear model (R-square= 0.59, P= 0.0002). No significant correlations were found for Knoxville parks species richness.

Table 3: Variable selection results for determine the most important variable(s) influencing snail species diversity, richness, abundance, and evenness. Diversity, richness, abundance, and evenness were averaged together for every park in each city and analyzed using SAS v. 9.3 variable selection for best R-square.

Category	**R-square**	**Selected variables**
Species diversity		
All parks	0.50	Degradation, distance, litter, Ca, CWD
Nashville	0.59	Acreage, distance, CWD
Knoxville	0.31	Acreage, degradation, distance
Chattanooga	0.74	Degradation, litter, CWD
Species richness		
All parks	0.38	Degradation, distance, Ca, CWD
Nashville	0.43	Acreage, distance, CWD
Knoxville	0.30	Acreage, degradation, distance, Ca
Chattanooga	0.59	CWD
Snail abundance		
All	0.07	pH, Ca
Nashville	0.11	Degradation, pH
Knoxville	0.37	Acreage, Ca
Chattanooga	0.53	Degradation, litter, pH, Ca
Species evenness		
All	0.31	Degradation
Nashville	0.23	Degradation
Knoxville	0.38	Litter, Ca
Chattanooga	0.70	Degradation, distance, Ca

Table 4: Best regression models for species diversity and all cities together and separately by park. Variables chosen by variable selection. MR=multiple regression, SLR=simple linear regression. SAS v. 9.3

Category	Model	Variables	Pr>|t|	Partial R-square	R-square	Pr>f
All parks	MR	Degradation	0.002	0.17	0.45	<0.0001
		Distance	0.031	0.08		
		CWD	0.031	0.08		
Nashville	MR	Distance	0.009	0.37	0.54	0.002
		Acreage	0.027	0.28		
Knoxville	SLR	Distance	0.030		0.18	0.071
Chattanooga	MR	CWD	0.004	0.42	0.69	0.0001
		Degradation	0.007	0.39		

Table 5: Best regression models for species richness and all cities together and separately by park. Variables chosen by variable selection. MR=multiple regression, SLR=simple linear regression, LOG=log transformation. SAS v. 9.3

Category	Model	Variables	Pr>|t|	Partial R-square	R-square	Pr>f
All parks	MR	CWD	0.005	0.14	0.38	<0.0001
		Ca	0.017	0.11		
		Degradation	0.049	0.08		
		Distance	0.041	0.07		
Nashville	SLR	Distance	0.027		0.27	0.027
Chattanooga	SLR	CWD	0.0002		0.59	0.0002

The best fit multiple regression model of species evenness in all parks indicated degradation as the most influential variable in a simple linear model (R-square= 0.31, P= 0.0001, Table 6). While Chattanooga and Nashville parks species evenness was best fit to a simple linear model with degradation (partial R-square= 0.57, 0.23, P= 0.0003, 0.040, respectively), Knoxville parks species evenness fit best to a simple linear model with calcium (R-square= 0.27, P<0.026).

Table 6: Best regression models for species evenness and all cities together and separately by park. Variables chosen by variable selection. SLR=simple linear regression, MR=multiple regression, PR=polynomial regression. SAS v. 9.3.

Category	**Model**	**Variables**	**R-square**	**Pr>f**
All	SLR	Degradation	0.31	<0.0001
Nashville	SLR	Degradation	0.23	0.040
Knoxville	SLR	Ca	0.27	0.026
Chattanooga	SLR	Degradation	0.57	0.0003

A simple linear regression, with all parks, comparing degradation to species diversity, richness, evenness, and abundance, found all but abundance to significantly related. Species diversity and evenness were found to be most influenced by degradation (R-square = 0.35, 02.31, P=0.0001, <0.0001, respectively, Table 7). Species richness was also related to degradation but to a lesser extent (R-square= 0.13, P=0.005)

Table 7: Simple linear regression models of all parks for degradation and three snail community metrics. SLR= simple linear regression. SAS v. 9.3.

Category	**Model**	**Community metric**	**r-square**	**pr>f**
All parks	SLR	Species diversity	0.35	0.0001
All parks	SLR	Species richness	0.14	0.005
All parks	SLR	Species evenness	0.31	<0.0001

Indicator Species Analysis for Park Type

Out of 95 species, only seven snails were weakly associated, but significant indicator species for nature, district, and downtown parks for all cities. For downtown parks, *Triodopsis hopetonensis*, the non-native *Opeas pyrgula* and extra-limital invasive *Polygyra cereolus* were indicators (IV= 39.1, 23.5, 22.2 respectively, P=0.0056, 0.0360, 0.0064, respectively, Table 8). In district parks, *Ventridens demissus* and *V. percallosus* were indicators (IV= 31.9, 20.4, P=0.04, 0.03, respectively). For nature parks, *Mesodon zaletus* and *Patera perigrapta* were weak indicators (IV=16.6, 14.7, P=0.03, 0.04, respectively).

When the indicator species analysis was conducted on each city separately, similar and additional indicator species were found. In Nashville, *Inflectarius inflectus* was moderately indicative of nature parks (IV= 67.5, P=0.05, Table 9). Nashville district parks included *Ventridens percallosus* as previously identified, though this was a stronger association and *Stenotrema stenotrema* was also found to be a moderate indicator (IV= 90.4, 59.2, P=0.008, 0.04, respectively). In Nashville downtown parks, *Zonitoides arboreus* was a strong indicator species (IV= 85.9, P=0.006).

When Knoxville was analyzed separately, *Inflectarius rugeli* and *Stenotrema stenotrema* were shown to be strong indicator species of nature parks (IV= 100, 88.8, P= 0.005, 0.012, respectively, Table 10). The only other significant indicator in Knoxville was *Opeas pyrgula* a non-native species, with a moderate association to Knoxville neighborhood parks (IV= 66.7, P= 0.01).

In Chattanooga, *Zonitoides arboreus*, a Nashville downtown park indicator, was strongly associated with nature parks, along with *Gastrodonta interna* (IV= 78.8, 99.2, P= 0.04, 0.005, respectively Table 11). District parks in Chattanooga were associated with *Gastrocopta pentadon* and *Helicodiscus parallelus* (IV= 58.3, 90.9, P= 0.03, 0.009, respectively). While a third species of *Ventridens, V. ligera*, was strongly associated with Chattanooga community parks (IV= 89.1, P= 0.001).

Table 8: Indicator species for all park types in Nashville, Knoxville, and Chattanooga. Species with an asterisk are non-native or extra-limital invasive.

Species	Indicator value± SD	P-value
All nature parks		
Mesodon zaletus	16.6±4.27	0.0396
Patera perigrapta	14.7±3.59	0.0460
All district parks		
Ventridens demissus	31.9±5.44	0.0406
Ventridens percallosus	20.4±4.67	0.0314
All downtown parks		
Triodopsis hopetonensis	39.1±5.63	0.0056
Polygyra cereolus *	23.5±5.42	0.0360
*Opeas pyrgula**	22.2±3.03	0.0064

Table 9: Indicator species for all park types in Nashville

Species	Indicator value± SD	P-value
Nashville nature parks		
Inflectarius inflectus	67.5±15.45	0.050
Nashville district parks		
Ventridens percallosus	90.4±17.30	0.0082
Stenotrema stenotrema	59.2±13.55	0.0484
Nashville downtown parks		
Zonitoides arboreus	85.9±18.08	0.0064

Table 10: Indicator species for all park types in Knoxville. Species with an asterisk are non-native

Species	Indicator value± SD	P-value
Knoxville nature parks		
Inflectarius rugeli	100.0±15.30	0.005
Stenotrema stenotrema	88.8±16.05	0.012
Knoxville neighborhood parks		
*Opeas pyrgula**	66.7±15.80	0.0192

Table 11: Indicator species for all park types in Chattanooga. Species with an asterisk are non-native or extra-limital invasive.

Species	Indicator value± SD	P-value
Chattanooga nature parks		
Zonitoides arboreus	78.8±15.21	0.0418
Gastrodonta interna	99.2±15.78	0.0056
Chattanooga district parks		
Gastrocopta pentadon	58.3±14.84	0.0326
Helicodiscus parallelus	90.9±15.38	0.009
Chattanooga community parks		
Ventridens ligera	89.1±17.93	0.0018

Indicator Species Analysis with Invasive Ground Cover

An Indicator species analysis was also conducted based on invasive plant cover for all parks in all cities. No strong associations were found, although many species were weakly, though significantly indicative of various amount of invasive species cover. The greatest association was between *Zonitoides arboreus* and no invasive species (IV= 36.1, P= 0.04, Table 12). Other species indicative of no invasive species were *Gastrodonta interna*, *Ventridens lawae, Patera perigrapta, Discus patulus, Ventridens pilsbryi, Triodopsis tridentate,* and *Glyphyalinia caroliniensis* (IV= 30.5, 22.6, 19.2, 17.6, 15.9, 11.5, 11.5, P= 0.0002, 0.001, 0.003, 0.01, 0.03, 0.04, 0.04, respectively).

Indicator species for invasive species rank 1, <20% invasive cover, were *Strobilops aeneus, Oligyra orbiculata,* and *Mesomphix vulgatus* (IV= 18.5, 17.8, 15.3, P= 0.004, 0.01, 0.03, respectively). Indicator species for invasive species rank 2, ~50% invasive cover, included a non-native species, *Cochlicopa lubrichella*, which had the greatest indicator value after *Z. arboreus* (IV= 31.6, P= 0.0002). Two other indicator species were identified in this category *Vallonia pulchella, Gastrocopta corticaria* (IV= 15.5, 9.5, P= 0.02, 0.04, respectively). Finally, invasive species rank 3, 100% invasive cover, included *Gastrocopta contracta, Hawaiia minuscula,* and *Columella simplex* (IV= 28.2, 22.0, 9.7, P= 0.01, 0.04, 0.04, respectively).

Synanthropic species analysis

Synanthropic snail species accounted for a greater percentage of species in increasingly urbanized parks. Nature parks have the lowest percentage of synanthropic species with downtown parks exhibiting 3 times that figure (22%, 67 % synanthropic species respectively, Table 13). District parks, community parks and neighborhood parks were each 10-20% different in percentage of synanthropic snail species. Nature parks also have fewer synanthropic snail individuals as a measure of total abundance (34%). District and downtown parks contained similar amounts of synanthropic individuals (84%, 81% respectively), while neighborhood and community parks contained 10% more snyanthropic individuals (92%, 95%, respectively).

Table 12: Indicator species for invasive vegetation coverage. 0= no invasive vegetation, 1= <20% invasive vegetation, 2= 50% invasive vegetation, 3= 100% invasive vegetation. Species with an asterisk is non-native

Species	**Indicator Value ± SD**	**P-value**
Invasive plant rank 0		
Zonitoides arboreus	36.1±5.80	0.0472
Gastrodonta interna	30.5±3.81	0.0002
Ventridens lawae	22.6±3.05	0.0014
Patera perigrapta	19.2±2.76	0.0032
Discus patulus	17.6±3.61	0.0164
Ventridens pilsbryi	15.9±3.52	0.0350
Triodopsis tridentata	11.5±2.56	0.0408
Glyphyalinia caroliniensis	11.5±2.5	0.0442
Invasive plant rank 1		
Strobilops aeneus	18.5±2.71	0.0040
Oligyra orbiculata	17.8±3.43	0.0140
Mesomphix vulgatus	15.3±3.25	0.0328
Invasive plant rank 2		
*Cochlicopa lubrichella**	31.6±3.69	0.0002
Vallonia pulchella	15.5±3.20	0.0252
Gastrocopta corticaria	9.5±2.16	0.0416
Invasive plant rank 3		
Gastrocopta contracta	28.2±4.12	0.0148
Hawaiia minuscula	22.0±3.66	0.0462
Columella simplex	9.7±2.63	0.0476

Table 13: Percent of synanthropic (Synan.) snails found in five park type in all cities as a function of total species or total abundance.

Park type	Community metric	Synan. (%)
Nature	Abundance	34%
	Species	22%
District	Abundance	84%
	Species	38%
Community	Abundance	95%
	Species	48%
Neighborhood	Abundance	92%
	Species	59%
Downtown	Abundance	81%
	Species	67%

Nonmetric Multidimensional Scaling Ordination

The NMDS ordination across all 54 parks indicated various differences in species composition across the five parks types (stress=16.49, Figure 18). The strongest degree of separation of snail communities can be seen with nature parks, which are completely separate from community, neighborhood, and downtown parks. Nature parks have a small overlap with district parks. District parks overlap with all other parks types, but have significant seperation from community, neighborhood, and dowtown parks. Downtown parks are almost completely contained within neighborhood parks, suggesting little difference in snail communities between those park types.

TDifferences in snail communities across degradation rank vary in terms of separation (stress=18.08, Figure 19). Degradation rank zero, two, and three are grouped closely together, indicating that species are being separated based on their lack of tolerance for degradation. One side of degradation rank seven also overlaps with zero, two, and three, indicating some shared species among the ranks. Degradation rank four overlaps with almost every other rank, barely missing rank zero. All other ranks overlap and show no significant community patterns.

The NMDS ordination for the nine nature and nine downtown parks shows that downtown parks are closer together in dimensional space than nature parks across all three cities (stress=12.01, Figure 20). This indicates that species composition in downtown parks is very similar across cities, meaning that some degree of homogenization is occuring. Nature parks do not show any overlap in species composition with each other, or with downtown parks, indicating that homegenization is not yet occuring in nature parks, and that snail communities found in nature parks are very different than species found in downtown parks.

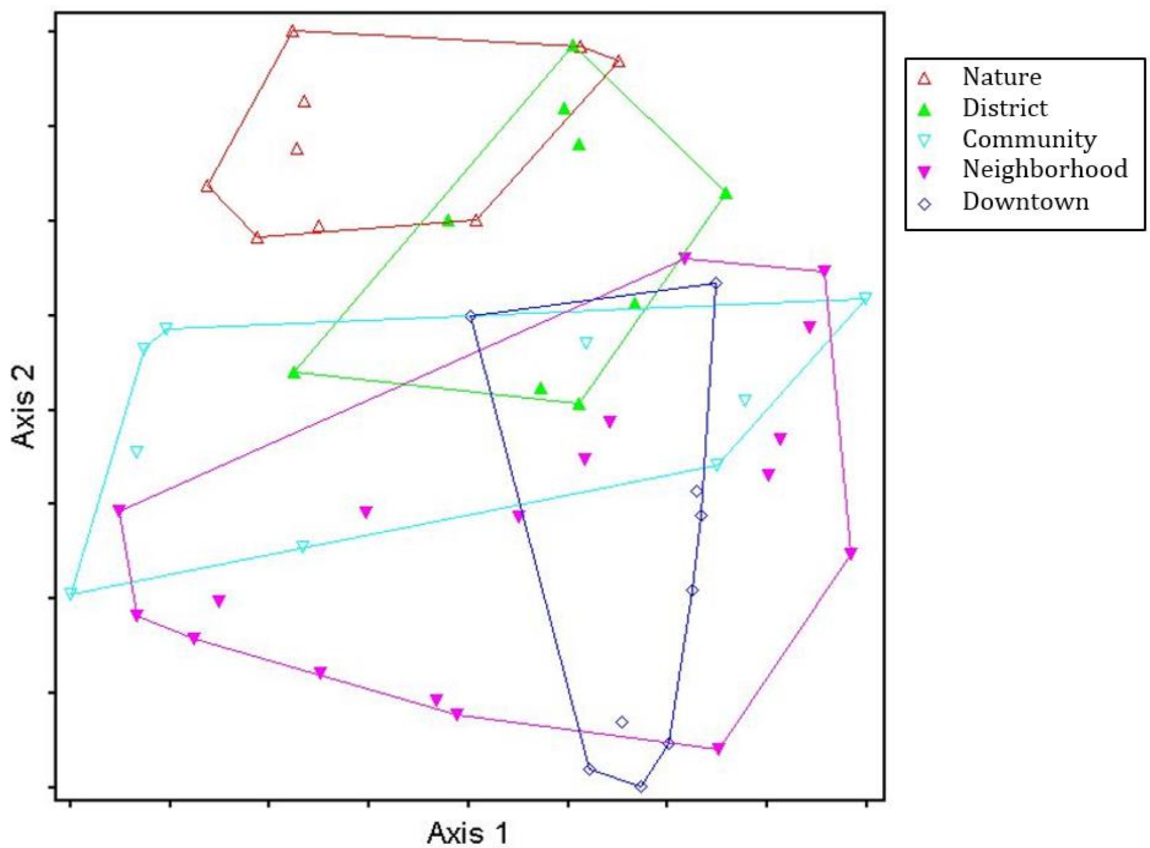

Figure 11: NMDS ordination of proportional abundance of land snail species separated by park types using the Bray-Curtis similarity index. Each symbol is one park.

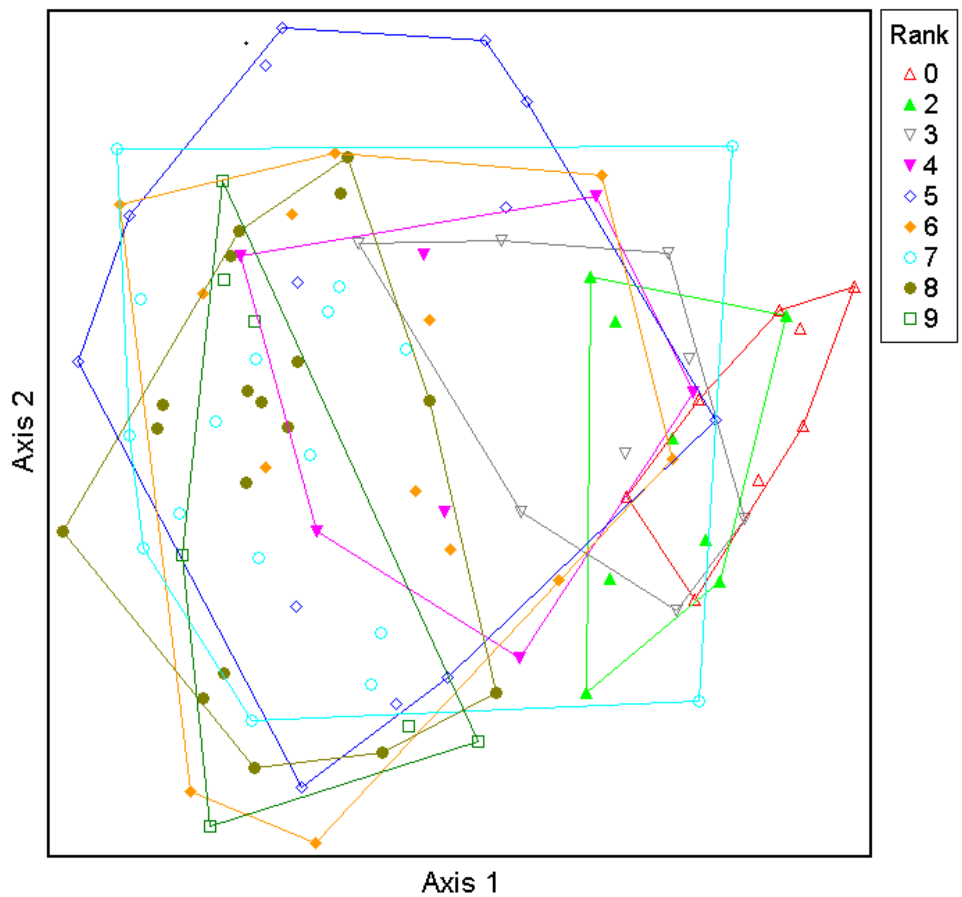

Figure 12: NMDS ordination of proportional abundance of land snails separated by degradation rank using the Bray-Curtis similarity index. Each shape represents a single park; 0=lowest degradation, 9=highest degradation.

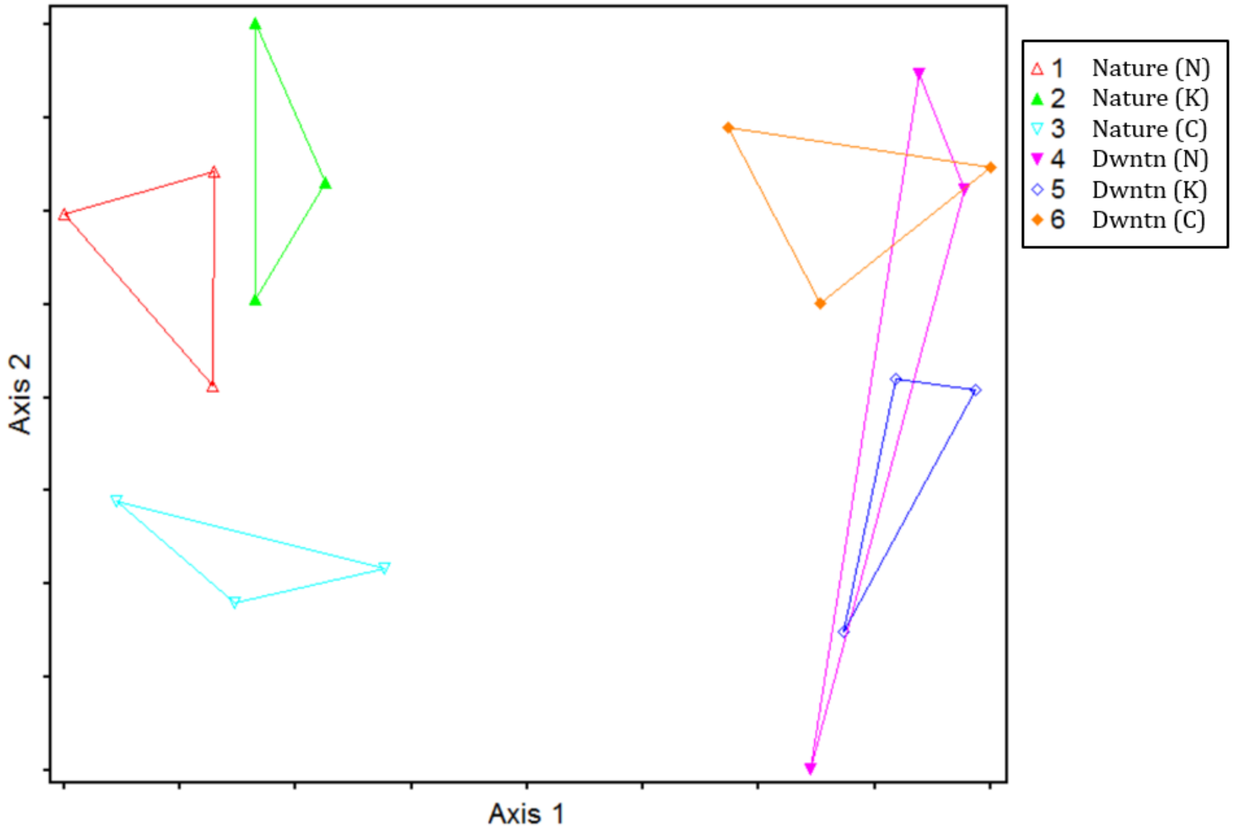

Figure 13. NMDS ordination of proportional abundance of land snail species separated by nature and downtown parks (dwntn) in each city (Nashville=N, Knoxville=K, Chattanooga=C) using the Bray-Curtis similarity index. Each symbol is one park.

CHAPTER 4
DISCUSSION

Overview

This study finds that urbanization is affecting land snail community composition across cities in Tennessee. Snail communities among five park types in three cities in Tennessee were compared in 2015. Several abiotic and biotic factors were measured to explain the variation in snail communities in these parks. Parks are segregated into categories that account for the size of the park (acreage) and the amount of anthropic disturbance (degradation). Park type correlated with acreage (spearman correlation= 0.87) and degradation rank (spearman correlation= 0.76). Increasing acreage was also correlated with decreased degradation (spearman correlation= 0.80). These two factors were the most commonly identified in variable selection models as correlated to snail community metrics (Table 3), and are considered to be the strongest influences on snail communities in this study. Additional factors measured to explain snail community metrics in a given plot included: soil pH, soil calcium, coarse woody debris present, the depth of leaf litter, distance to city center, and percentage of invasive species.

Nearly two thirds of all snails collected are within the Zonitidae family, the True Glass Snails (Figure 12), which have a nearly global distribution. Their small to medium, nearly transparent shell from which their common name is derived, has a simple lip with no teeth, although adults of some genera may have lamellae (teeth are thought to be a potential defense mechanism). Nearly half of all snails collected were within the genus *Ventridens* in the Zonitidae family (Figure 11). The most common species, making up 21% of all collected specimens, was *Ventridens demissus,* with *V. ligera* making up 15%, and *V. percallosus* comprising 5% (Figure 13). All three of these snails are known to inhabit urban and degraded areas. Another genus within the family, *Glyphyalinia*, made up 10.8% of collections. The most common Glyphyalinias were *G. indentata*, which made up 7% of the total and *G. solida,* comprising 3%. There is little to no information as to what makes this family so successful in the urban environment. One possibility is the close relationship between Zonitidae and various slug families. Most phylogenies place Zonitidae as being closely related to several of the slug families (Burch, 1962; Barker, 2001; Wade et al., 2001), which are typically found in greater proportion than land snails in urban environments (Dedov & Penev, 2004, 2004).

Among the snail community indices measured, Shannon-Weiner species diversity was the most clearly divergent among park types. Nature and district parks had nearly twice the diversity of community, neighborhood and downtown parks (Figure 14). After adjusting for sampling effort, species richness and species evenness were also found to be highly related to park type. For species richness, between 30 and 50% more species were found in nature and district parks compared to community, neighborhood and downtown parks (Figure 15). The evenness of snail species in these parks can also be explained by park type. On average, nature and district parks exhibited between 23 and 38 % greater species evenness than community, neighborhood, and downtown parks (Figure 16). It is apparent that increasing size of a park and the amount of degradation has a strong influence on snail communities. In particular, degradation of these parks explained over 30% of snail species diversity and evenness (Table 7). Nature and district parks contain more woody plants and mature forested landscapes, which benefit from limited disturbance, since human interaction in this landscape is limited compared to much smaller park parcels, with greater surrounding human populations.

The only community metric that did not align within this trend was mean snail abundance. No clear trend was evident and only neighborhood parks offered fewer individual snails per plot, an average of 37. All other park types, including downtown parks, had between 63 and 78 snails per 9 m^2 on average. One explanation for higher abundance in downtown parks is higher primary productivity. This is a result of fertilization, mulching, and irrigation that occurs with extensive plantscaping typically seen in downtown parks. Indeed, there is emerging evidence that anthropogenic food subsidies increase abundance of several opportunistic (Oro et al., 2013). Neighborhood parks are divergent in their habit availability for land snails, in that they are generally less maintained than downtown parks, with little incidence of irrigation, plant maintenance, or upkeep aside from lawn mowing. The full space of neighborhood parks is utilized daily for people and their companion pets, with disturbance occurring constantly and consistently. Neighborhood parks differ dramatically from the larger park types, which contain increasingly greater patches of mature forested area and larger tracts of land that see less human disturbance. Although the species diversity, evenness, and richness are similar for community, neighborhood, and downtown parks, neighborhood parks have almost half the abundance of other park type. This may be due to a lack of refugia (neighborhood parks typically have little to no landscaping, and consist mostly of lawn), leading to decreased reproduction and limited dispersal opportunities from the highly urbanized surrounding environment.

While these trends apply to all snails, clear differences are apparent in terms synanthropic snail types present at each park type. Synanthropic snails comprised increasingly greater percentages of abundance and species present in more urbanized parks (Figure 13). Only 22% of snail species and 34% of individuals were classified as synanthropic in nature parks, where more than 90% of all snails found in community and neighborhood parks were synanthropic species. The lower percentage of synanthropic snails in downtown parks is mainly due to the relatively high abundance, and surprising appearances of *Rabdotus dealbatus* and *Triodopsis alabamensi. Rabdotus dealbatus* belongs to a family of snails typically only found in South and Central America, but reaches the extent of its range near the Tennessee- Kentucky border (*R. dealbatus* is a threatened species in KY) (Dourson, 2010). It is a calciphile that prefers meadow like habitat, which may be mimicked in the open, grassy, downtown parks (Dourson, 2010). *Triodopsis alabamensis* is typically found in pine-oak forests, but 50 individuals were in one downtown Chattanooga park (Coney et al, 1982; Hubricht, 1985). These and the several other traditionally anthropophobic snail species found in heavily urbanized areas seem to have a higher tolerance for the degraded and fragmented habitat found in city parks.

Indicator species were also described based on likelihood of presence in each park type. No species were good indicators of percentage of invasive plants, but there were several species that were nearly perfect indicators of park type by city. Of the three downtown park indicator species, *Polygyra cereolus* is an extra-limital invasive, and *Opeas pyrgula,* is non-native (Table 8). Nearly a quarter of all downtown parks are expected to contain these species. *Triodopsis hopetonensis* was even more prevalent, and is likely to be found in nearly 40% of all downtown parks in these three cities. Within downtown areas in Knoxville, the non-native *Opeas pyrgula*, is likely to found in two thirds of parks (Table 9). No non-native snail species were statistically indicative of other park types. It is expected that the nursery plants that dominate downtown park foliage introduce these species, which would otherwise have limited dispersal due to their low mobility (Bergey et al., 2012). These snails may thrive in a relatively hostile environment where mulching and irrigation prevent desiccation and provide a more constant temperature. Linkage between invasive plant ground cover and non-native species was only found for one species, *Cochlicopa lubrichella*, which appears to be an indicator where about 50% invasive species ground cover areas (Table 12).

Confoundingly, *Zonitoides arboreus* is both a strong indicator for downtown Nashville parks (IV= 85.9±18.08), and for Chattanooga nature parks (78.8±15.21). It is also a weak, but significant indicator for no invasive plant species (36.1±5.80). This is likely due to its status as one of the most common snails in North America. The implications for this species as a true indicator are not likely, as these results are not biologically useful.

Comparison to Similar Studies

This study found that local variables (calcium, pH, leaf litter depth, and CWD) were not major factors in urban land snail communities. This is the opposite of what is seen in previous studies, where snails were found to be highly dependent on microhabitat conditions (Boycott, 1934; Burch 1955; Beyer & Saari, 1977). Of the local variables, CWD was the most important, especially for species richness and diversity (Tables 4, 5). This is not surprising as CWD is known to provide important refugia to land snails, as well as harbor uncommon species. According to Caldwell (1993), up to 25% of southeastern land snails depend on CWD. On average, downtown parks only had CWD covering 0.003% of the plot, compared to neighborhood parks which had 16% or nature parks which had 23% CWD coverage. Leaving CWD in downtown parks could provide habitat for land snails, as well as other invertebrates.

The landscape variable, degradation is the major factor found to influence land snails in urban environments for this study (Tables 4, 5, 6). Increasing degradation was significantly correlated with decreased species diversity, richness, and evenness. Horsak et al., (2008) also found a decline in species richness with increased degradation. Degradation, for this study, includes many general landscape factors like amount of forest, lawn care, invasive plant species presence, and landscaping. Degradation in actuality is a very broad term, while in this study it was defined to have very specific components. It is possible that unmeasured local variables associated with degradation could be significant drivers of snail communities.

In a study analyzing land snail communities in old-growth and second-growth forests in Kentucky, Douglas et al., (2013) found that disturbance from human land use can alter land snail communities for decades. Their research was not able to determine which variables were most influencing snail communities, but also came to the conclusion that the traditional variables most associated with land snails were not the strongest influences. In addition, Douglas found that 14 out of 18 snails identified as indicator species for old growth forests were micro-snails, strengthening the argument that micro-snails do best in an undisturbed environment.

One study, similar in design and goals, analyzed spiders in Californian urban gardens (Otashi et al., 2015). Researchers found that several local factors influenced spider richness and activity density, the trend that has been typically associated with snails. These factors included mulch cover, flowering plant species, and amounts of bare soil. They found the agricultural habitat within 500m and 1 km was positively correlated with spider activity density. This demonstrates that impacts associated with urbanization can affect taxonomic groups in different ways.

This study found that the homogenization of snail communities is occurring in downtown parks, which are located nearest the city center. While this conclusion is based on a small sample size, results are very strong compared to the degree of community separation seen in nature parks. In a comprehensive review of homogenization in urban areas, McKinney (2006) found urbanization to be one of largest contributors to the homogenization of species. One overarching reason thought to explain homogenization is that cities are traditionally built to optimally serve human beings (McKinney, 2006). This results in cities being built similarly across the world, which therefore provides habitat suited primarily for synanthropic species (Savard et al., 2000). The introduction of non-native species into urban habitats was proven to be one of the causes of biotic homogenization in snail communities in central Europe (Horsák et al. 2013). This study found that non-native species had no observable effects on snail community homogenization. This was concluded by running the NMDS without the non-native species and seeing no differences among park groupings. It must then be concluded that homogenization in this study was more a result of the large abundance and consistent presence of synanthropic species.

Introduction of Non-native Species

Humans have proven to be excellent dispersers for low-mobility organisms like land snails (Cowie & Robinson, 2003). Over the decades, snails have been deliberately and accidently introduced through numerous pathways. In one of the most comprehensive studies on how nonindigenous land snails and slugs are being introduced, Cowie and Robinson (2003), outline the known pathways. Pathways for deliberate introductions include the aquarium, food, pet, and medical industry, for biological control, and for aesthetics. Snails are being accidentally introduced via agricultural and horticulture products, including soil, through commercial, domestic, and military shipments, by vehicles, rail, airplanes, boats, and canals, and by the aquarium and aquaculture industry. Their analysis of all the pathways by which nonindigenous are introduced concluded that the horticultural industry constitutes the single biggest pathway (they also disclose that their data is highly biased due to high degree of effort put into intercepting agricultural pests).

Just a few, or even one non-native snail can start a new population with relative ease due to some of their specialized reproductive traits (Baur & Klemm, 1989; Cowie & Robinson, 2003; Örstan, 2011). Most pulmonate land snails and slugs are hermaphrodites, but the majority cross-fertilize when possible (Cowie and Robinson, 2003). However, a single individual within a species that does not need to cross-fertilize is capable of establishing a population outside its natural range (Cowie and Robinson, 2003). In addition, pulmonates are capable of storing sperm for long periods of time, more than a year with some species (Baminger & Haase, 1999), meaning even self-fertilizing pulmonates could establish non-native populations.

Researchers have identified four other traits that facilitate colonization of non-native snails: their ability to climb allows them to avoid the hot ground, and attach themselves to moving objects (to disperse); aestivation seals the aperture with dry mucus to prevent dessicaiton; hibernation, which allows the snail to survive harsh winters; the very small size of eggs and newly hatches juveniles can also aid in the dispersal of snails, as they are more likely to be missed in inspections (Aubry et al., 2006; Stojnić et al., 2011; Peltanová et al., 2012)

Non-native Species in this Study

The European land snail, *Cepaea nemoralis* (Family Helicidae), was first recorded in North America in 1857 in New Jersey, U.S.A. (Gould & Binney 1870). Since then it has been introduced deliberately and accidently and has been recorded from several sites in the U.S. and Canada, indicating that *C. nemoralis* is slowly dispersing across North America (La Rocque, 1962; Reed, 1964; Dundee, 1974; Forsyth, 1999). The characteristic bright colors and stripes of *C. nemoralis* (Figure 20) have led many people, including malacologists and biologists to introduce this snail to North America (Whiston, 2005). The railroad industry is thought to be a major vessel for unintentional dispersal and habitat, including transporting snails on rail cars, transporting railroad material like limestone and rails that make ideal *C. nemoralis* habitat, and providing habitat in the crushed limestone that is often used near along railroads (Örstan, 2010). Cars have also be identified as a dispersal method for *C. nemoralis* (Örstan, Sparks, & Pearce, 2011; Dundee, 1974). Fortunately for the agricultural industry, *C. nemoralis* prefers dead plant material and had not had any known impacts on crops. The main concern for this species is its potential to displace native species (Whitson, 2005). *Cepaea. nemoralis* has been recorded once before in Knoxville, Tennessee in 1918 (Barber, 1918). The population found in Chattanooga, TN was located in a small garden park near a university campus. The population seems to be established, as several life stages of the snail were found.

Paralaoma servilis (Family Punctidae) is a native micro-snail of New Zealand. The lack of information about this species is due to its constantly changing taxonomic history. It has been described under different names at least four different times, making it difficult to pinpoint exact introductions (Christensen, 2012). Records do indicate that *P. servilis* is globally invasive with records of populations in Hawaii, California, Europe, Africa, South America, and Australia (Roth, 1985; Wronski & Hausdorf, 2010; Christensen, 2012; Van den Neucker & Ronsman, 2015). Available records indicate that this snail has only been found in western U.S., indicating that this is most certainly a new species record for Tennessee. No life history or ecology about this species could be found, which is especially troublesome as one malacologist stated anecdotally that it was the second New Zealand snail on its way too conquering the world (Örstan, 2008).

Cochlicopa lubricella (Family Cionellidae) is a small, conical snail introduced from Europe. It can be found in high numbers on lawns and around driveways. Its current known distribution in North America ranges from Canada, south to Kentucky, and west to South Dakota (Hotopp et al., 2013). *Cochlicopa lubricella* can be easily confused with *Cochlicopa lubrica*, also a non-native species. The most reliable morphologically difference between the two snails is the width, which is a maximum of 2.5 mm in *C. lubricella* (Hotopp et al., 2013). All *Cochlicopa* snails found in this study had a width less than 2.5 mm. According to a comprehensive document on land snail distribution by Perez and others (2008), *C. lubrica* has previously been described in Tennessee, but available records do not yet list *C. lubricella* in Tennessee.

Figure 14. The invasive wood snail, *Cepaea nemoralis* in three color forms. The characteristic brown lip can be seen in the upper two specimens. These European land snails were found in Chattanooga, TN. (Whitson, 2005)

Oxychilus cellarius (Family Oxychilidae) originates from western Europe, and has spread to have an almost global distribution. It is known from several U.S. states, New Zealand, Canada, Asia, North Africa, and South America (White-McLean, 2011). This species non-native habitat preferences include greenhouses, meadows, gardens, trash piles, and yards (White-McLean, 2011; Hotopp et al., 2013). *Oxychilus cellarius* is one of the few carnivorous snails in North America. It is known to feed on other snails, slugs, and snail eggs, in addition to vegetation (Mason, 1970a; White-McLean, 2011). No negative impacts resulting from *O. cellarius* could be found (likely due to lack of research), but its close relative, *Oxychilus alliarius*, has been found to be highly invasive and predatory, and directly associated with decline of native snail populations where introduced (Cádiz et al., 2013). *Oxychilus cellarius* has been reported in states as close as South Carolina, Kentucky, and Virginia, but as far as records indicate, this snail is a new state record for Tennessee (Dourson, 2010; White-McLean, 2011; Hotopp et al., 2013). In this study, *O. cellarius* was found in colonies of hundreds of individuals at James Agee Park (a park with mostly nursery plants) in Knoxville, TN.

Opeas pyrgula (Family Subulinidae), a tropical and subtropical snail from Asia, has been recorded from the Gulf coast in Texas, up the Atlantic coast up to Pennsylvania. According to NatureServe (explorer.natureserve.org, 2016), *O. pyrgula* has been found in Tennessee previously, but the exact location of this record is unclear. North American habitat for this snail includes railroads, alleys, and developed habitats where it can be found in high numbers (Hotopp et al., 2013). It is thought that they bury themselves deep into the soil to avoid the colder temperatures in its introduced range (Örstan, 2008). *O. pyrgula* is a known greenhouse invader (Dourson, 2010), and one likely method of dispersal is the nursery industry. No information can be found on the impacts of this non-native snail.

Polygyra cereolus is listed as native only to Florida in the U.S, but has extended is range to the northern U.S. and west to Texas (NatureServe, 2016). It can also be found in Mexico, Hawaii, Cuba, and Bermuda (White-McLean, 2011). There are no records that indicate that *P. cereolus* has been found in Tennessee, but it is not surprising as it has been found in all of the surrounding states. Research on non-native snail species found in greenhouses in

Oklahoma found that *P. cereolus* was the most commonly encountered and numerous in greenhouses (Bergey et al., 2014). It has been reported to feed on alfalfa and clover, making it an agricultural pest in some situations (Bergey et al., 2014). *Polygyra cereolus* represents the spread of snails that are commonly transported across state lines with little to no regulation.

Implications and Future Work

Previous work on land snails has often focused on which microhabitat variables most influence land snails. This work has demonstrated that in an urban environment, local variables like Ca, pH, litter depth, and CWD are being outweighed by the effects of urbanization. Degradation was the most consistently and strongly correlated variable causing changes in species diversity, richness, and abundance in land snail communities. This demonstrates the broad reaching consequences and influences of urbanization. CWD was the single local variable that had significant influence on snail communities. CWD is often a place of refuge for snails and can provide invaluable habitat and protection from the harsh conditions of city life. We recommend that city park managers consider leaving (or providing) dead and downed wood in inconspicuous places to provide snail habitat.

The lack of research on not only native and non-native snail species, but snail genera and families prevents researchers from fully understanding the consequences of weedy, native species like *Ventridens demissus* and *Ventridens ligera,* and non-native species like the carnivorous *Oxychilus cellarius*. It is unknown why some species, like *Triodopsis hopetonensis* can be found thriving in colonies of several hundred individuals in a parking lot island, while other species completely disappear from the urban environment. This is a trend seen with other organisms living in the urban environment like raccoons, gray squirrels, and pigeons (Lotze and Anderson, 1979; Riley et al., 1998; Parker and Nilon, 2008). Researchers concluded that one reason these animals were occurring in densities up to 15 times greater in the urban environment, was a lack of predators in cities (McCleery et al., 2008). It is unknown if there is a main predator of *Ventridens*, or if they are preyed up by several organisms. The basic life history and ecology of these snails most be further studied in order to promote ecologically healthy urban environments for land snails.

Land snails are one of the most threatened and understudied organisms in North America (Lydeard et al., 2004). Snails and other organisms are continuously losing habitat to urbanization, leading to major declines in urban biodiversity (Czech et al., 2000; McKinney 2002). Green space that is converted to roads, buildings, and parking lots is often never restored, in fact, it is likely to expand further into previously undeveloped habitat (McKinney, 2002). As of 2014, more than 50% of the global population lives in cities (UNPD, 2014). It is critical, now more than ever, to develop cities sustainably with biodiversity in mind. Having urban green spaces in cities not only benefits wildlife, but has been shown to enhance the emotional capacity and intellect of children (Kellert, 2002; Miller, 2005), and have measurable psychological and physical benefits for adults living in urban areas (Fuller et al., 2007).

REFERENCES

Abbott, R.T. (1989). Compendium of Landshells. American Malacologists, Inc. Melbourne, Florida. 240 pp.

Alig, R. J., Kline, J.D., Lichtenstein, M. (2004) Urbanization on the US landscape: looking ahead in the 21st century. *Landscape and urban planning* **69**(2), 219-234.

Aubrey, S., Labaune, C., Magnin, F., Roche, P., Kiss, L., (2006). Active and passive dispersal of an invading land snailin Mediterranean France. *Journal of Animal Ecology* **75**, 802-813.

Bamminger, H. & Haase, M. (1999). Variation in spermathecal morphology and amount of sperm stored in populations in the simultaneously hermaphroditic land snail *Arianta arbustorum, Journal of Zoology* **249**, 165-171.

Barber, M.D. (1918). *Helix nemoralis* in Knoxville, Tenn. *The Nautilus* **31**, 107.

Barker, G.M. (2001). Chapter 1: Gastropods on Land: Phylogeny, Diversity, and Adaptive Morphology. Pp 1-146 In Barker, G.M. (ed.) *The Biology of Terrestrial Mollusks.* CABI Publishing, New York.

Baur, A., & Baur, B. (1988). Individual movement patterns of the minute land snail *Punctum pygmaeum* (Draparnaud)(Pulmonata: Endodontidae). *Veliger* **30**(4), 372-376.

Baur, B. & Klemm, M. (1989). Absence of isozyme variation in geographically isolated populations of the land snail *Chondrina clienta. Heredity* **63**, 239-244).

Bergey, E.A., Figueroa, L.L., Mather, C.M., Martin, R.J., Ray, E.J., et al. (2013). Trading in snails: plant nurseries as transport hubs for non-native species. *Biological Invasions* **16**, 1441-1451

Berry, F.G. (1973). Patterns of snail distribution at Ham Street Woods National Nature Reserve, East Kent. *Journal of Conchology* **28**, 23–35.

Beyer, W.N. & Saari, D.M. (1977). Effect of tree species on the distribution of slugs. *Journal of Animal Ecology* **46**, 697-702.

Bieler, R. (1992). Gastropod Phylogeny and Systematics. *Annual Review of Ecology and Systematics* **231** (1), 311-338.

Bishop, M.J. (1977). The Mollusca of acid woodland in West Cork and Kerry. *Proceedings of the Royal Irish Academy* **77B**, 227–244.

Boycott, A. E. (1934). The habitats of the land Mollusca of Britain. *Journal of Ecology* **22**, 1-38

Burch, J.B. (1955). Some ecological factors of the soil affecting the distribution and abundance of land snails in eastern Virginia. *The Nautilus* **69**, 62-69.

Burch, J.B. (1962). How to know the eastern land snail. William C. Brown Company Publishers, Dubuque, Iowa.

Burch, J.B., Pearce, T.A. (1990). Chapter 9: Terrestrial gastropods. Pp. 201-309 In Dindal, D.L. (ed.) *Soil Biology Guide*. John Wiley and Sons, New York. 1349 pp.

Cádiz, F.J., Cádiz, D.G., Grau, J.H. (2013). An invasive predatory snail *Oxychilus alliarius* (Miller, 1822) (Stylommatophora: Zonitidae) threatens the native malacofauna of continental Chile: a morphological and molecular confirmation. *Studies on Neotropical Fauna and Environment* **48**(2), 119-124.

Caldwell, R.S. (1993). Biodiversity and coarse woody debris in southern forests. Proceedings of the workshop on coarse woody debris in southern forests: effects on biodiversity. pp. 49-54 In McMinn, J. & Crossley, D.A. (eds.). *Macroinvertebrates and their relationship to coarse woody debris: with special reference to land snails*. Southern Research Station, Athens, GA. 156 pp.

Chiba, S., Okochi, I., Ohbayashi, T., Miura, D., Mori, H., Kimura, K., & Wada, S. (2009). Effects of habitat history and extinction selectivity on species-richness patterns of an island land snail fauna*. Journal of Biogeography* **36**, 1913–1922

Chiba, S. (2010). Invasive non-native species' provision of refugia for endangered native species. *Conservation Biology* **24**, 1141–1147

Chiba, S., Roy, K. (2011). Selectivity of terrestrial gastropod extinctions on an oceanic archipelago and insights into the anthropogenic extinction process. Proceedings of the National Academy of Science, USA 108:9496–9501

Christensen, C.C., Yeung, N.W., Hayes, K.A. (2012). First Records of *Paralaoma servillis* (Shuttleworth, 1852) (Gastropoda: Pulmonata: Punctidae) in the Hawaiian Islands. *Bishop Museum Occasional Papers* **112**, 3-7.

Clergeau, P., Noelie T., Benoit F. (2011) A simplified method for conducting ecological studies of land snail communities in urban landscapes. *Ecological research* **26.3**, 515-521.

Coney, C.C., Tarpley, W.A., Bohannan, R. (1982). Ecological studies of land snails in the Hiawassee River Basin of Tennessee, U.S.A. *Malacological Review* **15**, 69-106

Cowie, R.H. & Robinson, D.G. (2003). Pathways of introduction of nonindigenous land and freshwater snails and slugs. In: Ruiz, G. & Carlton, J.T. (eds*) Invasive species: vectors and management strategies*. Island Press, Washington, D.C. pp 93-122.

Czech, B., Krausman, P.R., Devers, P.K. (2000) Economic Associations among Causes of Species Endangerment in the United States Associations among causes of species endangerment in the United States reflect the integration of economic sectors, supporting the theory and evidence that economic growth proceeds at the competitive exclusion of nonhuman species in the aggregate. *BioScience* **50** (7) , 593-601.

Dallinger, R. (1994). Invertebrate organisms as biological indicators of heavy metal pollution. *Applied Biochemistry and Biotechnology* **48**, 27-31.

Dedov, I. & Penev, L. (2000) Species composition an origins of the terrestrial gastropod commnitites (Gastropoda, Pulmonata) along urban-rural gradients in Sofia City, Bulguria. *Ruthenica* **10**, 121-131.

Dedov, I. & Penev, L. (2004). Spatial variation in terrestrial gastropod communities (Gastropoda, Pulmonata) along urban-rural gradients in Sofia City, Bulgaria. In: Penev L, Niemela¨ J, Kotze J, Chipev N (eds) *Ecology of the city of Sofia. Species and communities in an urban environment*. Pensoft Publishers, Moscow. pp 307–318

Douglas, D.D., Brown, D.R., Pederson, N. (2013). Land snail diversity can reflect degrees of anthropogenic disturbance. ***Ecosphere* 4** (2) 28.

Dourson, D.C. (2010). *Kentucky's Land Snails and Their Ecological Communities*. Goatslug Publications, Bakersville, NC.

Dufrene, M. & Legendre, P. (1997). Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs* **67**, 345-366.

Dundee, D.S. (1974). Catalog of introduced molluscs of eastern North America (North of Mexico). *Sterkiana* **55**, 1-37.

Fontaine, B., Olivier G., & Eike N. (2007). Priority sites for conservation of land snails in Gabon: testing the umbrella species concept. *Diversity and Distributions* **13.6**, 725-734.

Forsyth, R.G. (1999). Distributions of nine new or little-known exotic land snails in British Columbia. *The Canadian Field-Naturalist* **113**, 559-568.

Frest, T.J. & Johannes, E.J. (1995). Interior Columbia Basin mollusk species of special concern.

Frest, T.J. (2002). Native snails: Indicators of Ecosystem Health. In: Wuerthner & Matteson, M. (eds) *Welfare Ranching*. Island Press, Sausalito, California pp. 211-215,

Getz, L.L. & Uetz, G.W. (1994). Species diversity of terrestrial snails in the southern Appalachian Mountains, USA. *Malacological Review* **27**, 61–74.

Gilbert, O.L. (1989). The ecology of urban habitats. Chapman and Hall, London.

Goodfriend G.A., Cameron R.A.D., Cook L.M. (1994). Fossil evidence of recent human impact on the land snail fauna of Madeira. *Journal of Biogeography* **21**, 309–320.

Gould, A.A., Binney, W.G. (1870). Report in the Invertebra of Massachusetts. Wright and Potter, Boston. 524 pp.

Graveland, J. et al. (1994). Poor reproduction in forest passerines from decline of snail abundance on acidified soils. *Nature* **368**, 446-448.

Graveland, J. (1996). Avian eggshell formation in calcium-rich and calcium-poor habitats: importance of snail shells and anthropogenic calcium sources. *Canadian Journal of Zoology* **74**, 1035-1044.

Horsák, M., Juřičková, L., Kintrová, K., & Hájek, O. (2009). Patterns of land snail diversity over a gradient of habitat degradation: a comparison of three Czech cities. *Biodiversity and conservation*, **18**(13), 3453-3466.

Horsák, M., Lososová, Z., Čejka, T., Juřičková, L., & Chytrý, M. (2013). Diversity and biotic homogenization of urban land-snail faunas in relation to habitat types and macroclimate in 32 central European cities. *PloS one*, ***8***(8), e71783.

Hotopp, K.P., Pearce, T.A., Nekola, J.C., Slapcinsky, J., Dourson, D.C., Winslow, M., Kimber G., and Watson, B. (2013). *Land Snails and Slugs of the Mid-Atlantic and Northeastern United States*. Carnegie Museum of Natural History, Pittsburgh, PA, USA.

Hotopp, K.P. (2002). Land snails and soil calcium in central Appalachian Mountain Forest. *Southeastern Naturalist* **1**, 27–44.

Kruskal, J. (1964). Nonmetric multidimensional scaling: a numerical method. *Psychometrika* **29**, 115-129.

Kühn, I., Klotz, S. (2006) Urbanization and homogenization – comparing the floras of urban and rural areas in Germany. *Biology and Conservation* **127**, 292–300.

La Rocque, A. (1962). Checklist of the non-marine Mollusca of Quebec. *Sterkiana* **7**, 23-44.

Locasciulli, O. & Boag, D.A. (1987). Microdistribution of terrestrial snails (Stylommatophora) in forest litter. *The Canadian Field-Naturalist* **101**, 76–81.

Loranger, G., Bandyopadhyaya, I., Razaka, B. & Ponge, J.F. (2001) Does soil acidity explain altitudinal sequences in collembolan communities? *Soil Biology and Biochemistry* **33**, 381–393.

Lydeard, Charles, et al. (2004). The global decline of nonmarine mollusks.*BioScience* **54.4**, 321-330.

Martin, K. & Sommer, M. (2004) Relationships between land snail assemblage patterns and soil properties in temperate humid ecosystems. *Journal of Biogeography* **31**, 531-545.

Mason, C.F. (1970a). Food, feeding rates and assimilation in woodland snails. *Oecologia* **4**(4), 358-373.

Mason, C.F. (1970b). Snail populations, beech litter production, and the role of snails in litter decomposition. *Oecologia* **5**, 215-239.

McCune, B. & Grace, J.B. (2002). Analysis of ecological communities. MjM Software Design, Glenden Beach, Oregon, USA.

McCune, B. & Mefford, M.J. (2011). PC-ORD. Multivariate analysis of ecological data. Version 6.19. MjM Software Design, Glenden Beach, Oregon, USA.

McKinney, M. L. (2002).Urbanization, Biodiversity, and Conservation. The impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems. *BioScience* **52.10**, 883-890.

McKinney, M. L.(2004). Do exotics homogenize or differentiate communities? Roles of sampling and exotic species richness. *Biological Invasions* **6.4**, 495-504.

McKinney, M. L. (2006). Urbanization as a major cause of biotic homogenization. *Biological conservation* **127.3**, 247-260.

McKinney, M. L. (2008). Effects of urbanization on species richness: a review of plants and animals. *Urban ecosystems* **11.2**, 161-176.

Millar, A.J. & Waite, S. (1999) Molluscs in coppice woodland. *Journal of Conchology* **36**, 25–48. Nekola, J.C. & Smith, T.M. (1999) Terrestrial gastropod richness patterns in Wisconsin carbonate cliff communities. *Malacologia* **41**, 253–269.

Natureserve (2016). NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, VA. U.S.A. Available at: http://explorer.natureserve.org/servlet/NatureServe?init=Species

Nekola, J.C. (2005). Geographic variation in richness and shell size of eastern North American land snail communities. *Records of the Western Australian Museum Supplement* **68**, 39-51.

Örstan, A. (2008). Punctidae. *Snail's Tales: snails, slugs, and natural history, evolution, and everything else*. Blogger. Available at: http://snailstales.blogspot.com/2008/05/punctidae.html

Örstan, A. (2010). Gastropoda, Pulmonata, Helicidae, Cepaea nemoralis (Linnaeus, 1758): New records for Montreal, Canada. *Check List* **6**, 54-55.

Örstan, A., Sparks Jr., J.L., Pearce, T.A. (2011). Wayne Grimm's legacy: A 40 year experiment in the dispersal of Cepaea nemoralis in Frederick County, Maryland. *American Malacological Bulletin* **29**, 139-142.

Otashi, M.D., Bichier, P., Philpott, S.M. (2015). Local and landscape correlates of spider activity density and species richness in urban gardens*. Environmental Entomology* **44** (4), 1043-51.

Peltanová, A., Petrusek, A., Kment, P., Juřiĉková, L. (2012). A fast snail's pace: colonization of Central Europe by Mediterranean gastropods. *Biological Invasions* **14**, 759-764.

Perez, K.E., Cordeiro, J.R., Coppolino, M.L. (2008). A guide for terrestrial gastropod identification. In: American Malacological Society Annual Meeting, Carbondale, Illinois.

Perez, E.K., Defreitas, N.,Slapcinsky, J., Russell, L., Minton, F. E., Anderson, Pearce, T.A. (2014). Molecular Phylogeny, Evolution of Shell Shape, and DNA Barcoding in Polygyridae (Gastropoda: Pulmonata), an Endemic North American Clade of Land Snails. *American Malacological Bulletin.* **32**(1), 1-31

Perrins, C. M. (1996). Eggs, egg formation and the timing of breeding. *Ibis* **138**, 2-15.

Pilsbry, H.A. (1940). *Land Mollusca of North America (north of Mexico). Volume I, Part II.* The Academy of Natural Science of Philadelphia. Philadelphia, PA.

Pilsbry, H. A. (1946). *Land Mollusca of North America (north of Mexico). Volume II, Part I.* The Academy of Natural Science of Philadelphia. Philadelphia, PA.

Pilsbry, H.A. (1948). *Land Mollusca of North America (north of Mexico). Volume II, Part II.* The Academy of Natural Sciences of Philadelphia. Philadelphia, PA.

Ponder, W.F. (1994). Australian freshwater Mollusca: Conservation priorities and indicator species. *Records of the Queensland Museum* **36**, 191-196.

Pyšek, P., Bacher, S., Chytrý, M., Jarošík, V., Wild, J. et al. (2010) Contrasting patterns in the invasions of European terrestrial and freshwater habitats by alien plants, insects and vertebrates. *Global Ecology and Biogeography* **19,** 317–331.

Reed, C.F. (1964). *Cepaea nemoralis* (Linn) in eastern North America. *Sterkiana* **16**, 11-18.

Roth, B. (1985). A new species of Punctum (Gastropoda: Pulmonata: Punctidae) from the Klamath Mountains, California, and first Californian records of *Planogyra clappi* (Valloniidae). *Malacological Review* **18**, 51–56.

Roy, D.B., Hill, M.O., Rothery, P. (1999) Effects of urban land cover on the local species pool in Britain. *Ecography* **22**, 507–515.

Savard, J.P.L., Clergeau, P., Mennechez, G. (2000). Biodiversity concepts and urban ecosystems. *Landscape and Urban Planning* **48**, 131–142.

Saxton, A. (2015) Variable Selection. Design and Analysis of Biological Research. University of Tennessee Knoxville. Lecture.

Saxton, A.M. (1998). A macro for converting mean separation output to letter groupings in Proc Mixed. In Proc. *23rd SAS Users Group International*, SAS Institute, Cary, NC, 1243-1246.

Schifferli, L. (1973). The effect of egg weight on the subsequent growth of nestling great tits *Parus major. Ibis* **115**, 549-558.

Smith, W.G., Bennett, H.H. (1903) Soil Survey of Davidson County, Tennessee. Natural Resources Conservation Service. Available at: http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/tennessee/davidsonTN1903/davidsonTN1903.pdf

Stojnić, B., Vukŝa, M. Jokić, G., & Čkrić, M. (2011). First record of introduced Valencia slug, *Lehmannia valentiana* (Ferussac, 1822), in Serbia. *Pestic Fitomed* **26**, 213-220.

Ström, L., Hylander, K., & Dynesius, M. (2009). Different long-term and short-term responses of land snails to clear-cutting of boreal stream-side forests. *Biological conservation*. **142**(8), 1580-1587.

Sumrall, C. (2015). Personal communications, May 2014.

Tattersfield, P. (1998) Patterns of diversity and endemism in East African land snails, and the implications for conservation. *Journal of Conchology* **2**, 77-86.

Valovirta, I. (1968). Land molluscs in relation to acidity on hyperite hills in Central Finland. *Annales Zoologici Fennici* **5**, 245-253.

Van den Neucker T. & Ronsmans J. (2015). The globally invasive *Paralaoma servilis* (Gastropoda: Punctidae) reported for the first time in Belgium. *Journal of Conchology* **42**(1), 95-96.

Vermeulen, J.J., Liew, T.S., Schilthuizen, M. (2015). Additions to the knowledge of the land snails of Sabah (Malaysia, Borneo), including 48 new species. *ZooKeys* **531**, 1-139

Wade, C.M., Mordan, P.B., Clarke, B. (2001). A phylogeny of the land snails (Gastropoda: Pulmonata). *The Royal Society* **268,** 413-422.

Wang, G., Jiang, G., Zhou, Y., Liu, Q., Ji, Y., Wang, S., Chen, S., Liu, H. (2007) Biodiversity conservation in a fast growing metropolitan area in China: a case study of plant diversity in Beijing. *Biodiversity and Conservation* **16**, 4025–4038.

Wardhaugh, A.A. (1995) The terrestrial molluscan fauna of some woodlands in North East Yorkshire, England. *Journal of Conchology* **35**, 313–327.

Wareborn, I. (1992) Changes in the land mollusk fauna ans soil chemistry in an inland district in southern Sweden. *Ecography* **15**, 62-69.

Wa¨reborn, I. (1969) Land molluscs and their environments in an oligotrophic area in southern Sweden. *Oikos* **20**, 461– 479.

White-McLean, J.A. (2011).Terrestrial Mollusc Tool. USDA/APHIS/PPQ Center for Plant Health Science and Technology and the University of Florida. February, 2016. Available at: http://idtools.org/id/mollusc/factsheet.php?name=Oxychilus%20spp.

Whitson, M. (2005). *Cepaea nemoralis* (Gastropoda, Helicidae): The Invited Invader. *Journal of the Kentucky Academy of Science* **66**(2), 82-85.

Wronski T. & Hausdorf B. (2010). Diversity and body-size patterns of land snails in rain forests in Uganda. *Journal of Molluscan Studies* **76**(1), 87-100.

Yanes, Y. (2012). Anthropogenic effect recorded in the live-dead fidelity of land snail assemblages from San Salvador Island (Bahamas). *Biodiversity and Conservation* **21**, 3445–3466.

APPENDIX

Table A1: Records of all land snails encountered in this study by county and park. Spaces between parks represent different plots.

Davidson CO Parks	Latitude	Longitude	Scientific name	Common name	# Found
Hamilton Creek	36.10917°	86.61806°	*Gastrocopta tappaniana*	White Snaggletooth	2
Hamilton Creek	36.10917°	86.61806°	*Strobilops labyrinthicus*	Maze Pinecone	27
Hamilton Creek	36.10917°	86.61806°	*Euconulus trochulus*	Silk Hive	1
Hamilton Creek	36.10917°	86.61806°	*Helicodiscus parallelus*	Compound Coil	2
Hamilton Creek	36.10917°	86.61806°	*Gastrocopta armifera*	Armed Snaggletooth	9
Hamilton Creek	36.10917°	86.61806°	*Pupoides albilabris*	White-Lip Dagger	1
Hamilton Creek	36.10917°	86.61806°	*Glyphyalnia wheatleyi*	Bright Glyph	1
Hamilton Creek	36.10917°	86.61806°	*Glyphyalinia indentata*	Carved Glyph	12
Hamilton Creek	36.10917°	86.61806°	*Millerelix troostiana*	Nashville Liptooth	3
Hamilton Creek	36.10917°	86.61806°	*Oligyra orbiculata*	Globular Drop	47
Hamilton Creek	36.10917°	86.61806°	*Ventridens percallosus*	Tennessee Dome	5
Hamilton Creek	36.10917°	86.61806°	*Ventridens demissus*	Perforate Dome	5
Hamilton Creek	36.10917°	86.61806°	*Rabdotus dealbatus*	Whitewashed Rabdotus	1
Hamilton Creek	36.10917°	86.61806°	*Mesomphix vulgatus*	Common Button	5
Hamilton Creek	36.10917°	86.61806°	*Helicodiscus sp.*		5
Hamilton Creek	36.10639°	86.62528°	*Strobilops labyrinthicus*	Maze Pinecone	11
Hamilton Creek	36.10639°	86.62528°	*Hawaiia minuscula*	Minute Gem	1
Hamilton Creek	36.10639°	86.62528°	*Heliodiscus notius*	Tight Coil	13
Hamilton Creek	36.10639°	86.62528°	*Gastrocopta armifera*	Armed Snaggletooth	6
Hamilton Creek	36.10639°	86.62528°	*Glyphyalinia indentata*	Carved Glyph	4
Hamilton Creek	36.10639°	86.62528°	*Millerelix troostiana*	Nashville Liptooth	13
Hamilton Creek	36.10639°	86.62528°	*Oligyra orbiculata*	Globular Drop	48
Hamilton Creek	36.10639°	86.62528°	*Ventridens demissus*	Perforate Dome	12

Table A1. (Continued.)					
Davidson CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Hamilton Creek	36.10639°	86.62528°	*Stenotrema stenotrema*	Inland Slitmouth	1
Hamilton Creek	36.10639°	86.62528°	*Inflectarius inflectus*	Shagreen	3
Hamilton Creek	36.10639°	86.62528°	*Mesomphix vulgatus*	Common Button	48
Hamilton Creek	36.10639°	86.62528°	*Mesodon thyroidus*	White-lip Globe	3
Hamilton Creek	36.10417°	86.625°	*Striatura meridionalis*	Median Striate	1
Hamilton Creek	36.10417°	86.625°	*Strobilops labyrinthicus*	Maze Pinecone	26
Hamilton Creek	36.10417°	86.625°	*Hawaiia minuscula*	Minute Gem	9
Hamilton Creek	36.10417°	86.625°	*Strobilops aeneus*	Bronze Pinecone	1
Hamilton Creek	36.10417°	86.625°	*Euconulus trochulus*	Silk Hive	3
Hamilton Creek	36.10417°	86.625°	*Helicodiscus parallelus*	Compound Coil	2
Hamilton Creek	36.10417°	86.625°	*Gastrocopta armifera*	Armed Snaggletooth	5
Hamilton Creek	36.10417°	86.625°	*Glyphyalnia wheatleyi*	Bright Glyph	3
Hamilton Creek	36.10417°	86.625°	*Glyphyalinia indentata*	Carved Glyph	1
Hamilton Creek	36.10417°	86.625°	*Oligyra orbiculata*	Globular Drop	34
Hamilton Creek	36.10417°	86.625°	*Euchemotrema leai*	Lowland Pillsnail	6
Hamilton Creek	36.10417°	86.625°	*Ventridens percallosus*	Tennessee Dome	24
Hamilton Creek	36.10417°	86.625°	*Stenotrema stenotrema*	Inland Slitmouth	1
Hamilton Creek	36.10417°	86.625°	*Inflectarius inflectus*	Shagreen	2
Hamilton Creek	36.10417°	86.625°	*Mesodon thyroidus*	White-lip Globe	6
Hamilton Creek	36.10417°	86.625°	*Mesomphix capnodes*	Dusky Button	9
Hamilton Creek	36.10222°	86.63139°	*Gastrocopta armifera*	Armed Snaggletooth	3
Hamilton Creek	36.10222°	86.63139°	*Glyphyalinia indentata*	Carved Glyph	1
Hamilton Creek	36.10222°	86.63139°	*Oligyra orbiculata*	Globular Drop	20

Table A1. (Continued.)					
Davidson CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Hamilton Creek	36.10222°	86.63139°	*Ventridens percallosus*	Tennessee Dome	6
Hamilton Creek	36.10222°	86.63139°	*Mesomphix vulgatus*	Common Button	21
Hamilton Creek	36.10222°	86.63139°	*Mesodon thyroidus*	White-lip Globe	8
Hamilton Creek	36.10222°	86.63139°	*Mesomphix capnodes*	Dusky Button	2
Percy Warner	36.08222°	86.875°	*Strobilops labyrinthicus*	Maze Pinecone	2
Percy Warner	36.08222°	86.875°	*Zonitoides arboreus*	Quick Gloss	2
Percy Warner	36.08222°	86.875°	*Ventridens demissus*	Perforate Dome	13
Percy Warner	36.08222°	86.875°	*Stenotrema stenotrema*	Inland Slitmouth	19
Percy Warner	36.08222°	86.875°	*Inflectarius inflectus*	Shagreen	4
Percy Warner	36.08222°	86.875°	*Triodopsis vulgata*	Dished Threetooth	15
Percy Warner	36.08222°	86.875°	*Haplotrema concavum*	Gray-foot Lancetooth	1
Percy Warner	36.08222°	86.875°	*Xolotrema obstrictum*	Sharp Wedge	15
Percy Warner	36.08222°	86.875°	*Mesomphix vulgatus*	Common Button	11
Percy Warner	36.08222°	86.875°	*Anguispira alternata*	Flamed Tigersnail	1
Percy Warner	36.08222°	86.875°	*Mesodon zaletus*	Toothed Globe	2
Percy Warner	36.06111°	86.89778°	*Glyphyalnia wheatleyi*	Bright Glyph	2
Percy Warner	36.06111°	86.89778°	*Glyphyalinia cryptomphala*	Thin Glyph	11
Percy Warner	36.06111°	86.89778°	*Glyphyalinia indentata*	Carved Glyph	9
Percy Warner	36.06111°	86.89778°	*Oligyra orbiculata*	Globular Drop	4
Percy Warner	36.06111°	86.89778°	*Ventridens demissus*	Perforate Dome	1
Percy Warner	36.06111°	86.89778°	*Stenotrema stenotrema*	Inland Slitmouth	1
Percy Warner	36.06111°	86.89778°	*Inflectarius inflectus*	Shagreen	10
Percy Warner	36.06111°	86.89778°	*Triodopsis vulgata*	Dished Threetooth	1

Table A1. (Continued.)					
Davidson CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Percy Warner	36.06111°	86.89778°	*Haplotrema concavum*	Gray-foot Lancetooth	18
Percy Warner	36.06111°	86.89778°	*Xolotrema obstrictum*	Sharp Wedge	1
Percy Warner	36.06111°	86.89778°	*Mesomphix vulgatus*	Common Button	34
Percy Warner	36.06111°	86.89778°	*Mesomphix cupreus*	Copper Button	3
Percy Warner	36.06111°	86.89778°	*Anguispira alternata*	Flamed Tigersnail	1
Percy Warner	36.06111°	86.89778°	*Mesodon zaletus*	Toothed Globe	9
Percy Warner	36.06361°	86.88611°	*Glyphyalnia wheatleyi*	Bright Glyph	2
Percy Warner	36.06361°	86.88611°	*Glyphyalinia cryptomphala*	Thin Glyph	2
Percy Warner	36.06361°	86.88611°	*Glyphyalinia indentata*	Carved Glyph	2
Percy Warner	36.06361°	86.88611°	*Ventridens demissus*	Perforate Dome	6
Percy Warner	36.06361°	86.88611°	*Inflectarius inflectus*	Shagreen	8
Percy Warner	36.06361°	86.88611°	*Triodopsis vulgata*	Dished Threetooth	4
Percy Warner	36.06361°	86.88611°	*Haplotrema concavum*	Gray-foot Lancetooth	3
Percy Warner	36.06361°	86.88611°	*Mesomphix vulgatus*	Common Button	11
Percy Warner	36.06361°	86.88611°	*Anguispira alternata*	Flamed Tigersnail	1
Percy Warner	36.06361°	86.88611°	*Mesodon zaletus*	Toothed Globe	10
Percy Warner	36.06778°	86.87917°	*Glyphyalnia wheatleyi*	Bright Glyph	3
Percy Warner	36.06778°	86.87917°	*Glyphyalinia cryptomphala*	Thin Glyph	9
Percy Warner	36.06778°	86.87917°	*Stenotrema stenotrema nudum*		1
Percy Warner	36.06778°	86.87917°	*Stenotrema stenotrema*	Inland Slitmouth	1
Percy Warner	36.06778°	86.87917°	*Inflectarius inflectus*	Shagreen	7
Percy Warner	36.06778°	86.87917°	*Triodopsis vulgata*	Dished Threetooth	10
Percy Warner	36.06778°	86.87917°	*Haplotrema concavum*	Gray-foot Lancetooth	8
Percy Warner	36.06778°	86.87917°	*Xolotrema obstrictum*	Sharp Wedge	2

Table A1. (Continued.)					
Davidson CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Percy Warner	36.06778°	86.87917°	*Mesomphix vulgatus*	Common Button	6
Percy Warner	36.06778°	86.87917°	*Mesodon zaletus*	Toothed Globe	12
Shelby Bottoms	36.06778°	86.73444°	*Gastrocopta pentodon*	Comb Snaggletooth	3
Shelby Bottoms	36.06778°	86.73444°	*Gastrocopta contracta*	Bottleneck Snaggletooth	6
Shelby Bottoms	36.06778°	86.73444°	*Hawaiia minuscula*	Minute Gem	9
Shelby Bottoms	36.06778°	86.73444°	*Euconulus chersinus*	Wild Hive	4
Shelby Bottoms	36.06778°	86.73444°	*Gastrocopta armifera*	Armed Snaggletooth	60
Shelby Bottoms	36.06778°	86.73444°	*Zonitoides arboreus*	Quick Gloss	5
Shelby Bottoms	36.06778°	86.73444°	*Glyphyalinia solida*	Imperforate Glyph	89
Shelby Bottoms	36.06778°	86.73444°	*Inflectarius inflectus*	Shagreen	85
Shelby Bottoms	36.06778°	86.73444°	*Inflectarius rugeli*	Deep-tooth Shagreen	7
Shelby Bottoms	36.06778°	86.73444°	*Haplotrema concavum*	Gray-foot Lancetooth	5
Shelby Bottoms	36.06778°	86.73444°	*Anguispira alternata*	Flamed Tigersnail	7
Shelby Bottoms	36.06778°	86.73444°	*Mesodon thyroidus*	White-lip Globe	3
Shelby Bottoms	36.16556°	86.72361°	*Gastrocopta pentodon*	Comb Snaggletooth	1
Shelby Bottoms	36.16556°	86.72361°	*Hawaiia minuscula*	Minute Gem	2
Shelby Bottoms	36.16556°	86.72361°	*Pomatiopsis lapidaria*	Slender Walker	2
Shelby Bottoms	36.16556°	86.72361°	*Glyphyalinia solida*	Imperforate Glyph	47
Shelby Bottoms	36.16556°	86.72361°	*Stenotrema hirsutum*	Hairy Slitmouth	3
Shelby Bottoms	36.16556°	86.72361°	*Inflectarius inflectus*	Shagreen	8
Shelby Bottoms	36.16556°	86.72361°	*Ventridens ligera*	Globose Dome	79
Shelby Bottoms	36.16556°	86.72361°	*Anguispira alternata*	Flamed Tigersnail	8
Shelby Bottoms	36.16556°	86.72361°	*Mesodon thyroidus*	White-lip Globe	6

Table A1. (Continued.)					
Davidson CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Shelby Bottoms	36.17972°	86.70972°	*Carychium exile*	Ice Thorn	1
Shelby Bottoms	36.17972°	86.70972°	*Glyphyalinia solida*	Imperforate Glyph	84
Shelby Bottoms	36.17972°	86.70972°	*Stenotrema barbatum*	Bristled Slitmouth	1
Shelby Bottoms	36.17972°	86.70972°	*Ventridens demissus*	Perforate Dome	12
Shelby Bottoms	36.17972°	86.70972°	*Inflectarius inflectus*	Shagreen	1
Shelby Bottoms	36.17972°	86.70972°	*Mesodon thyroidus*	White-lip Globe	3
Cane Ridge	35.99167°	86.62194°	*Striatura meridionalis*	Median Striate	2
Cane Ridge	35.99167°	86.62194°	*Gastrocopta armifera*	Armed Snaggletooth	1
Cane Ridge	35.99167°	86.62194°	*Glyphyalinia indentata*	Carved Glyph	3
Cane Ridge	35.99167°	86.62194°	*Millerelix troostiana*	Nashville Liptooth	33
Cane Ridge	35.99167°	86.62194°	*Ventridens percallosus*	Tennessee Dome	36
Cane Ridge	35.99167°	86.62194°	*Ventridens demissus*	Perforate Dome	59
Cane Ridge	35.99167°	86.62194°	*Stenotrema stenotrema*	Inland Slitmouth	3
Cane Ridge	35.99167°	86.62194°	*Inflectarius inflectus*	Shagreen	8
Cane Ridge	35.99167°	86.62194°	*Anguispira alternata*	Flamed Tigersnail	30
Cane Ridge	35.98944°	35.98944°	*Vertigo tridentata*	Honey Vertigo	2
Cane Ridge	35.98944°	35.98944°	*Hawaiia minuscula*	Minute Gem	4
Cane Ridge	35.98944°	35.98944°	*Gastrocopta armifera*	Armed Snaggletooth	4
Cane Ridge	35.98944°	35.98944°	*Glyphyalinia indentata*	Carved Glyph	2
Cane Ridge	35.98944°	35.98944°	*Millerelix troostiana*	Nashville Liptooth	37
Cane Ridge	35.98944°	35.98944°	*Ventridens percallosus*	Tennessee Dome	140
Cane Ridge	35.98944°	35.98944°	*Ventridens demissus*	Perforate Dome	246
Cane Ridge	35.98944°	35.98944°	*Inflectarius inflectus*	Shagreen	8

Table A1. (Continued.)

Davidson CO Parks	Latitude	Longitude	Scientific name	Common name	# Found
Cane Ridge	35.99056°	86.61944°	*Gastrocopta pentodon*	Comb Snaggletooth	1
Cane Ridge	35.99056°	86.61944°	*Strobilops labyrinthicus*	Maze Pinecone	12
Cane Ridge	35.99056°	86.61944°	*Helicodiscus parallelus*	Compound Coil	1
Cane Ridge	35.99056°	86.61944°	*Heliodiscus notius*	Tight Coil	4
Cane Ridge	35.99056°	86.61944°	*Glyphyalnia wheatleyi*	Bright Glyph	5
Cane Ridge	35.99056°	86.61944°	*Zonitoides arboreus*	Quick Gloss	3
Cane Ridge	35.99056°	86.61944°	*Glyphyalinia indentata*	Carved Glyph	3
Cane Ridge	35.99056°	86.61944°	*Millerelix troostiana*	Nashville Liptooth	8
Cane Ridge	35.99056°	86.61944°	*Ventridens lawae*	Rounded Dome	5
Cane Ridge	35.99056°	86.61944°	*Ventridens pilsbryi*	Yellow Dome	3
Cane Ridge	35.99056°	86.61944°	*Ventridens demissus*	Perforate Dome	31
Cane Ridge	35.99056°	86.61944°	*Triodopsis hopetonensis*	Magnolia Threetooth	1
Cane Ridge	35.99056°	86.61944°	*Inflectarius inflectus*	Shagreen	9
Cane Ridge	35.99056°	86.61944°	*Anguispira alternata*	Flamed Tigersnail	12
Cane Ridge	35.98889°	86.62389°	*Hawaiia minuscula*	Minute Gem	1
Cane Ridge	35.98889°	86.62389°	*Gastrocopta armifera*	Armed Snaggletooth	2
Cane Ridge	35.98889°	86.62389°	*Millerelix troostiana*	Nashville Liptooth	19
Cane Ridge	35.98889°	86.62389°	*Ventridens percallosus*	Tennessee Dome	260
Cane Ridge	35.98889°	86.62389°	*Ventridens demissus*	Perforate Dome	263
Cane Ridge	35.98889°	86.62389°	*Euchemotrema fraternum*	Upland Pillsnail	1
Cane Ridge	35.98889°	86.62389°	*Stenotrema stenotrema*	Inland Slitmouth	2
Cane Ridge	35.98889°	86.62389°	*Inflectarius inflectus*	Shagreen	25
Cane Ridge	35.98889°	86.62389°	*Anguispira alternata*	Flamed Tigersnail	29
Mill Creek	36.02111°	86.68194°	*Gastrocopta pentodon*	Comb Snaggletooth	2
Mill Creek	36.02111°	86.68194°	*Striatura meridionalis*	Median Striate	2

Table A1. (Continued.)					
Davidson CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Mill Creek	36.02111°	86.68194°	*Gastrocopta tappaniana*	White Snaggletooth	1
Mill Creek	36.02111°	86.68194°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Mill Creek	36.02111°	86.68194°	*Vallonia pulchella*	Lovely Vallonia	10
Mill Creek	36.02111°	86.68194°	*Hawaiia minuscula*	Minute Gem	3
Mill Creek	36.02111°	86.68194°	*Euconulus trochulus*	Silk Hive	2
Mill Creek	36.02111°	86.68194°	*Gastrocopta armifera*	Armed Snaggletooth	26
Mill Creek	36.02111°	86.68194°	*Pupoides albilabris*	White-Lip Dagger	18
Mill Creek	36.02111°	86.68194°	*Glyphyalinia cryptomphala*	Thin Glyph	9
Mill Creek	36.02111°	86.68194°	*Zonitoides arboreus*	Quick Gloss	2
Mill Creek	36.02111°	86.68194°	*Glyphyalinia indentata*	Carved Glyph	4
Mill Creek	36.02111°	86.68194°	*Opeas pyrgula*	Sharp Awlsnail	1
Mill Creek	36.02111°	86.68194°	*Euchemotrema leai*	Lowland Pillsnail	6
Mill Creek	36.02111°	86.68194°	*Ventridens demissus*	Perforate Dome	52
Mill Creek	36.02111°	86.68194°	*Catinella vermeta*	Suboval Ambersnail	5
Mill Creek	36.02111°	86.68194°	*Triodopsis hopetonensis*	Magnolia Threetooth	15
Mill Creek	36.02111°	86.68194°	*Mesodon clausus*	Yellow Globelet	1
Mill Creek	36.02111°	86.68194°	*Novisuccinea ovalis*	Oval Ambersnail	22
Mill Creek	36.02167°	86.68333°	*Columella simplex*	High-Spire Simplex	1
Mill Creek	36.02167°	86.68333°	*Vertigo tridentata*	Honey Vertigo	1
Mill Creek	36.02167°	86.68333°	*Gastrocopta armifera*	Armed Snaggletooth	1
Mill Creek	36.02167°	86.68333°	*Glyphyalinia cryptomphala*	Thin Glyph	5
Mill Creek	36.02167°	86.68333°	*Ventridens demissus*	Perforate Dome	10
Mill Creek	36.02167°	86.68333°	*Stenotrema stenotrema*	Inland Slitmouth	1
Mill Creek	36.02167°	86.68333°	*Triodopsis hopetonensis*	Magnolia Threetooth	2
Mill Creek	36.02167°	86.68333°	*Ventridens ligera*	Globose Dome	11
Mill Creek	36.02167°	86.68333°	*Mesodon clausus*	Yellow Globelet	1

Table A1. (Continued.)					
Davidson CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Mill Creek	36.02167°	86.68333°	*Novisuccinea ovalis*	Oval Ambersnail	1
Mill Creek	36.01472°	86.68722°	*Heliodiscus notius*	Tight Coil	1
Mill Creek	36.01472°	86.68722°	*Zonitoides arboreus*	Quick Gloss	1
Mill Creek	36.01472°	86.68722°	*Glyphyalinia indentata*	Carved Glyph	2
Mill Creek	36.01472°	86.68722°	*Euchemotrema leai*	Lowland Pillsnail	5
Mill Creek	36.01472°	86.68722°	*Ventridens percallosus*	Tennessee Dome	39
Mill Creek	36.01472°	86.68722°	*Ventridens demissus*	Perforate Dome	39
Mill Creek	36.01472°	86.68722°	*Stenotrema stenotrema*	Inland Slitmouth	14
Mill Creek	36.01472°	86.68722°	*Triodopsis hopetonensis*	Magnolia Threetooth	26
Crooked Branch	36.23889°	86.65028°	*Carychium exile*	Ice Thorn	6
Crooked Branch	36.23889°	86.65028°	*Glyphyalinia cryptomphala*	Thin Glyph	1
Crooked Branch	36.23889°	86.65028°	*Paravitrea capsella*	Dimple Supercoil	2
Crooked Branch	36.23889°	86.65028°	*Ventridens acerra*	Glossy Dome	11
Crooked Branch	36.23889°	86.65028°	*Haplotrema concavum*	Gray-foot Lancetooth	6
Crooked Branch	36.23889°	86.65028°	*Xolotrema obstrictum*	Sharp Wedge	2
Crooked Branch	36.23889°	86.65028°	*Mesomphix vulgatus*	Common Button	26
Crooked Branch	36.23889°	86.65028°	*Anguispira alternata*	Flamed Tigersnail	9
Crooked Branch	36.24028°	86.64333°	*Carychium exile*	Ice Thorn	5
Crooked Branch	36.24028°	86.64333°	*Vertigo milium*	Blade Vertigo	2
Crooked Branch	36.24028°	86.64333°	*Lucilla scintilla*	Oldfield Coil	6
Crooked Branch	36.24028°	86.64333°	*Gastrocopta contracta*	Bottleneck Snaggletooth	2
Crooked Branch	36.24028°	86.64333°	*Strobilops aeneus*	Bronze Pinecone	1
Crooked Branch	36.24028°	86.64333°	*Heliodiscus notius*	Tight Coil	1

Table A1. (Continued.)					
Davidson CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Crooked Branch	36.24028°	86.64333°	*Gastrocopta armifera*	Armed Snaggletooth	3
Crooked Branch	36.24028°	86.64333°	*Glyphyalinia cryptomphala*	Thin Glyph	10
Crooked Branch	36.24028°	86.64333°	*Glyphyalinia indentata*	Carved Glyph	5
Crooked Branch	36.24028°	86.64333°	*Ventridens percallosus*	Tennessee Dome	106
Crooked Branch	36.24028°	86.64333°	*Ventridens demissus*	Perforate Dome	20
Crooked Branch	36.24028°	86.64333°	*Stenotrema stenotrema*	Inland Slitmouth	17
Crooked Branch	36.24028°	86.64333°	*Triodopsis hopetonensis*	Magnolia Threetooth	18
Crooked Branch	36.24028°	86.64333°	*Inflectarius rugeli*	Deep-tooth Shagreen	36
Crooked Branch	36.24028°	86.64333°	*Anguispira alternata*	Flamed Tigersnail	2
Crooked Branch	36.24028°	86.64333°	*Mesodon thyroidus*	White-lip Globe	30
Sevier park	36.11833°	86.78806°	*Gastrocopta tappaniana*	White Snaggletooth	1
Sevier park	36.11833°	86.78806°	*Gastrocopta contracta*	Bottleneck Snaggletooth	3
Sevier park	36.11833°	86.78806°	*Gastrocopta corticaria*	Bark Snaggletooth	3
Sevier park	36.11833°	86.78806°	*Gastrocopta procera*	Wing Snaggletooth	1
Sevier park	36.11833°	86.78806°	*Gastrocopta armifera*	Armed Snaggletooth	3
Sevier park	36.11833°	86.78806°	*Pupoides albilabris*	White-Lip Dagger	3
Sevier park	36.11833°	86.78806°	*Cochlicopa lubricella*	Thin Pillar	1
Sevier park	36.11833°	86.78806°	*Glyphyalinia solida*	Imperforate Glyph	2
Sevier park	36.11833°	86.78806°	*Ventridens demissus*	Perforate Dome	12
Sevier park	36.11833°	86.78806°	*Triodopsis hopetonensis*	Magnolia Threetooth	9
Sevier park	36.11833°	86.78806°	*Inflectarius inflectus*	Shagreen	3
Sevier park	36.11833°	86.78806°	*Patera appressa*	Flat Bladetooth	40
Whitsett Park	36.11778°	86.72389°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Whitsett Park	36.11778°	86.72389°	*Hawaiia minuscula*	Minute Gem	3

Table A1. (Continued.)

Davidson CO Parks	Latitude	Longitude	Scientific name	Common name	# Found
Whitsett Park	36.11778°	86.72389°	*Ventridens demissus*	Perforate Dome	11
Whitsett Park	36.11778°	86.72389°	*Stenotrema stenotrema*	Inland Slitmouth	2
Whitsett Park	36.11778°	86.72389°	*Triodopsis hopetonensis*	Magnolia Threetooth	17
Whitsett Park	36.11778°	86.72389°	*Inflectarius inflectus*	Shagreen	1
Whitsett Park	36.12028°	86.72583°	*Gastrocopta pentodon*	Comb Snaggletooth	1
Whitsett Park	36.12028°	86.72583°	*Ventridens demissus*	Perforate Dome	94
William Pitts	36.05722°	86.70722°	*Hawaiia minuscula*	Minute Gem	9
William Pitts	36.05722°	86.70722°	*Strobilops aeneus*	Bronze Pinecone	1
William Pitts	36.05722°	86.70722°	*Helicodiscus parallelus*	Compound Coil	1
William Pitts	36.05722°	86.70722°	*Zonitoides arboreus*	Quick Gloss	1
William Pitts	36.05722°	86.70722°	*Glyphyalinia indentata*	Carved Glyph	26
William Pitts	36.05722°	86.70722°	*Ventridens lawae*	Rounded Dome	3
William Pitts	36.05722°	86.70722°	*Triodopsis hopetonensis*	Magnolia Threetooth	7
William Pitts	36.05694°	86.70583°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
William Pitts	36.05694°	86.70583°	*Vallonia pulchella*	Lovely Vallonia	2
William Pitts	36.05694°	86.70583°	*Hawaiia minuscula*	Minute Gem	3
William Pitts	36.05694°	86.70583°	*Euconulus trochulus*	Silk Hive	2
William Pitts	36.05694°	86.70583°	*Glyphyalnia wheatleyi*	Bright Glyph	1
William Pitts	36.05694°	86.70583°	*Glyphyalinia indentata*	Carved Glyph	18
William Pitts	36.05694°	86.70583°	*Millerelix troostiana*	Nashville Liptooth	4
William Pitts	36.05694°	86.70583°	*Ventridens percallosus*	Tennessee Dome	27
William Pitts	36.05694°	86.70583°	*Ventridens demissus*	Perforate Dome	50
William Pitts	36.05694°	86.70583°	*Triodopsis hopetonensis*	Magnolia Threetooth	4
William Pitts	36.05694°	86.70583°	*Ventridens ligera*	Globose Dome	6

Table A1. (Continued.)					
Davidson CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Brookemeade	36.13056°	86.90389°	*Gastrocopta pentodon*	Comb Snaggletooth	3
Brookemeade	36.13056°	86.90389°	*Gastrocopta contracta*	Bottleneck Snaggletooth	4
Brookemeade	36.13056°	86.90389°	*Paralaoma servilis*	Pinhead Spot	5
Brookemeade	36.13056°	86.90389°	*Hawaiia minuscula*	Minute Gem	6
Brookemeade	36.13056°	86.90389°	*Euconulus trochulus*	Silk Hive	1
Brookemeade	36.13056°	86.90389°	*Pupoides albilabris*	White-Lip Dagger	3
Brookemeade	36.13056°	86.90389°	*Glyphyalinia cryptomphala*	Thin Glyph	3
Brookemeade	36.13056°	86.90389°	*Oligyra orbiculata*	Globular Drop	7
Brookemeade	36.13056°	86.90389°	*Euchemotrema leai*	Lowland Pillsnail	3
Brookemeade	36.13056°	86.90389°	*Stenotrema stenotrema*	Inland Slitmouth	1
Brookemeade	36.13056°	86.90389°	*Ventridens ligera*	Globose Dome	17
Brookemeade	36.13056°	86.90389°	*Rabdotus dealbatus*	Whitewashed Rabdotus	2
Rachel's Walk	36.25642	86.64875	*Gastrocopta contracta*	Bottleneck Snaggletooth	2
Rachel's Walk	36.25642	86.64875	*Hawaiia minuscula*	Minute Gem	6
Rachel's Walk	36.25642	86.64875	*Zonitoides arboreus*	Quick Gloss	1
Rachel's Walk	36.25642	86.64875	*Glyphyalinia indentata*	Carved Glyph	1
Rachel's Walk	36.25642	86.64875	*Ventridens demissus*	Perforate Dome	12
Rachel's Walk	36.25642	86.64875	*Triodopsis hopetonensis*	Magnolia Threetooth	20
Rachel's Walk	36.25642	86.64875	*Inflectarius inflectus*	Shagreen	9
Rachel's Walk	36.25642	86.64875	*Patera appressa*	Flat Bladetooth	4
Rachel's Walk	36.25642	86.64875	*Anguispira alternata*	Flamed Tigersnail	78
Cecil Rhea	36.00083°	86.63722°	*Striatura meridionalis*	Median Striate	1
Cecil Rhea	36.00083°	86.63722°	*Glyphyalinia cryptomphala*	Thin Glyph	1
Cecil Rhea	36.00083°	86.63722°	*Ventridens demissus*	Perforate Dome	12
Cecil Rhea	36.00083°	86.63722°	*Catinella vermeta*	Suboval Ambersnail	1

Table A1. (Continued.)

Davidson CO Parks	Latitude	Longitude	Scientific name	Common name	# Found
Cecil Rhea	36.00083°	86.63722°	*Triodopsis hopetonensis*	Magnolia Threetooth	13
Cecil Rhea	36.00083°	86.63722°	*Anguispira alternata*	Flamed Tigersnail	1
Parmer	36.10361°	86.86111°	*Gastrocopta contracta*	Bottleneck Snaggletooth	2
Parmer	36.10361°	86.86111°	*Vallonia pulchella*	Lovely Vallonia	11
Parmer	36.10361°	86.86111°	*Hawaiia minuscula*	Minute Gem	4
Parmer	36.10361°	86.86111°	*Glyphyalinia cryptomphala*	Thin Glyph	8
Parmer	36.10361°	86.86111°	*Cochlicopa lubricella*	Thin Pillar	2
Parmer	36.10361°	86.86111°	*Catinella oklahomarum*	Detritus Ambersnail	4
Parmer	36.10361°	86.86111°	*Triodopsis hopetonensis*	Magnolia Threetooth	15
Parmer	36.10361°	86.86111°	*Oxyloma retusum*	Blunt Ambersnail	4
Dallas H. Neal	36.13435	86.780217	*Hawaiia minuscula*	Minute Gem	3
Dallas H. Neal	36.13435	86.780217	*Pupoides albilabris*	White-Lip Dagger	4
Dallas H. Neal	36.13435	86.780217	*Zonitoides arboreus*	Quick Gloss	6
Dallas H. Neal	36.13435	86.780217	*Ventridens percallosus*	Tennessee Dome	1
Benham Williams	36.11°	86.80861°	*Gastrocopta pentodon*	Comb Snaggletooth	4
Benham Williams	36.11°	86.80861°	*Gastrocopta contracta*	Bottleneck Snaggletooth	15
Benham Williams	36.11°	86.80861°	*Hawaiia minuscula*	Minute Gem	11
Benham Williams	36.11°	86.80861°	*Euconulus chersinus*	Wild Hive	2
Benham Williams	36.11°	86.80861°	*Gastrocopta armifera*	Armed Snaggletooth	1
Benham Williams	36.11°	86.80861°	*Zonitoides arboreus*	Quick Gloss	2
Benham Williams	36.11°	86.80861°	*Glyphyalinia indentata*	Carved Glyph	8
Benham Williams	36.11°	86.80861°	*Euchemotrema leai*	Lowland Pillsnail	5
Benham Williams	36.11°	86.80861°	*Ventridens demissus*	Perforate Dome	2
Benham Williams	36.11°	86.80861°	*Triodopsis hopetonensis*	Magnolia Threetooth	6

Table A1. (Continued.)

Davidson CO Parks	Latitude	Longitude	Scientific name	Common name	# Found
Benham Williams	36.11°	86.80861°	*Inflectarius inflectus*	Shagreen	8
Church St. Park	36.162669	86.783654	*Vallonia pulchella*	Lovely Vallonia	4
Church St. Park	36.162669	86.783654	*Hawaiia minuscula*	Minute Gem	1
Church St. Park	36.162669	86.783654	*Gastrocopta armifera*	Armed Snaggletooth	6
Church St. Park	36.162669	86.783654	*Pupoides albilabris*	White-Lip Dagger	10
Church St. Park	36.162669	86.783654	*Zonitoides arboreus*	Quick Gloss	11
Church St. Park	36.162669	86.783654	*Glyphyalinia indentata*	Carved Glyph	1
Church St. Park	36.162669	86.783654	*Opeas pyrgula*	Sharp Awlsnail	4
Church St. Park	36.162669	86.783654	*Oligyra orbiculata*	Globular Drop	1
Church St. Park	36.162669	86.783654	*Euchemotrema leai*	Lowland Pillsnail	7
Church St. Park	36.162669	86.783654	*Ventridens demissus*	Perforate Dome	9
Church St. Park	36.162669	86.783654	*Triodopsis hopetonensis*	Magnolia Threetooth	13
Church St. Park	36.162669	86.783654	*Polygyra cereolus*	Southern Flatcoil	2
Church St. Park	36.162669	86.783654	*Patera appressa*	Flat Bladetooth	1
Church St. Park	36.162669	86.783654	*Rabdotus dealbatus*	Whitewashed Rabdotus	23
Cumberland	36.162448	86.772307	*Gastrocopta contracta*	Bottleneck Snaggletooth	9
Cumberland	36.162448	86.772307	*Hawaiia minuscula*	Minute Gem	8
Cumberland	36.162448	86.772307	*Zonitoides arboreus*	Quick Gloss	104
Cumberland	36.162448	86.772307	*Glyphyalinia indentata*	Carved Glyph	1
Cumberland	36.162448	86.772307	*Millerelix troostiana*	Nashville Liptooth	1
Cumberland	36.162448	86.772307	*Triodopsis hopetonensis*	Magnolia Threetooth	7
Public Square	36.16735	86.796148	*Vallonia pulchella*	Lovely Vallonia	1

Table A1. (Continued.)

Davidson CO Parks	Latitude	Longitude	Scientific name	Common name	# Found
Public Square	36.16735	86.796148	*Zonitoides arboreus*	Quick Gloss	8
Public Square	36.16735	86.796148	*Opeas pyrgula*	Sharp Awlsnail	35
Public Square	36.16735	86.796148	*Triodopsis hopetonensis*	Magnolia Threetooth	72

Knox CO Parks	Latitude	Longitude	Scientific name	Common name	# Found
Fort Dickerson	**83.91861°**	**35.94361°**	***Punctum vitreum***	**Glass Spot**	**2**
Fort Dickerson	83.91861°	35.94361°	*Gastrocopta pentodon*	Comb Snaggletooth	2
Fort Dickerson	83.91861°	35.94361°	*Columella simplex*	High-Spire Simplex	2
Fort Dickerson	83.91861°	35.94361°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Fort Dickerson	83.91861°	35.94361°	*Hawaiia minuscula*	Minute Gem	7
Fort Dickerson	83.91861°	35.94361°	*Gastrocopta procera*	Wing Snaggletooth	2
Fort Dickerson	83.91861°	35.94361°	*Euconulus chersinus*	Wild Hive	9
Fort Dickerson	83.91861°	35.94361°	*Gastrocopta armifera*	Armed Snaggletooth	6
Fort Dickerson	83.91861°	35.94361°	*Pupoides albilabris*	White-Lip Dagger	1
Fort Dickerson	83.91861°	35.94361°	*Glyphyalnia wheatleyi*	Bright Glyph	2
Fort Dickerson	83.91861°	35.94361°	*Zonitoides arboreus*	Quick Gloss	2
Fort Dickerson	83.91861°	35.94361°	*Glyphyalinia indentata*	Carved Glyph	11
Fort Dickerson	83.91861°	35.94361°	*Stenotrema stenotrema*	Inland Slitmouth	37
Fort Dickerson	83.91861°	35.94361°	*Ventridens ligera*	Globose Dome	266
Fort Dickerson	83.91861°	35.94361°	*Inflectarius rugeli*	Deep-tooth Shagreen	9
Fort Dickerson	83.91861°	35.94361°	*Patera appressa*	Flat Bladetooth	35
Fort Dickerson	35.945°	83.91722°	*Vallonia pulchella*	Lovely Vallonia	2
Fort Dickerson	35.945°	83.91722°	*Euconulus chersinus*	Wild Hive	4
Fort Dickerson	35.945°	83.91722°	*Gastrocopta armifera*	Armed Snaggletooth	6

Table A1. (Continued.)					
Knox CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Fort Dickerson	35.945°	83.91722°	*Pupoides albilabris*	White-Lip Dagger	2
Fort Dickerson	35.945°	83.91722°	*Glyphyalinia indentata*	Carved Glyph	2
Fort Dickerson	35.945°	83.91722°	*Ventridens demissus*	Perforate Dome	11
Fort Dickerson	35.945°	83.91722°	*Stenotrema stenotrema*	Inland Slitmouth	9
Fort Dickerson	35.945°	83.91722°	*Ventridens ligera*	Globose Dome	129
Fort Dickerson	35.945°	83.91722°	*Inflectarius rugeli*	Deep-tooth Shagreen	43
Fort Dickerson	35.945°	83.91722°	*Patera appressa*	Flat Bladetooth	1
Fort Dickerson	35.945°	83.91722°	*Haplotrema concavum*	Gray-foot Lancetooth	1
Fort Dickerson	35.94694°	83.91972°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Fort Dickerson	35.94694°	83.91972°	*Glyphyalinia indentata*	Carved Glyph	5
Fort Dickerson	35.94694°	83.91972°	*Ventridens demissus*	Perforate Dome	13
Fort Dickerson	35.94694°	83.91972°	*Stenotrema stenotrema*	Inland Slitmouth	3
Fort Dickerson	35.94694°	83.91972°	*Ventridens ligera*	Globose Dome	25
Fort Dickerson	35.94694°	83.91972°	*Inflectarius rugeli*	Deep-tooth Shagreen	20
Ijams	35.95639°	85.86917°	*Gastrocopta armifera*	Armed Snaggletooth	1
Ijams	35.95639°	85.86917°	*Pupoides albilabris*	White-Lip Dagger	4
Ijams	35.95639°	85.86917°	*Inflectarius inflectus*	Shagreen	2
Ijams	35.95639°	85.86917°	*Ventridens ligera*	Globose Dome	105
Ijams	35.95722°	83.86361°	*Columella simplex*	High-Spire Simplex	1
Ijams	35.95722°	83.86361°	*Helicodiscus parallelus*	Compound Coil	1
Ijams	35.95722°	83.86361°	*Stenotrema stenotrema*	Inland Slitmouth	6
Ijams	35.95722°	83.86361°	*Inflectarius inflectus*	Shagreen	10
Ijams	35.95722°	83.86361°	*Stenotrema spinosum*	Carinate Slitmouth	5

Table A1. (Continued.)					
Knox CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Ijams	35.95722°	83.86361°	*Ventridens ligera*	Globose Dome	67
Ijams	35.95722°	83.86361°	*Patera appressa*	Flat Bladetooth	1
Ijams	35.95722°	83.86361°	*Haplotrema concavum*	Gray-foot Lancetooth	20
Ijams	35.95722°	83.86361°	*Mesodon elevatus*	Proud Globe	3
Ijams	35.95722°	83.86361°	*Mesodon zaletus*	Toothed Globe	5
Ijams	35.955°	83.86583°	*Carychium exile*	Ice Thorn	5
Ijams	35.955°	83.86583°	*Zonitoides arboreus*	Quick Gloss	1
Ijams	35.955°	83.86583°	*Paravitrea petrophila*	Cherokee Supercoil	2
Ijams	35.955°	83.86583°	*Glyphyalinia indentata*	Carved Glyph	6
Ijams	35.955°	83.86583°	*Ventridens pilsbryi*	Yellow Dome	8
Ijams	35.955°	83.86583°	*Stenotrema stenotrema*	Inland Slitmouth	1
Ijams	35.955°	83.86583°	*Ventridens ligera*	Globose Dome	5
Ijams	35.955°	83.86583°	*Haplotrema concavum*	Gray-foot Lancetooth	6
Ijams	35.955°	83.86583°	*Triodopsis complanata*	Glossy Threetooth	12
Ijams	35.95167°	83.87028°	*Punctum vitreum*	Glass Spot	4
Ijams	35.95167°	83.87028°	*Carychium exile*	Ice Thorn	2
Ijams	35.95167°	83.87028°	*Striatura meridionalis*	Median Striate	1
Ijams	35.95167°	83.87028°	*Columella simplex*	High-Spire Simplex	1
Ijams	35.95167°	83.87028°	*Gastrocopta contracta*	Bottleneck Snaggletooth	5
Ijams	35.95167°	83.87028°	*Zonitoides arboreus*	Quick Gloss	2
Ijams	35.95167°	83.87028°	*Paravitrea petrophila*	Cherokee Supercoil	1
Ijams	35.95167°	83.87028°	*Discus patulus*	Domed Disc	5
Ijams	35.95167°	83.87028°	*Ventridens collisella*	Sculptured Dome	33
Ijams	35.95167°	83.87028°	*Ventridens demissus*	Perforate Dome	38
Ijams	35.95167°	83.87028°	*Stenotrema stenotrema*	Inland Slitmouth	2

Table A1. (Continued.)					
Knox CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Ijams	35.95167°	83.87028°	*Inflectarius inflectus*	Shagreen	11
Ijams	35.95167°	83.87028°	*Inflectarius rugeli*	Deep-tooth Shagreen	8
Ijams	35.95167°	83.87028°	*Ventridens acerra*	Glossy Dome	59
Sharps Ridge Memorial	35.92556°	83.95028°	*Zonitoides arboreus*	Quick Gloss	5
Sharps Ridge Memorial	35.92556°	83.95028°	*Glyphyalinia indentata*	Carved Glyph	12
Sharps Ridge Memorial	35.92556°	83.95028°	*Ventridens demissus*	Perforate Dome	33
Sharps Ridge Memorial	35.92556°	83.95028°	*Stenotrema stenotrema*	Inland Slitmouth	59
Sharps Ridge Memorial	35.92556°	83.95028°	*Inflectarius inflectus*	Shagreen	13
Sharps Ridge Memorial	35.92556°	83.95028°	*Patera appressa*	Flat Bladetooth	25
Sharps Ridge Memorial	35.99972°	83.94639°	*Strobilops aeneus*	Bronze Pinecone	2
Sharps Ridge Memorial	35.99972°	83.94639°	*Heliodiscus notius*	Tight Coil	4
Sharps Ridge Memorial	35.99972°	83.94639°	*Glyphyalnia wheatleyi*	Bright Glyph	3
Sharps Ridge Memorial	35.99972°	83.94639°	*Zonitoides arboreus*	Quick Gloss	3
Sharps Ridge Memorial	35.99972°	83.94639°	*Paravitrea petrophila*	Cherokee Supercoil	3
Sharps Ridge Memorial	35.99972°	83.94639°	*Glyphyalinia indentata*	Carved Glyph	12
Sharps Ridge Memorial	35.99972°	83.94639°	*Ventridens lasmodon*	Hollow Dome	1
Sharps Ridge Memorial	35.99972°	83.94639°	*Ventridens demissus*	Perforate Dome	8
Sharps Ridge Memorial	35.99972°	83.94639°	*Stenotrema stenotrema*	Inland Slitmouth	2
Sharps Ridge Memorial	35.99972°	83.94639°	*Inflectarius inflectus*	Shagreen	9
Sharps Ridge Memorial	35.99972°	83.94639°	*Ventridens ligera*	Globose Dome	9
Sharps Ridge Memorial	35.99972°	83.94639°	*Patera appressa*	Flat Bladetooth	1
Sharps Ridge Memorial	35.00056°	83.94583°	*Hawaiia minuscula*	Minute Gem	2

Table A1. (Continued.)					
Knox CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Sharps Ridge Memorial	35.00056°	83.94583°	*Helicodiscus parallelus*	Compound Coil	1
Sharps Ridge Memorial	35.00056°	83.94583°	*Heliodiscus notius*	Tight Coil	5
Sharps Ridge Memorial	35.00056°	83.94583°	*Zonitoides arboreus*	Quick Gloss	3
Sharps Ridge Memorial	35.00056°	83.94583°	*Glyphyalinia indentata*	Carved Glyph	12
Sharps Ridge Memorial	35.00056°	83.94583°	*Ventridens lasmodon*	Hollow Dome	32
Sharps Ridge Memorial	35.00056°	83.94583°	*Ventridens demissus*	Perforate Dome	5
Sharps Ridge Memorial	35.00056°	83.94583°	*Inflectarius inflectus*	Shagreen	1
Sharps Ridge Memorial	35.00056°	83.94583°	*Ventridens ligera*	Globose Dome	2
Sharps Ridge Memorial	35.00056°	83.94583°	*Inflectarius rugeli*	Deep-tooth Shagreen	7
Sharps Ridge Memorial	35.00056°	83.94583°	*Ventridens intertextus*	Pyramid Dome	1
Sharps Ridge Memorial	35.00056°	83.94583°	*Mesodon thyroidus*	White-lip Globe	1
Holston River Park	35.97417°	83.86139°	*Vertigo gouldii*	Variable Vertigo	1
Holston River Park	35.97417°	83.86139°	*Gastrocopta tappaniana*	White Snaggletooth	3
Holston River Park	35.97417°	83.86139°	*Gastrocopta procera*	Wing Snaggletooth	1
Holston River Park	35.97417°	83.86139°	*Zonitoides arboreus*	Quick Gloss	1
Holston River Park	35.97417°	83.86139°	*Glyphyalinia indentata*	Carved Glyph	5
Holston River Park	35.97417°	83.86139°	*Ventridens pilsbryi*	Yellow Dome	31
Holston River Park	35.97417°	83.86139°	*Inflectarius inflectus*	Shagreen	1
Holston River Park	35.97278°	83.85861°	*Glyphyalnia wheatleyi*	Bright Glyph	1
Holston River Park	35.97278°	83.85861°	*Zonitoides arboreus*	Quick Gloss	1
Holston River Park	35.97278°	83.85861°	*Ventridens demissus*	Perforate Dome	2
Holston River Park	35.97278°	83.85861°	*Stenotrema stenotrema*	Inland Slitmouth	12

Table A1. (Continued.)					
Knox CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Holston River Park	35.97278°	83.85861°	*Inflectarius inflectus*	Shagreen	5
Holston River Park	35.97278°	83.85861°	*Patera appressa*	Flat Bladetooth	47
Holston River Park	35.97278°	83.85861°	*Stenotrema spinosum*	Carinate Slitmouth	1
Holston River Park	35.97278°	83.85861°	*Haplotrema concavum*	Gray-foot Lancetooth	14
Holston River Park	35.97278°	83.85861°	*Triodopsis complanata*	Glossy Threetooth	14
Holston River Park	35.97278°	83.85861°	*Mesodon zaletus*	Toothed Globe	6
Lakeshore Park	35.92417°	83.98778°	*Euconulus chersinus*	Wild Hive	2
Lakeshore Park	35.92417°	83.98778°	*Gastrocopta armifera*	Armed Snaggletooth	1
Lakeshore Park	35.92417°	83.98778°	*Pupoides albilabris*	White-Lip Dagger	1
Lakeshore Park	35.92417°	83.98778°	*Ventridens demissus*	Perforate Dome	60
Lakeshore Park	35.92194°	83.98778°	*Gastrocopta tappaniana*	White Snaggletooth	1
Lakeshore Park	35.92194°	83.98778°	*Glyphyalinia indentata*	Carved Glyph	3
Lakeshore Park	35.92194°	83.98778°	*Ventridens demissus*	Perforate Dome	126
Lakeshore Park	35.92194°	83.98778°	*Triodopsis hopetonensis*	Magnolia Threetooth	150
Lakeshore Park	35.92556°	83.98972°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Lakeshore Park	35.92556°	83.98972°	*Hawaiia minuscula*	Minute Gem	3
Lakeshore Park	35.92556°	83.98972°	*Euconulus chersinus*	Wild Hive	3
Lakeshore Park	35.92556°	83.98972°	*Zonitoides arboreus*	Quick Gloss	1
Lakeshore Park	35.92556°	83.98972°	*Glyphyalinia indentata*	Carved Glyph	85
Lakeshore Park	35.92556°	83.98972°	*Ventridens demissus*	Perforate Dome	42
Lakeshore Park	35.92556°	83.98972°	*Triodopsis hopetonensis*	Magnolia Threetooth	1
Lakeshore Park	35.92556°	83.98972°	*Ventridens ligera*	Globose Dome	20

Table A1. (Continued.)					
Knox CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Victor Ashe	35.98278°	83.99778°	*Hawaiia minuscula*	Minute Gem	2
Victor Ashe	35.98278°	83.99778°	*Helicodiscus parallelus*	Compound Coil	1
Victor Ashe	35.98278°	83.99778°	*Zonitoides arboreus*	Quick Gloss	1
Victor Ashe	35.98278°	83.99778°	*Glyphyalinia indentata*	Carved Glyph	21
Victor Ashe	35.98278°	83.99778°	*Ventridens pilsbryi*	Yellow Dome	1
Victor Ashe	35.98278°	83.99778°	*Ventridens demissus*	Perforate Dome	57
Victor Ashe	35.98278°	83.99778°	*Triodopsis hopetonensis*	Magnolia Threetooth	4
Victor Ashe	35.98167°	83.99278°	*Striatura meridionalis*	Median Striate	3
Victor Ashe	35.98167°	83.99278°	*Helicodiscus parallelus*	Compound Coil	1
Victor Ashe	35.98167°	83.99278°	*Zonitoides arboreus*	Quick Gloss	9
Victor Ashe	35.98167°	83.99278°	*Glyphyalinia indentata*	Carved Glyph	10
Victor Ashe	35.98167°	83.99278°	*Ventridens demissus*	Perforate Dome	22
Tyson Park	35.95389°	83.94528°	*Triodopsis hopetonensis*	Magnolia Threetooth	2
Tyson Park	35.95389°	83.94528°	*Oxychilus cellarius*	Cellar Glass-snail	18
Tyson Park	35.95389°	83.94528°	*Ventridens ligera*	Globose Dome	63
Tyson Park	35.95389°	83.94528°	*Patera appressa*	Flat Bladetooth	30
Tyson Park	35.95552	83.94648	*Gastrocopta pentodon*	Comb Snaggletooth	1
Tyson Park	35.95552	83.94648	*Striatura meridionalis*	Median Striate	1
Tyson Park	35.95552	83.94648	*Gastrocopta contracta*	Bottleneck Snaggletooth	2
Tyson Park	35.95552	83.94648	*Strobilops labyrinthicus*	Maze Pinecone	2
Tyson Park	35.95552	83.94648	*Gastrocopta armifera*	Armed Snaggletooth	4
Tyson Park	35.95552	83.94648	*Zonitoides arboreus*	Quick Gloss	8
Tyson Park	35.95552	83.94648	*Ventridens pilsbryi*	Yellow Dome	4
Tyson Park	35.95552	83.94648	*Triodopsis hopetonensis*	Magnolia Threetooth	45

Table A1. (Continued.)					
Knox CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Tyson Park	35.95552	83.94648	*Inflectarius inflectus*	Shagreen	10
Tyson Park	35.95552	83.94648	*Ventridens ligera*	Globose Dome	181
Morningside	35.97111°	83.90111°	*Glyphyalinia indentata*	Carved Glyph	3
Morningside	35.97111°	83.90111°	*Cochlicopa lubricella*	Thin Pillar	1
Morningside	35.97111°	83.90111°	*Ventridens demissus*	Perforate Dome	24
Charter Doyle	35.92083°	83.90194°	*Striatura meridionalis*	Median Striate	2
Charter Doyle	35.92083°	83.90194°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Charter Doyle	35.92083°	83.90194°	*Glyphyalinia indentata*	Carved Glyph	17
Charter Doyle	35.92083°	83.90194°	*Stenotrema calvescens*	Chattanooga Slitmouth	1
Charter Doyle	35.92083°	83.90194°	*Ventridens collisella*	Sculptured Dome	19
Charter Doyle	35.92083°	83.90194°	*Ventridens pilsbryi*	Yellow Dome	4
Charter Doyle	35.92083°	83.90194°	*Inflectarius inflectus*	Shagreen	2
Charter Doyle	35.92083°	83.90194°	*Ventridens ligera*	Globose Dome	27
James Smith	35.9858	83.8791	*Ventridens ligera*	Globose Dome	32
Edgewood	36.00122	83.92545	*Glyphyalinia indentata*	Carved Glyph	1
Edgewood	36.00122	83.92545	*Ventridens ligera*	Globose Dome	31
Edgewood	36.00122	83.92545	*Hawaiia minuscula*	Minute Gem	2
Edgewood	36.00122	83.92545	*Opeas pyrgula*	Sharp Awlsnail	1
Edgewood	36.00122	83.92545	*Triodopsis hopetonensis*	Magnolia Threetooth	3
Lonsdale	35.98222°	83.95667°	*Gastrocopta pentodon*	Comb Snaggletooth	1
Lonsdale	35.98222°	83.95667°	*Gastrocopta tappaniana*	White Snaggletooth	1
Lonsdale	35.98222°	83.95667°	*Gastrocopta contracta*	Bottleneck Snaggletooth	9

Table A1. (Continued.)					
Knox CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Lonsdale	35.98222°	83.95667°	*Vallonia pulchella*	Lovely Vallonia	1
Lonsdale	35.98222°	83.95667°	*Gastrocopta procera*	Wing Snaggletooth	3
Lonsdale	35.98222°	83.95667°	*Lucilla singleyanus*	Smooth Coil	5
Lonsdale	35.98222°	83.95667°	*Zonitoides arboreus*	Quick Gloss	28
Lonsdale	35.98222°	83.95667°	*Glyphyalinia indentata*	Carved Glyph	3
Lonsdale	35.98222°	83.95667°	*Cochlicopa lubricella*	Thin Pillar	17
Lonsdale	35.98222°	83.95667°	*Opeas pyrgula*	Sharp Awlsnail	9
Lonsdale	35.98222°	83.95667°	*Triodopsis hopetonensis*	Magnolia Threetooth	113
Lonsdale	35.98222°	83.95667°	*Oxychilus cellarius*	Cellar Glass-snail	3
Lonsdale	35.98222°	83.95667°	*Ventridens ligera*	Globose Dome	16
Lonsdale	35.98222°	83.95667°	*Patera appressa*	Flat Bladetooth	1
Mary James	35.9525°	83.88861°	*Carychium exile*	Ice Thorn	2
Mary James	35.9525°	83.88861°	*Vallonia excentrica*	Iroquois Vallonia	1
Mary James	35.9525°	83.88861°	*Gastrocopta contracta*	Bottleneck Snaggletooth	3
Mary James	35.9525°	83.88861°	*Gastrocopta corticaria*	Bark Snaggletooth	1
Mary James	35.9525°	83.88861°	*Zonitoides arboreus*	Quick Gloss	1
Mary James	35.9525°	83.88861°	*Ventridens demissus*	Perforate Dome	48
Mary James	35.9525°	83.88861°	*Triodopsis hopetonensis*	Magnolia Threetooth	14
Mary James	35.9525°	83.88861°	*Patera appressa*	Flat Bladetooth	1
Mary Vestal	35.93694°	83.91528°	*Gastrocopta contracta*	Bottleneck Snaggletooth	4
Mary Vestal	35.93694°	83.91528°	*Gastrocopta procera*	Wing Snaggletooth	1
Mary Vestal	35.93694°	83.91528°	*Gastrocopta armifera*	Armed Snaggletooth	2
Mary Vestal	35.93694°	83.91528°	*Zonitoides arboreus*	Quick Gloss	4
Mary Vestal	35.93694°	83.91528°	*Glyphyalinia indentata*	Carved Glyph	1

Table A1. (Continued.)					
Knox CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Mary Vestal	35.93694°	83.91528°	*Opeas pyrgula*	Sharp Awlsnail	2
Mary Vestal	35.93694°	83.91528°	*Ventridens demissus*	Perforate Dome	14
Mary Vestal	35.93694°	83.91528°	*Stenotrema stenotrema*	Inland Slitmouth	1
Mary Vestal	35.93694°	83.91528°	*Triodopsis hopetonensis*	Magnolia Threetooth	1
Mary Vestal	35.93694°	83.91528°	*Ventridens ligera*	Globose Dome	40
West Hills	35.93222°	84.04417°	*Gastrocopta contracta*	Bottleneck Snaggletooth	4
West Hills	35.93222°	84.04417°	*Gastrocopta contracta*	Bottleneck Snaggletooth	3
West Hills	35.93222°	84.04417°	*Hawaiia minuscula*	Minute Gem	3
West Hills	35.93222°	84.04417°	*Euconulus chersinus*	Wild Hive	1
West Hills	35.93222°	84.04417°	*Pupoides albilabris*	White-Lip Dagger	1
West Hills	35.93222°	84.04417°	*Zonitoides arboreus*	Quick Gloss	3
West Hills	35.93222°	84.04417°	*Glyphyalinia indentata*	Carved Glyph	6
West Hills	35.93222°	84.04417°	*Opeas pyrgula*	Sharp Awlsnail	1
West Hills	35.93222°	84.04417°	*Ventridens demissus*	Perforate Dome	17
West Hills	35.93222°	84.04417°	*Triodopsis hopetonensis*	Magnolia Threetooth	19
West Hills	35.9325°	84.04472°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
West Hills	35.9325°	84.04472°	*Strobilops labyrinthicus*	Maze Pinecone	3
West Hills	35.9325°	84.04472°	*Helicodiscus parallelus*	Compound Coil	8
West Hills	35.9325°	84.04472°	*Heliodiscus notius*	Tight Coil	5
West Hills	35.9325°	84.04472°	*Gastrocopta armifera*	Armed Snaggletooth	1
West Hills	35.9325°	84.04472°	*Zonitoides arboreus*	Quick Gloss	10
West Hills	35.9325°	84.04472°	*Glyphyalinia indentata*	Carved Glyph	24
West Hills	35.9325°	84.04472°	*Cochlicopa lubricella*	Thin Pillar	2
West Hills	35.9325°	84.04472°	*Discus whitneyi*	Forest Disc	1

Table A1. (Continued.)					
Knox CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
West Hills	35.9325°	84.04472°	*Ventridens demissus*	Perforate Dome	13
West Hills	35.9325°	84.04472°	*Triodopsis hopetonensis*	Magnolia Threetooth	1
West View	35.96611°	83.91222°	*Gastrocopta pentodon*	Comb Snaggletooth	1
West View	35.96611°	83.91222°	*Gastrocopta contracta*	Bottleneck Snaggletooth	8
West View	35.96611°	83.91222°	*Strobilops labyrinthicus*	Maze Pinecone	13
West View	35.96611°	83.91222°	*Hawaiia minuscula*	Minute Gem	2
West View	35.96611°	83.91222°	*Helicodiscus parallelus*	Compound Coil	2
West View	35.96611°	83.91222°	*Gastrocopta armifera*	Armed Snaggletooth	3
West View	35.96611°	83.91222°	*Zonitoides arboreus*	Quick Gloss	9
West View	35.96611°	83.91222°	*Glyphyalinia indentata*	Carved Glyph	6
West View	35.96611°	83.91222°	*Ventridens demissus*	Perforate Dome	72
West View	35.96611°	83.91222°	*Stenotrema stenotrema*	Inland Slitmouth	1
West View	35.96611°	83.91222°	*Triodopsis hopetonensis*	Magnolia Threetooth	41
West View	35.96611°	83.91222°	*Inflectarius inflectus*	Shagreen	2
West View	35.96611°	83.91222°	*Ventridens ligera*	Globose Dome	8
West View	35.96611°	83.91222°	*Patera appressa*	Flat Bladetooth	14
Worlds Fair	35.960092	83.926508	*Gastrocopta contracta*	Bottleneck Snaggletooth	10
Worlds Fair	35.960092	84.926508	*Hawaiia minuscula*	Minute Gem	6
Worlds Fair	35.960092	85.926508	*Gastrocopta procera*	Wing Snaggletooth	1
Worlds Fair	35.960092	86.926508	*Zonitoides arboreus*	Quick Gloss	41
Worlds Fair	35.960092	87.926508	*Ventridens demissus*	Perforate Dome	2
Worlds Fair	35.960092	88.926508	*Catinella vermeta*	Suboval Ambersnail	1
Worlds Fair	35.960092	89.926508	*Stenotrema stenotrema*	Inland Slitmouth	2
Worlds Fair	35.960092	90.926508	*Triodopsis hopetonensis*	Magnolia Threetooth	57

Table A1. (Continued.)

Knox CO Parks	Latitude	Longitude	Scientific name	Common name	# Found
Worlds Fair	35.960092	91.926508	*Polygyra cereolus*	Southern Flatcoil	1
James Agee	35.960563	83.931807	*Gastrocopta contracta*	Bottleneck Snaggletooth	5
James Agee	35.960563	84.931807	*Zonitoides arboreus*	Quick Gloss	2
James Agee	35.960563	85.931807	*Cochlicopa lubricella*	Thin Pillar	5
James Agee	35.960563	86.931807	*Ventridens demissus*	Perforate Dome	276
James Agee	35.960563	87.931807	*Oxychilus cellarius*	Cellar Glass-snail	5
James Agee	35.960563	88.931807	*Ventridens ligera*	Globose Dome	53
Krutch	35.964177	83.921108	*Carychium exile*	Ice Thorn	1
Krutch	35.964177	83.921108	*Vallonia excentrica*	Iroquois Vallonia	2
Krutch	35.964177	83.921108	*Gastrocopta contracta*	Bottleneck Snaggletooth	3
Krutch	35.964177	83.921108	*Strobilops labyrinthicus*	Maze Pinecone	1
Krutch	35.964177	83.921108	*Glyphyalinia indentata*	Carved Glyph	3
Krutch	35.964177	83.921108	*Triodopsis hopetonensis*	Magnolia Threetooth	38
Krutch	35.964177	83.921108	*Ventridens ligera*	Globose Dome	1

Marion CO Parks	Latitude	Longitude	Scientific name	Common name	# Found
Prentice Cooper State Forest	35.13528°	85.13528°	*Striatura meridionalis*	Median Striate	1
Prentice Cooper State Forest	35.13528°	85.13528°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Prentice Cooper State Forest	35.13528°	85.13528°	*Zonitoides arboreus*	Quick Gloss	1
Prentice Cooper State Forest	35.13528°	85.13528°	*Glyphyalinia indentata*	Carved Glyph	4

Table A1. (Continued.)					
Marion CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Prentice Cooper State Forest	35.13528°	85.13528°	*Glyphyalinia solida*	Imperforate Glyph	24
Prentice Cooper State Forest	35.13528°	85.13528°	*Ventridens lawae*	Rounded Dome	22
Prentice Cooper State Forest	35.13528°	85.13528°	*Stenotrema stenotrema*	Inland Slitmouth	1
Prentice Cooper State Forest	35.13528°	85.13528°	*Haplotrema concavum*	Gray-foot Lancetooth	11
Prentice Cooper State Forest	35.12944°	85.3425°	*Glyphyalinia indentata*	Carved Glyph	3
Prentice Cooper State Forest	35.12944°	85.3425°	*Ventridens lawae*	Rounded Dome	26
Prentice Cooper State Forest	35.12944°	85.3425°	*Stenotrema stenotrema*	Inland Slitmouth	1
Prentice Cooper State Forest	35.12944°	85.3425°	*Haplotrema concavum*	Gray-foot Lancetooth	4
Prentice Cooper State Forest	35.12944°	85.3425°	*Mesodon zaletus*	Toothed Globe	1
Prentice Cooper State Forest	35.12528°	85.45472°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Prentice Cooper State Forest	35.12528°	85.45472°	*Paravitrea lamellidens*	Lamellate Supercoil	1
Prentice Cooper State Forest	35.12528°	85.45472°	*Glyphyalinia indentata*	Carved Glyph	13
Prentice Cooper State Forest	35.12528°	85.45472°	*Glyphyalinia solida*	Imperforate Glyph	16
Prentice Cooper State Forest	35.12528°	85.45472°	*Discus patulus*	Domed Disc	1
Prentice Cooper State Forest	35.12528°	85.45472°	*Ventridens lawae*	Rounded Dome	35

Table A1. (Continued.)					
Marion CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Prentice Cooper State Forest	35.12528°	85.45472°	*Stenotrema stenotrema*	Inland Slitmouth	2
Prentice Cooper State Forest	35.14444°	85.36833°	*Zonitoides arboreus*	Quick Gloss	2
Prentice Cooper State Forest	35.14444°	85.36833°	*Glyphyalinia indentata*	Carved Glyph	2
Prentice Cooper State Forest	35.14444°	85.36833°	*Gastrodonta interna*	Brown Bellytooth	4
Prentice Cooper State Forest	35.14444°	85.36833°	*Glyphyalinia solida*	Imperforate Glyph	5
Prentice Cooper State Forest	35.14444°	85.36833°	*Discus patulus*	Domed Disc	1
Prentice Cooper State Forest	35.14444°	85.36833°	*Ventridens lawae*	Rounded Dome	32
Prentice Cooper State Forest	35.14444°	85.36833°	*Stenotrema stenotrema*	Inland Slitmouth	1
Prentice Cooper State Forest	35.14444°	85.36833°	*Haplotrema concavum*	Gray-foot Lancetooth	3
Prentice Cooper State Forest	35.05194°	85.45611°	*Zonitoides arboreus*	Quick Gloss	5
Prentice Cooper State Forest	35.05194°	85.45611°	*Glyphyalinia praecox*	Brilliant Glyph	11
Prentice Cooper State Forest	35.05194°	85.45611°	*Gastrodonta interna*	Brown Bellytooth	8
Prentice Cooper State Forest	35.05194°	85.45611°	*Glyphyalinia solida*	Imperforate Glyph	1
Prentice Cooper State Forest	35.05194°	85.45611°	*Discus patulus*	Domed Disc	4
Prentice Cooper State Forest	35.05194°	85.45611°	*Ventridens pilsbryi*	Yellow Dome	18

Table A1. (Continued.)					
Marion CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Prentice Cooper State Forest	35.05194°	85.45611°	*Stenotrema stenotrema*	Inland Slitmouth	6
Prentice Cooper State Forest	35.05194°	85.45611°	*Inflectarius inflectus*	Shagreen	2
Prentice Cooper State Forest	35.05194°	85.45611°	*Ventridens intertextus*	Pyramid Dome	1
Prentice Cooper State Forest	35.05194°	85.45611°	*Haplotrema concavum*	Gray-foot Lancetooth	6
Prentice Cooper State Forest	35.05194°	85.45611°	*Patera perigrapta*	Engraved Bladetooth	1
Prentice Cooper State Forest	35.05194°	85.45611°	*Anguispira alternata*	Flamed Tigersnail	1
Prentice Cooper State Forest	35.05806°	85.4725°	*Lucilla scintilla*	Oldfield Coil	1
Prentice Cooper State Forest	35.05806°	85.4725°	*Glyphyalinia cryptomphala*	Thin Glyph	10
Prentice Cooper State Forest	35.05806°	85.4725°	*Zonitoides arboreus*	Quick Gloss	25
Prentice Cooper State Forest	35.05806°	85.4725°	*Glyphyalinia praecox*	Brilliant Glyph	3
Prentice Cooper State Forest	35.05806°	85.4725°	*Gastrodonta interna*	Brown Bellytooth	38
Prentice Cooper State Forest	35.05806°	85.4725°	*Discus patulus*	Domed Disc	1
Prentice Cooper State Forest	35.05806°	85.4725°	*Stenotrema hirsutum*	Hairy Slitmouth	3
Prentice Cooper State Forest	35.05806°	85.4725°	*Ventridens pilsbryi*	Yellow Dome	6
Prentice Cooper State Forest	35.05806°	85.4725°	*Stenotrema stenotrema*	Inland Slitmouth	2

Table A1. (Continued.)					
Marion CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Prentice Cooper State Forest	35.05806°	85.4725°	*Inflectarius inflectus*	Shagreen	4
Prentice Cooper State Forest	35.05806°	85.4725°	*Patera perigrapta*	Engraved Bladetooth	2
Prentice Cooper State Forest	35.08583°	85.42556°	*Zonitoides arboreus*	Quick Gloss	1
Prentice Cooper State Forest	35.08583°	85.42556°	*Glyphyalinia indentata*	Carved Glyph	12
Prentice Cooper State Forest	35.08583°	85.42556°	*Gastrodonta interna*	Brown Bellytooth	2
Prentice Cooper State Forest	35.08583°	85.42556°	*Glyphyalinia solida*	Imperforate Glyph	2
Prentice Cooper State Forest	35.08583°	85.42556°	*Stenotrema hirsutum*	Hairy Slitmouth	1
Prentice Cooper State Forest	35.08583°	85.42556°	*Ventridens pilsbryi*	Yellow Dome	8
Prentice Cooper State Forest	35.08583°	85.42556°	*Triodopsis tridentata*	Northern Threetooth	2
Prentice Cooper State Forest	35.08583°	85.42556°	*Patera perigrapta*	Engraved Bladetooth	1
Prentice Cooper State Forest	35.11333°	85.43583°	*Zonitoides arboreus*	Quick Gloss	9
Prentice Cooper State Forest	35.11333°	85.43583°	*Glyphyalinia indentata*	Carved Glyph	1
Prentice Cooper State Forest	35.11333°	85.43583°	*Gastrodonta interna*	Brown Bellytooth	7
Prentice Cooper State Forest	35.11333°	85.43583°	*Glyphyalinia solida*	Imperforate Glyph	9
Prentice Cooper State Forest	35.11333°	85.43583°	*Ventridens lawae*	Rounded Dome	24

Table A1. (Continued.)					
Marion CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Prentice Cooper State Forest	35.11333°	85.43583°	*Triodopsis tridentata*	Northern Threetooth	2
Prentice Cooper State Forest	35.11333°	85.43583°	*Patera perigrapta*	Engraved Bladetooth	1

Hamilton CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Enterprise	35.07778°	85.11583°	*Glyphyalinia indentata*	Carved Glyph	8
Enterprise	35.07778°	85.11583°	*Gastrodonta interna*	Brown Bellytooth	49
Enterprise	35.07778°	85.11583°	*Ventridens pilsbryi*	Yellow Dome	8
Enterprise	35.07778°	85.11583°	*Stenotrema barbatum*	Bristled Slitmouth	3
Enterprise	35.07778°	85.11583°	*Inflectarius inflectus*	Shagreen	17
Enterprise	35.07778°	85.11583°	*Ventridens intertextus*	Pyramid Dome	7
Enterprise	35.07778°	85.11583°	*Mesodon thyroidus*	White-lip Globe	4
Enterprise	35.07778°	85.11583°	*Mesodon normalis*	Grand Globe	2
Enterprise	35.10944°	85.14°	*Glyphyalnia wheatleyi*	Bright Glyph	2
Enterprise	35.10944°	85.14°	*Zonitoides arboreus*	Quick Gloss	2
Enterprise	35.10944°	85.14°	*Glyphyalinia indentata*	Carved Glyph	11
Enterprise	35.10944°	85.14°	*Discus patulus*	Domed Disc	48
Enterprise	35.10944°	85.14°	*Ventridens pilsbryi*	Yellow Dome	14
Enterprise	35.10944°	85.14°	*Triodopsis hopetonensis*	Magnolia Threetooth	4
Enterprise	35.10944°	85.14°	*Inflectarius inflectus*	Shagreen	12
Enterprise	35.10944°	85.14°	*Ventridens intertextus*	Pyramid Dome	2
Enterprise	35.09889°	85.10361°	*Millerelix plicata*	Cumberland Liptooth	5

Table A1. (Continued.)					
Hamilton CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Enterprise	35.09889°	85.10361°	*Zonitoides arboreus*	Quick Gloss	2
Enterprise	35.09889°	85.10361°	*Glyphyalinia indentata*	Carved Glyph	2
Enterprise	35.09889°	85.10361°	*Opeas pyrgula*	Sharp Awlsnail	2
Enterprise	35.09889°	85.10361°	*Ventridens intertextus*	Pyramid Dome	7
Enterprise	35.09889°	85.10361°	*Mesodon thyroidus*	White-lip Globe	2
Enterprise	35.09047	85.11332	*Glyphyalinia indentata*	Carved Glyph	56
Enterprise	35.09047	85.11332	*Gastrodonta interna*	Brown Bellytooth	36
Enterprise	35.09047	85.11332	*Stenotrema barbatum*	Bristled Slitmouth	2
Enterprise	35.09047	85.11332	*Inflectarius inflectus*	Shagreen	2
Enterprise	35.09047	85.11332	*Ventridens intertextus*	Pyramid Dome	6
Enterprise	35.09047	85.11332	*Mesodon normalis*	Grand Globe	2
Enterprise	35.09047	85.119893	*Zonitoides arboreus*	Quick Gloss	1
Enterprise	35.09047	85.119893	*Glyphyalinia indentata*	Carved Glyph	15
Enterprise	35.09047	85.119893	*Gastrodonta interna*	Brown Bellytooth	5
Enterprise	35.09047	85.119893	*Ventridens pilsbryi*	Yellow Dome	14
Enterprise	35.09047	85.119893	*Inflectarius inflectus*	Shagreen	3
Enterprise	35.09047	85.119893	*Ventridens intertextus*	Pyramid Dome	3
Enterprise	35.09047	85.119893	*Mesomphix perlaevis*	Smooth Button	2
Enterprise	35.09047	85.119893	*Xolotrema denotatum*	Velvet Wedge	1
Enterprise	35.09047	85.119893	*Mesodon thyroidus*	White-lip Globe	6
Enterprise	35.09047	85.119893	*Mesodon normalis*	Grand Globe	1
Stringers Ridge	35.07972°	85.30806°	*Strobilops labyrinthicus*	Maze Pinecone	1
Stringers Ridge	35.07972°	85.30806°	*Heliodiscus notius*	Tight Coil	13
Stringers Ridge	35.07972°	85.30806°	*Glyphyalnia wheatleyi*	Bright Glyph	2

Table A1. (Continued.)					
Hamilton CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Stringers Ridge	35.07972°	85.30806°	*Millerelix plicata*	Cumberland Liptooth	2
Stringers Ridge	35.07972°	85.30806°	*Zonitoides arboreus*	Quick Gloss	49
Stringers Ridge	35.07972°	85.30806°	*Glyphyalinia indentata*	Carved Glyph	2
Stringers Ridge	35.07972°	85.30806°	*Gastrodonta interna*	Brown Bellytooth	79
Stringers Ridge	35.07972°	85.30806°	*Glyphyalinia caroliniensis*	Spiral Mountain Glyph	62
Stringers Ridge	35.07972°	85.30806°	*Stenotrema stenotrema*	Inland Slitmouth	23
Stringers Ridge	35.07972°	85.30806°	*Inflectarius inflectus*	Shagreen	59
Stringers Ridge	35.07972°	85.30806°	*Ventridens acerra*	Glossy Dome	10
Stringers Ridge	35.07972°	85.30806°	*Ventridens intertextus*	Pyramid Dome	10
Stringers Ridge	35.07972°	85.30806°	*Mesodon thyroidus*	White-lip Globe	6
Stringers Ridge	35.07423	85.314739	*Strobilops labyrinthicus*	Maze Pinecone	1
Stringers Ridge	35.07423	85.314739	*Zonitoides arboreus*	Quick Gloss	24
Stringers Ridge	35.07423	85.314739	*Glyphyalinia indentata*	Carved Glyph	12
Stringers Ridge	35.07423	85.314739	*Glyphyalinia caroliniensis*	Spiral Mountain Glyph	1
Stringers Ridge	35.07423	85.314739	*Stenotrema stenotrema*	Inland Slitmouth	20
Stringers Ridge	35.07423	85.314739	*Inflectarius inflectus*	Shagreen	3
Stringers Ridge	35.07423	85.314739	*Ventridens intertextus*	Pyramid Dome	2
Stringers Ridge	35.07423	85.314739	*Triodopsis tridentata*	Northern Threetooth	24
Stringers Ridge	35.07423	85.314739	*Haplotrema concavum*	Gray-foot Lancetooth	12
Stringers Ridge	35.07278°	85.31556°	*Zonitoides arboreus*	Quick Gloss	9
Stringers Ridge	35.07278°	85.31556°	*Glyphyalinia indentata*	Carved Glyph	11
Stringers Ridge	35.07278°	85.31556°	*Gastrodonta interna*	Brown Bellytooth	4

Table A1. (Continued.)					
Hamilton CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Stringers Ridge	35.07278°	85.31556°	*Glyphyalinia caroliniensis*	Spiral Mountain Glyph	8
Stringers Ridge	35.07278°	85.31556°	*Stenotrema stenotrema*	Inland Slitmouth	31
Stringers Ridge	35.07278°	85.31556°	*Inflectarius inflectus*	Shagreen	14
Stringers Ridge	35.07278°	85.31556°	*Ventridens intertextus*	Pyramid Dome	9
TN River Park	35.09667°	85.25361°	*Gastrocopta tappaniana*	White Snaggletooth	2
TN River Park	35.09667°	85.25361°	*Gastrocopta contracta*	Bottleneck Snaggletooth	3
TN River Park	35.09667°	85.25361°	*Hawaiia minuscula*	Minute Gem	2
TN River Park	35.09667°	85.25361°	*Gastrocopta procera*	Wing Snaggletooth	1
TN River Park	35.09667°	85.25361°	*Helicodiscus parallelus*	Compound Coil	2
TN River Park	35.09667°	85.25361°	*Zonitoides arboreus*	Quick Gloss	4
TN River Park	35.09667°	85.25361°	*Glyphyalinia indentata*	Carved Glyph	27
TN River Park	35.09667°	85.25361°	*Pomatiopsis lapidaria*	Slender Walker	8
TN River Park	35.09667°	85.25361°	*Glyphyalinia solida*	Imperforate Glyph	2
TN River Park	35.09667°	85.25361°	*Opeas pyrgula*	Sharp Awlsnail	7
TN River Park	35.09667°	85.25361°	*Ventridens demissus*	Perforate Dome	229
TN River Park	35.09667°	85.25361°	*Triodopsis hopetonensis*	Magnolia Threetooth	4
TN River Park	35.09667°	85.25361°	*Inflectarius inflectus*	Shagreen	15
TN River Park	35.09667°	85.25361°	*Anguispira alternata*	Flamed Tigersnail	1
TN River Park	35.09667°	85.25361°	*Mesodon thyroidus*	White-lip Globe	1
TN River Park	35.08889°	85.24667°	*Gastrocopta pentodon*	Comb Snaggletooth	4
TN River Park	35.08889°	85.24667°	*Gastrocopta procera*	Wing Snaggletooth	1
TN River Park	35.08889°	85.24667°	*Helicodiscus parallelus*	Compound Coil	5
TN River Park	35.08889°	85.24667°	*Zonitoides arboreus*	Quick Gloss	5

Table A1. (Continued.)					
Hamilton CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
TN River Park	35.08889°	85.24667°	*Paravitrea capsella*	Dimple Supercoil	3
TN River Park	35.08889°	85.24667°	*Glyphyalinia indentata*	Carved Glyph	5
TN River Park	35.08889°	85.24667°	*Pomatiopsis lapidaria*	Slender Walker	7
TN River Park	35.08889°	85.24667°	*Glyphyalinia solida*	Imperforate Glyph	1
TN River Park	35.08889°	85.24667°	*Ventridens demissus*	Perforate Dome	137
TN River Park	35.08889°	85.24667°	*Inflectarius inflectus*	Shagreen	45
TN River Park	35.08889°	85.24667°	*Anguispira alternata*	Flamed Tigersnail	11
Dupont	35.10694°	85.24889°	*Helicodiscus parallelus*	Compound Coil	1
Dupont	35.10694°	85.24889°	*Gastrocopta armifera*	Armed Snaggletooth	5
Dupont	35.10694°	85.24889°	*Pupoides albilabris*	White-Lip Dagger	1
Dupont	35.10694°	85.24889°	*Zonitoides arboreus*	Quick Gloss	2
Dupont	35.10694°	85.24889°	*Glyphyalinia indentata*	Carved Glyph	11
Dupont	35.10694°	85.24889°	*Cochlicopa lubricella*	Thin Pillar	1
Dupont	35.10694°	85.24889°	*Opeas pyrgula*	Sharp Awlsnail	1
Dupont	35.10694°	85.24889°	*Ventridens demissus*	Perforate Dome	2
Dupont	35.10694°	85.24889°	*Inflectarius inflectus*	Shagreen	10
Dupont	35.10694°	85.24889°	*Ventridens ligera*	Globose Dome	6
Dupont	35.10694°	85.24889°	*Ventridens intertextus*	Pyramid Dome	53
Greenway Farm	35.11389°	85.22417°	*Carychium exile*	Ice Thorn	2
Greenway Farm	35.11389°	85.22417°	*Hawaiia minuscula*	Minute Gem	1
Greenway Farm	35.11389°	85.22417°	*Paravitrea capsella*	Dimple Supercoil	5
Greenway Farm	35.11389°	85.22417°	*Glyphyalinia indentata*	Carved Glyph	25
Greenway Farm	35.11389°	85.22417°	*Glyphyalinia solida*	Imperforate Glyph	2

Table A1. (Continued.)					
Hamilton CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Greenway Farm	35.11389°	85.22417°	*Stenotrema stenotrema*	Inland Slitmouth	6
Greenway Farm	35.11389°	85.22417°	*Inflectarius inflectus*	Shagreen	1
Greenway Farm	35.11389°	85.22417°	*Inflectarius rugeli*	Deep-tooth Shagreen	1
Greenway Farm	35.11389°	85.22417°	*Triodopsis vulgata*	Dished Threetooth	15
Greenway Farm	35.11389°	85.22417°	*Haplotrema concavum*	Gray-foot Lancetooth	14
Greenway Farm	35.11389°	85.22417°	*Mesomphix vulgatus*	Common Button	34
Greenway Farm	35.11778°	85.22333°	*Carychium exile*	Ice Thorn	10
Greenway Farm	35.11778°	85.22333°	*Gastrocopta pentodon*	Comb Snaggletooth	1
Greenway Farm	35.11778°	85.22333°	*Hawaiia minuscula*	Minute Gem	1
Greenway Farm	35.11778°	85.22333°	*Strobilops aeneus*	Bronze Pinecone	1
Greenway Farm	35.11778°	85.22333°	*Paravitrea capsella*	Dimple Supercoil	2
Greenway Farm	35.11778°	85.22333°	*Glyphyalinia indentata*	Carved Glyph	10
Greenway Farm	35.11778°	85.22333°	*Glyphyalinia solida*	Imperforate Glyph	8
Greenway Farm	35.11778°	85.22333°	*Oligyra orbiculata*	Globular Drop	1
Greenway Farm	35.11778°	85.22333°	*Stenotrema stenotrema*	Inland Slitmouth	6
Greenway Farm	35.11778°	85.22333°	*Inflectarius inflectus*	Shagreen	5
Greenway Farm	35.11778°	85.22333°	*Mesodon clausus*	Yellow Globelet	3
Greenway Farm	35.11778°	85.22333°	*Triodopsis vulgata*	Dished Threetooth	10
Greenway Farm	35.11778°	85.22333°	*Haplotrema concavum*	Gray-foot Lancetooth	17
Greenway Farm	35.11778°	85.22333°	*Xolotrema denotatum*	Velvet Wedge	2
Greenway Farm	35.11778°	85.22333°	*Mesomphix vulgatus*	Common Button	20
Greenway Farm	35.11778°	85.22333°	*Anguispira alternata*	Flamed Tigersnail	1
Greenway Farm	35.12361°	85.21889°	*Carychium exile*	Ice Thorn	55

Table A1. (Continued.)					
Hamilton CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Greenway Farm	35.12361°	85.21889°	*Gastrocopta pentodon*	Comb Snaggletooth	2
Greenway Farm	35.12361°	85.21889°	*Gastrocopta tappaniana*	White Snaggletooth	3
Greenway Farm	35.12361°	85.21889°	*Lucilla scintilla*	Oldfield Coil	16
Greenway Farm	35.12361°	85.21889°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Greenway Farm	35.12361°	85.21889°	*Helicodiscus parallelus*	Compound Coil	2
Greenway Farm	35.12361°	85.21889°	*Gastrocopta armifera*	Armed Snaggletooth	2
Greenway Farm	35.12361°	85.21889°	*Zonitoides arboreus*	Quick Gloss	1
Greenway Farm	35.12361°	85.21889°	*Paravitrea capsella*	Dimple Supercoil	1
Greenway Farm	35.12361°	85.21889°	*Glyphyalinia indentata*	Carved Glyph	8
Greenway Farm	35.12361°	85.21889°	*Oligyra orbiculata*	Globular Drop	2
Greenway Farm	35.12361°	85.21889°	*Ventridens demissus*	Perforate Dome	56
Greenway Farm	35.12361°	85.21889°	*Triodopsis alabamensis*	Alabama Threetooth	3
Greenway Farm	35.12361°	85.21889°	*Stenotrema stenotrema*	Inland Slitmouth	1
Greenway Farm	35.12361°	85.21889°	*Triodopsis hopetonensis*	Magnolia Threetooth	1
Greenway Farm	35.12361°	85.21889°	*Inflectarius inflectus*	Shagreen	1
Greenway Farm	35.12361°	85.21889°	*Patera appressa*	Flat Bladetooth	6
Greenway Farm	35.12361°	85.21889°	*Novisuccinea ovalis*	Oval Ambersnail	2
Greenway Farm	35.12361°	85.21889°	*Haplotrema concavum*	Gray-foot Lancetooth	1
Greenway Farm	35.12361°	85.21889°	*Mesomphix vulgatus*	Common Button	1
Greenway Farm	35.12361°	85.21889°	*Mesodon thyroidus*	White-lip Globe	8
Greenway Farm	35.12361°	85.21889°	*Mesodon zaletus*	Toothed Globe	1
East Lake	35.00028°	85.27694°	*Gastrocopta armifera*	Armed Snaggletooth	4
East Lake	35.00028°	85.27694°	*Pupoides albilabris*	White-Lip Dagger	1
East Lake	35.00028°	85.27694°	*Zonitoides arboreus*	Quick Gloss	2

Table A1. (Continued.)

Hamilton CO Parks	Latitude	Longitude	Scientific name	Common name	# Found
East Lake	35.00028°	85.27694°	*Glyphyalinia indentata*	Carved Glyph	10
East Lake	35.00028°	85.27694°	*Gastrodonta interna*	Brown Bellytooth	2
East Lake	35.00028°	85.27694°	*Ventridens demissus*	Perforate Dome	5
East Lake	35.00028°	85.27694°	*Inflectarius inflectus*	Shagreen	1
East Lake	35.00028°	85.27694°	*Ventridens ligera*	Globose Dome	389
East Lake	35.00028°	85.27694°	*Patera appressa*	Flat Bladetooth	1
Brainerd	35.02583°	85.21667°	*Punctum minutissimum*	Small Spot	4
Brainerd	35.02583°	85.21667°	*Striatura meridionalis*	Median Striate	5
Brainerd	35.02583°	85.21667°	*Gastrocopta tappaniana*	White Snaggletooth	9
Brainerd	35.02583°	85.21667°	*Gastrocopta contracta*	Bottleneck Snaggletooth	3
Brainerd	35.02583°	85.21667°	*Hawaiia minuscula*	Minute Gem	1
Brainerd	35.02583°	85.21667°	*Euconulus trochulus*	Silk Hive	6
Brainerd	35.02583°	85.21667°	*Pupoides albilabris*	White-Lip Dagger	1
Brainerd	35.02583°	85.21667°	*Zonitoides arboreus*	Quick Gloss	3
Hamilton CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Brainerd	35.02583°	85.21667°	*Glyphyalinia indentata*	Carved Glyph	183
Brainerd	35.02583°	85.21667°	*Glyphyalinia solida*	Imperforate Glyph	5
Brainerd	35.02583°	85.21667°	*Opeas pyrgula*	Sharp Awlsnail	2
Brainerd	35.02583°	85.21667°	*Triodopsis hopetonensis*	Magnolia Threetooth	3
Brainerd	35.02583°	85.21667°	*Ventridens ligera*	Globose Dome	45
Brainerd	35.02583°	85.21667°	*Haplotrema concavum*	Gray-foot Lancetooth	11
Carver	35.04417°	85.27194°	*Hawaiia minuscula*	Minute Gem	1
Carver	35.04417°	85.27194°	*Triodopsis hopetonensis*	Magnolia Threetooth	1
Carver	35.04417°	85.27194°	*Ventridens ligera*	Globose Dome	34
Carver	35.04417°	85.27194°	*Novisuccinea ovalis*	Oval Ambersnail	1

Table A1. (Continued.)					
Hamilton CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Lake Hille	35.08083°	85.19778°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Lake Hille	35.08083°	85.19778°	*Glyphyalinia indentata*	Carved Glyph	2
Lake Hille	35.08083°	85.19778°	*Pomatiopsis lapidaria*	Slender Walker	1
Lake Hille	35.08083°	85.19778°	*Glyphyalinia solida*	Imperforate Glyph	4
Lake Hille	35.08083°	85.19778°	*Opeas pyrgula*	Sharp Awlsnail	1
Lake Hille	35.08083°	85.19778°	*Ventridens demissus*	Perforate Dome	37
Harris Johnson	35.02441	85.315	*Gastrocopta tappaniana*	White Snaggletooth	1
Harris Johnson	35.02441	85.315	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Harris Johnson	35.02441	85.315	*Hawaiia minuscula*	Minute Gem	5
Harris Johnson	35.02441	85.315	*Helicodiscus parallelus*	Compound Coil	2
Harris Johnson	35.02441	85.315	*Gastrocopta armifera*	Armed Snaggletooth	2
Harris Johnson	35.02441	85.315	*Glyphyalinia indentata*	Carved Glyph	3
Harris Johnson	35.02441	85.315	*Glyphyalinia solida*	Imperforate Glyph	10
Harris Johnson	35.02441	85.315	*Stenotrema barbatum*	Bristled Slitmouth	1
Harris Johnson	35.02441	85.315	*Ventridens ligera*	Globose Dome	15
Overlook	35.02972°	83.2575°	*Zonitoides arboreus*	Quick Gloss	6
Overlook	35.02972°	83.2575°	*Cochlicopa lubricella*	Thin Pillar	3
Overlook	35.02972°	83.2575°	*Opeas pyrgula*	Sharp Awlsnail	12
Overlook	35.02972°	83.2575°	*Ventridens ligera*	Globose Dome	39
Perkins	35.04583°	85.29194°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Perkins	35.04583°	85.29194°	*Gastrocopta armifera*	Armed Snaggletooth	1
Perkins	35.04583°	85.29194°	*Glyphyalinia indentata*	Carved Glyph	6
Perkins	35.04583°	85.29194°	*Ventridens ligera*	Globose Dome	49

Table A1. (Continued.)					
Hamilton CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Perkins	35.04583°	85.29194°	*Patera appressa*	Flat Bladetooth	2
Perkins	35.04583°	85.29194°	*Cepaea nemoralis*	Grovesnail	5
Bird Sanctuary	35.0728	85.2844	*Glyphyalinia indentata*	Carved Glyph	2
Bird Sanctuary	35.0728	85.2844	*Glyphyalinia solida*	Imperforate Glyph	1
Bird Sanctuary	35.0728	85.2844	*Ventridens demissus*	Perforate Dome	39
Bird Sanctuary	35.0728	85.2844	*Triodopsis hopetonensis*	Magnolia Threetooth	4
Bird Sanctuary	35.0728	85.2844	*Inflectarius inflectus*	Shagreen	1
Bird Sanctuary	35.0728	85.2844	*Anguispira alternata*	Flamed Tigersnail	9
Caruthers	35.00583°	85.29722°	*Carychium exile*	Ice Thorn	3
Caruthers	35.00583°	85.29722°	*Gastrocopta pentodon*	Comb Snaggletooth	1
Caruthers	35.00583°	85.29722°	*Vallonia excentrica*	Iroquois Vallonia	1
Caruthers	35.00583°	85.29722°	*Gastrocopta contracta*	Bottleneck Snaggletooth	1
Caruthers	35.00583°	85.29722°	*Hawaiia minuscula*	Minute Gem	2
Caruthers	35.00583°	85.29722°	*Zonitoides arboreus*	Quick Gloss	2
Caruthers	35.00583°	85.29722°	*Paravitrea capsella*	Dimple Supercoil	1
Caruthers	35.00583°	85.29722°	*Glyphyalinia indentata*	Carved Glyph	15
Caruthers	35.00583°	85.29722°	*Ventridens demissus*	Perforate Dome	63
Caruthers	35.00583°	85.29722°	*Novisuccinea ovalis*	Oval Ambersnail	3
Miller	35.04583°	85.30361°	*Hawaiia minuscula*	Minute Gem	1
Miller	35.04583°	85.30361°	*Gastrocopta armifera*	Armed Snaggletooth	11
Miller	35.04583°	85.30361°	*Pupoides albilabris*	White-Lip Dagger	14
Miller	35.04583°	85.30361°	*Zonitoides arboreus*	Quick Gloss	5
Miller	35.04583°	85.30361°	*Glyphyalinia indentata*	Carved Glyph	2

Table A1. (Continued.)					
Hamilton CO Parks	**Latitude**	**Longitude**	**Scientific name**	**Common name**	**# Found**
Miller	35.04583°	85.30361°	*Opeas pyrgula*	Sharp Awlsnail	2
Miller	35.04583°	85.30361°	*Ventridens demissus*	Perforate Dome	115
Fountain	35.05048	85.30912	*Gastrocopta contracta*	Bottleneck Snaggletooth	2
Fountain	35.05048	85.30912	*Hawaiia minuscula*	Minute Gem	5
Fountain	35.05048	85.30912	*Zonitoides arboreus*	Quick Gloss	9
Fountain	35.05048	85.30912	*Glyphyalinia indentata*	Carved Glyph	1
Fountain	35.05048	85.30912	*Ventridens demissus*	Perforate Dome	18
Fountain	35.05048	85.30912	*Triodopsis hopetonensis*	Magnolia Threetooth	7
Coolidge	35.06078	85.30967	*Gastrocopta armifera*	Armed Snaggletooth	4
Coolidge	35.06078	85.30967	*Pupoides albilabris*	White-Lip Dagger	1
Coolidge	35.06078	85.30967	*Paravitrea capsella*	Dimple Supercoil	4
Coolidge	35.06078	85.30967	*Glyphyalinia indentata*	Carved Glyph	10
Coolidge	35.06078	85.30967	*Ventridens demissus*	Perforate Dome	31
Coolidge	35.06078	85.30967	*Triodopsis hopetonensis*	Magnolia Threetooth	43
Coolidge	35.06078	85.30967	*Patera appressa*	Flat Bladetooth	3

VITA

Mackenzie Hodges grew up in middle Tennessee where she attended Harpeth High School, graduating in 2008. Her love of flora and fauna was nurtured by her parents and grandparents who, understandably, kept her and her four older brothers outside as much as possible.

She pursued a degree in Environmental Studies, where she focused on Wildlife Ecology, and graduated with a Bachelors of Science in Geology and Environmental Studies from The University of Tennessee in Knoxville in 2012.

Mackenzie took a year off of school after obtaining her Bachelor's degree to learn about bees and beekeeping with her partner, a hobby which has today turned into Honey Possum Apiary. It was at this point she realized (through the constant hints from Dr. McKinney) that she wasn't done with academics. She was accepted into the Master of Geology program at The University of Tennessee in 2013 where her growing interest in gastropods led to this two year exploration into the small world urban snails.