An Inventory of the Land Snails and Slugs (Gastropoda: Caenogastropoda and Pulmonata) of Knox County, Tennessee

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An Inventory of the Land Snails and Slugs (Gastropoda: Caenogastropoda and Pulmonata) of Knox County, Tennessee

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Abstract: Terrestrial mollusks (land snails and slugs) are an important component of the terrestrial ecosystem, yet for most species their distribution is not well known. This study was a comprehensive inventory of terrestrial mollusks in Knox County, Tennessee; an area within the Valley and Ridge physiographic region rich in calcareous soils and bluffs. Knox County supports a total of 151 species, including 70 newly reported to the county and 15 newly reported to Tennessee. Sixteen species non-native to North America were found, mostly in urban/residential habitats. Limestone/sandstone bluffs were found to have the highest diversity of terrestrial mollusks.

Key words: Terrestrial Gastropoda, Knox County, Tennessee, Ridge and Valley physiographic region

Land snails and slugs (Gastropoda: Caenogastropopoda and Pulmonata) are a vital component of the terrestrial ecosystem. As a group, they serve many roles: they can be detritivorous, herbivorous, or predaceous and be an important source of calcium and food for other animal groups, including insects, birds, reptiles and amphibians, and small mammals (Ingram 1950, Martin *et al.* 1951, Speiser 2001, Allen 2004, Symondson 2004). In the Netherlands, passerine birds had significantly lower eggshell quality in areas of low snail density (Graveland 1996). Some salamander species rely on land snails as a calcium source and their density is linked to the density of land snails (Harper and Guyen 1999). Empty land snail shells are often used as shelter by other invertebrates (Taylor *et al.* 1977, Dourson 2010, pers. obs.). Snails are present and often abundant in most terrestrial habitats in eastern U.S.A. and the Southeast supports an extraordinarily high diversity, as shown by Coney *et al.* (1982), Hubricht (1985), Dourson and Freeman (2006), Dourson (2007, 2010, 2013), Caldwell and Dourson (2008), and Douglas *et al.* (2010, 2014).

Specimens of terrestrial mollusks from Knox County, Tennessee have been archived in several institutions, and were collected as early as the 1800's by a number of notable researchers, including Mrs. George Andrews, George H. Clapp, Leslie Hubricht, Arnold Ortmann, Henry Pilsbry, Victor Sterki, and Bryant Walker. Several publications have dealt with the occurrence of land snails in Tennessee. Lutz (1950) surveyed Claiborne County and reported 20 species. Bogan *et al.* (1982) reported on the distribution of Polygyridae in Tennessee and reported 75 species. Hubricht (1985) presented distributional information on land snails in eastern U.S.A. counties and provided a map for each species. For Knox County, he reported 76 species. Hubricht's maps were a compilation of published sources, and combined his collecting efforts with specimens collected by others but verified by him. Nekola and Coles (2010) provided distributional information on Pupillidae in North America, and for Knox County they reported 7 species. Except for Lutz (1950), our survey is the first inventory of terrestrial mollusks in Tennessee that focused on an individual county. Herein, we use the term "land snail" for all species of terrestrial mollusks, *i.e.*, including slugs.

MATERIALS AND METHODS

Study area

Knox County is situated in the eastern third of Tennessee and is entirely within the Southern Appalachian Valley and Ridge physiographic region, a 60–90 km wide belt of northeast-southwest trending ridges and valleys extending from Maryland south to Georgia and Alabama. Knox County is situated approximately midway between the Kentucky and Georgia borders and has a total area of 1,360 km^2, of which 1317 km^2 is land and 43 km^2 is water. Knox County's land area is 54% tree canopy, 28% open space, 13% impervious surface, and 5% bare ground (American Forests 2002). The average annual temperature and precipitation for Knoxville (Knox County's largest city), is 15.3° C and 122.4 cm, respectively (Your Weather Service 2017). Significant land features in Knox County include House Mountain (the county's highest point located in its northeast corner), Bays Mountains complex, McAnnally Ridge, Beaver Ridge, Copper Ridge, Bullrun Ridge and several large cliffs bordering the Holston, French Broad, and Tennessee Rivers.

Sampling sites

After reviewing USGS topographic maps and the soil survey of Knox County (Roberts *et al.* 1955), and using our knowledge of the study area, we chose 116 sites to sample for land snails (Fig. 1). Fieldwork was conducted in 2015-2017.

On each of the different significant land features we chose sites within various habitats and slope aspects, including wetlands, floodplains, rock bluffs and forested slopes. Although we concentrated our survey efforts on limestone-rich public areas and forested parks, we included a number of private properties and urbanized settings (*e.g.*, abandoned and occupied parcels in downtown Knoxville) to document the diversity of land snails across a wide range of habitats.

Sampling methods and processing

At each site, one to three person-hours were spent assessing habitat and searching for medium to large land snails; several liters of soil and fine woody material were gathered at various places across the site, composited into a single sample, and returned to the laboratory. Fine-scale habitats examined at most survey sites included large tree trunks, the underside, surface and interior of coarse woody debris, large rocks and rock outcrops, human-made debris, and wetland edges. A hand-held Global Positioning System device was used to record the coordinates for the geographic center of each site. Sites ranged from 400 to 1600 m^2. Each site was characterized using a generalized list of habitat categories: Seep/wetland/floodplain, pine forest/cedar grove, open disturbed, mature oak/hickory, sandstone/limestone outcrops and river bluff, urban/residential, cave, disturbed second growth forest, and disturbed sandstone/limestone outcrop (Appendix 1). Soil samples returned to the laboratory were dried and sifted through a series of four sieves with openings measuring 4.75 mm to 0.50 mm. The larger factions of the soil and fine woody debris samples were examined using a 10X lens and the smaller factions were examined for the presence of microsnails (<5mm at the greatest dimension) using a dissecting microscope. Land snails encountered opportunistically (*i.e.*, not associated with a survey site) were included in the county species list. At some sites, snails were encountered that were identified to

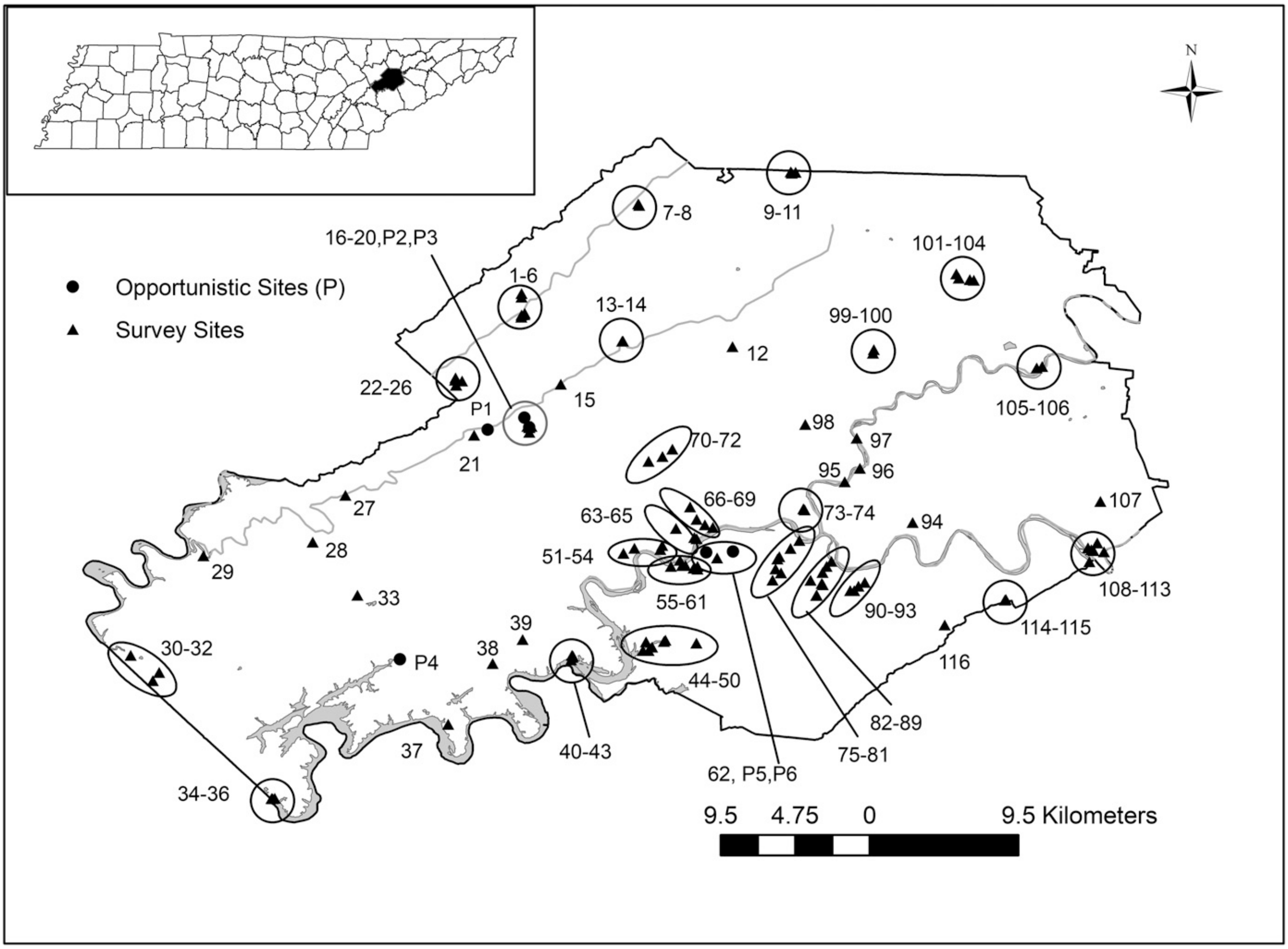

Figure 1. Map of Knox County survey sites.

the genus level only; identification to the species level could not be reached because of shell condition or age. These were included in the species total for the site if they represented the only member of the genus present. Specimens collected in this study were archived at the University of Tennessee, McClung Museum of Natural History and Culture.

We used a number of references to identify specimens, notably Pilsbry (1940, 1946, 1948), Burch (1962), Kerney and Cameron (1979), Emberton (1988, 1991), Grimm *et al.* (2009), Dourson (2010, 2013), and Nekola and Coles (2010). We compared problematic specimens to material at the Chicago Field Museum (FMNH), Carnegie Museum of Natural History (CMNH), the Ohio State Museum of Biological Diversity (OSUM), University of Michigan Museum of Zoology (UMMZ), and the McClung Museum of Natural History and Culture (MMNHC). Additionally, selected problematic specimens were sent for verification to Dan Dourson (Belize Foundation for Research and Environmental Education), John Slapcinsky (Florida Museum of Natural History [FLMNH]), Amy and Wayne Van Devender (Appalachian State University), and Francisco Borrero (Animal and Plant Health Inspection Service [APHIS]). County and state records were determined using Bogan *et al.* (1982), Hubricht (1985), Dourson (2013), and pertinent literature. We searched the database of several institutions for Knox County records. Only published or verified records were considered for the list of Knox county species. Some species found in our field survey representing a potentially new county record also were found in one or more museum databases. Due to time considerations, we did not examine these specimens or ask the museum curator for verification. Species in a museum database not found in our field survey representing a potential new county record were examined by us or verified by the collection manager. We followed Turgeon et al. (1998) for genus and species names with three exceptions: We followed Gargonimy (2011) for *Ambigolimax valentianus*, Roth (2003) for *Cochlicopa,* and Coles and Walsh (2006) for *Daedalochila*. For family designations we followed MolluscaBase (2018) with one exception. Following Pokryszko *et al.* 2009, we retained Columella and Gastrocopta in Vertiginidae as this group is presently under study (Nekola and Coles 2016).

RESULTS

Approximately 10,630 specimens were collected in this survey. Our survey results combined with museum specimens and published literature revealed the land snail fauna in Knox County comprises 151 species in 60 genera (Table 1). Our list for Knox County includes eight species not found in this survey but reported by Hubricht (1985) and/or Bogan *et al.* (1982), and eight species not found by us but cataloged in CMNH and/or FLMNH. We document 70 species previously unreported in Knox County. Most of these new county records are common elsewhere in east Tennessee (e.g., 51 of these have been recorded in at least one adjacent county). Our list of new county records includes three species we found live or fresh dead but which previously were known from Tennessee only in the fossil record (Hubricht 1985): *Gastrocopta holzingeri* (Sterki, 1889), *Cochlicopa lubrica* (Müller, 1774), *Lucilla singleyanus* (Pilsbry, 1889). It should be noted two of our new county records that are based on museum specimens: *Stenotrema edgarianum* (I. Lea, 1841) and *Ventridens coelaxis* (Pilsbry, 1899) may be questionable based on imprecise locality data, published distributional information, and habitat preference. This is discussed in the species accounts. Fifteen species are new state records; all are common in the southeastern U.S.A. and have been reported from a state adjacent to Tennessee. Eleven of the state records are species not native to North America.

Land snails are widespread in Knox County, and were found at all 116 sites. The three most commonly encountered species were *Striatura meridionalis* (Pilsbry and Ferriss, 1906), *Inflectarius inflectus* (Say, 1821), and *Zonitoides arboreus* (Say, 1816), occurring at 57%, 56%, and 54% of all sites, respectively. Twenty-six (26) species were found at only a single site. The most speciose site was a limestone/sandstone bluff complex on Texas Valley Road in the northeast corner of the county (Site 9, N = 45 species). In general, limestone/sandstone bluff habitat was the most speciose.

Including museum records, we found 16 nonindigenous species. Except for *Arion subfuscus* (Draparnaud, 1805) and *Vertigo pygmaea* (Draparnaud, 1801), all non-native species were found exclusively in urban, residential or otherwise anthropogenically disturbed sites.

Taxonomic Notes on Selected Taxa

Allopeas cf. clavulinum (Potiez and Michaud, 1838): *Allopeas clavulinum* is an introduced snail documented in Pennsylvania, Massachusetts, and Florida (Pilsbry 1946, Dundee 1971). Several live immature specimens were found in a degraded roadside area in Knoxville (Site 65) and were verified by F. Borrero as generally matching *A. clavulinum*.

Anguispira Morse 1864 spp.: Hubricht (1985) reported four species of *Anguispira* from Knox County: *Anguispira alternata* (Say, 1816), *Anguispira mordax* Kutchka, 1938, *Anguispira knoxensis* (Pilsbry, 1899), and *Anguispira jessica* Kutchka, 1938. We did not find *A. mordax* or *A. knoxensis* in this survey. Individuals resembling *A. strongylodes/jessica* were sent to J. Slapcinsky (FLMNH) for identification. He separated them into two species we tentatively refer to as *Anguispira* cf. *strongylodes* (Pheiffer, 1854) and *Anguispira* cf. *jessica*. Future studies are needed to reveal the taxonomic placement of these taxa. We found *A.* cf. *strongylodes* at eight

Table 1. List of land snail taxa of Knox County, Tennessee. For those species not found at any study sites, the reference to its Knox County record or the museum curating the record is provided (CM and FLMNH refer respectively to Carnegie Museum of Natural History and Florida Museum of Natural History catalogue numbers). Site numbers are described in Appendix 1. Habitat designations are as follows: CV = Caves, DF = Disturbed second growth forest, DO = Disturbed sandstone/limestone outcrops, MF = Mature hardwood forest, MX = Mixed habitats, OD = Open disturbed, PC = Pine forest/cedar groves, SL = Sandstone//limestone outcrops and river bluffs, UR = Urban/residential, WT = Seeps/wetlands/floodplains. Species non-native to North American are indicated by an asterisk (*). [1] = County record; [2] = State record.

Taxon	Site Numbers, Reference or Museum Collection	Habitat Codes
Arionidae		
Arion fasciatus (Nilsson, 1923)*[1,2]	38	MX
Arion hortensis Férussac, 1816*[1,2]	21	OD
Arion intermedius Normand, 1852*[1,2]	3,13,27	WT
Arion subfuscus (Draparnaud, 1805)*[1,2]	51	MF
Camaenidae		
Bradybaena similaris (Ferussac, 1821)*[1,2]	P6	UR
Cionellidae		
Cochlicopa lubrica (Muller, 1774)*[1]	21,38,63	MX,OD,UR
Cochlicopa lubricella (Porro, 1838)*	21,53,66,69	MX,OD,UR
Cochlicopa morseana (Doherty, 1878)	1,4,7,9,26,45,50,55,57,59,99,101,103,104,115	MF,SL,WT
Gastrocoptidae		
Gastrocopta armifera (Say, 1821)	20,35,52,53,56,61,63,66,65,69,73,76–78,84,85	DO,OD,PC,SL,WT
Gastrocopta clappi (Sterki, 1909)	64,78,82,84,85	MF,MX,OD,PC
Gastrocopta contracta (Say, 1822)[1]	1,3,4,7,9,22,24,29–31,35–38,43,45,50–53,56,58,61,63,64,66, 68–70,74–77,79,91,93,99,102–104,109,113,116	DO,MF,MX,OD,SL,UR,WT
Gastrocopta corticaria (Say, 1816)	3,4,9,24,33–35,38,39,46,47,55,57,58,75,77–82,86,93,94	DO,MF,MX,OD,PC,SL,WT
Gastrocopta holzingeri (Sterki, 1889)[1]	34	SL
Gastrocopta pentodon (Say, 1822)	1,4,7,8,9,11,14,15,21,22,24,29,31,33–35,37,38,45–47,48,50,52, 55–57,62,65,66,68,74,75,77–84,86,89,94,96,99,102–104,109, 112,113,115,116	DO,DF,MF,MX,OD,PC,SL,UR,WT
Gastrocopta procera (Gould, 1840)	31,52,53,56,64,65,69,76,77,78	DO,OD,UR,WT
Gastrocopta tappaniana (C.B. Adams, 1842)[1]	11,15,64,86	MX,WT
Discidae		
Anguispira alternata (Say, 1816)	3-6,8–10,29,36,44,45,51,86,103,116	MF,SL,WT
Anguispira cf. *jessica* Kutchka, 1938	99	MF
Anguispira cf. *strongylodes* (Pheiffer, 1854)	1,4,37,101,103,109,112,113	MF,SL
Anguispira knoxensis (Pilsbry, 1899)	Hubricht (1985)	Unknown
Anguispira mordax (Shuttleworth, 1952)	Hubricht (1985)	Unknown
Discus bryanti (Harper, 1881)[1]	CM 62.39894	Unknown
Discus nigrimontanus (Pilsbry, 1924)[1]	9,103	MF,SL
Discus patulus (Deshayes, 1830)	1,3,5,8,9,17,19,22,24,26,29,32,37,39,44–46,50,51,55, 57–59,77, 79,81–83,86–88,92,93,99,101–104,109,116	DF,DO,MF,PC,SL,WT
Ellobiidae		
Carychium clappi Hubricht, 1959	4,8,9,10,18,45	PC,MF,SL,WT
Carychium exiguum (Say, 1822)[1]	10,11,86,89	WT
Carychium exile I. Lea, 1842	1–4,9,10,15,16,18,22–27,29,30,35,37,42–52,59,60,73,77,79, 81–83,86,89,91–95,99,100,102,104,106,109,113,115,116	CV,DO,MF,PC,SL,WT,

Table 1. (Continued)

Taxon	Site Numbers, Reference or Museum Collection	Habitat Codes
Carychium nannodes Clapp, 1905	8–10,12,23,24,26,45,47,81,93,99,102,103	CV,MF,SL,WT
Carychium stygium Call, 1897[1]	23	CV
Euconulidae		
Dryachloa dauca F. G. Thompson and H. G. Lee, 1960[1,2]	39	DF
Euconulus chersinus (Say, 1821)	38,64,75,77	DO,MX,SL
Euconulus dentatus (Sterki, 1893)	8,9,17,22,24,25,35,36,49,55,78,83,91,94,99,102,103,105,109,112	DO,MF,OD,SL,WT
Euconulus fulvus (Müller, 1774)[1]	3	WT
Euconulus trochulus (Reinhardt, 1883)	3,12,24,32,35,37,47,71,74,76,77,81,95,99,104,105,109,116	DO,MF,SL,WT
Guppya sterkii (Dall, 1888)	1,2,4,5,7–9,12,16–19,24–26,29,35–37,39,45–50,59,77–79,81,82, 89,91,93–95,99,101–105,109,112,113,115	DF,DO,MF,OD,PC,SL,WT
Gastrodontidae		
Gastrodonta interna (Say, 1822)	Hubricht (1985)	Unknown
Glyphyalinia cryptomphala (G.H. Clapp, 1915)	9,10,23–25,35,37,47,50,79,81–85,91,93,94,109,114–116	CV,DO,MF,PC,SL,WT
Glyphyalinia indentata (Say, 1823)	1,3,5–7,9,13–15,18–21,24,26,27,29,35,39,42–45,50–53,55,58,59, 74–77,79,81,93,99–101,103,116	DF,DO,MF,OD,PC,SL,WT
Glyphyalinia lewisiana (G.H. Clapp, 1908)	34,35,109,112	SL
Glyphyalinia luticola Hubricht, 1966	1,13,38,40,52,102	MF,MX,WT
Glyphyalinia praecox (H.B. Baker, 1930)	1,35,45,47,55,59,70,80	MF,PC,SL
Glyphyalinia rhoadsi (Pilsbry, 1899)	59,99	MF
Glyphyalinia rimula Hubricht, 1968[1]	26,35,51,77,79	DO,MF,SL,WT
Glyphyalinia solida (H.B. Baker, 1930)	4,7,24,112,114	SL
Glyphyalinia wheatleyi (Bland, 1883)	1,2,4–10,16,17,19,22,24–26,30,33,35,38,39,45,47,50,51, 55,57–59,70–76,78,81,87,89,90,91,95,96,99,103,115	DF,DO,MF,MX,OD,SL,WT
Mesomphix capnodes (W.G. Binney, 1857)[1]	35	SL
Mesomphix cupreus (Rafinseque, 1831)	45,50,55,77,81,82,85,91,93,94,115,116	DO.MF,PC,SL
Mesomphix perlaevis (Pilsbry, 1900)[1]	1,4,5,7–9,24,25,29,37,42,44,45,50,91,93,99,103,104,114–116	MF,SL
Nesovitrea electrina (Gould, 1841)[1]	CM 66340	Unknown
Striatura meridionalis (Pilsbry and Ferriss, 1906)	3,4,7-9,11,16,18,19,22,24,27,28–30,34–38,43,45–51, 53,55,57,60, 62,68,70,72,73,75,77–84,87–89,91,93–96,99, 101–105,109,112–116	WT,PC,OD,MF,SL,DF,DO,MX
Ventridens acerra (J. Lewis, 1870)[1]	91,116	MF
Ventridens coelaxis (Pilsbry, 1899)[1]	CM 111095	Unknown
Ventridens collisella (Pilsbry, 1896)	1,4,12,17,23,33,37,45,49,66,77–79,81–83,85,93,101,103,109,111,112	SL,CV,DF,DO,MF,OD,PC
Ventridens demissus (A. Binney, 1843)[1]	3,6,8,13–15,21,25–29,31,33,38–42,52,54,63,64, 66,67,69,79,100	DF,DO,MF,MX,OD,SL,UR,WT
Ventridens gularis (Say, 1822)	15,17,18,24,34,36,38,43,51,56–58,66,71,78–83,88,89,94, 96,102, 103,109,111	DF,DO,MF,MX,OD,PC,SL,WT
Ventridens intertextus (A. Binney, 1841)	17,59	MF
Ventridens lasmodon (Phillips, 1941)	4,70,71,72,99,105	MF,SL
Ventridens lawae (W.G. Binney, 1892)	5,9,24,94,101,104,114–116,	DO,MF,SL
Ventridens ligera (Say, 1821)[1]	30,38,41,51,54–,58,59,61,63–65,70,72,73,75–79,81–83,86–90, 92,96,97,106,113	DF,DO,MF,MX,OD,SL,UR,WT

Table 1. (Continued)

Taxon	Site Numbers, Reference or Museum Collection	Habitat Codes
Ventridens pilsbryi Hubricht, 1964[1]	38,50	MF,MX
Ventridens theloides (Walker and Pilsbry, 1902)[1]	7,8,31,32	MF,SL
Vitrinizonites latissimus (J. Lewis, 1875)[1]	CM 62.39896	Unknown
Zonitoides arboreus (Say, 1816)	1,3,6,8,9,12–15,17–19,21,22,24,26,27,29,30,32,34–37,39,41,42, 44,45,47,51,52,54–59,61,63–67,70,74, 76,79,81,86–88,93, 94,96, 99,101–105,109,111	DF,DO,MF,OD,SL,UR,MX,PC,WT
Haplotrematidae		
Haplotrema concavum (Say, 1821)	1,3–7,9,12,16–19,23–25,29,30,33–35,37,42,44,45,47,49,50, 55–57,59,70,73–75,81–85,87,88,91,93, 99, 101–05,107,109,113–116	CV,DF,DO,MF,PC,SL,WT
Helicidae		
Cepaea nemoralis (Linnaeus, 1758)*	CM 62.30312, FLMNH 096665	Unknown
Helicinidae		
Oligyra orbiculata Say, 1818	Hubricht (1985)	Unknown
Helicodiscidae		
Helicodiscus barri Hubricht, 1962[1]	P4	CV
Helicodiscus multidens Hubricht, 1962[1]	1,7,32,104,109	MF,SL
Helicodiscus notius Hubricht, 1962	9,29,42,44,50,94,99,109	DO,MF,SL
Helicodiscus parallelus (Say, 1817)	27	WT
Lucilla scintilla H.B. Baker, 1929[1]	34	SL
Lucilla singleyanus (Pilsbry, 1889)[1]	4,9,35,52,65,66,74,91,99,104,105,109,113	MF,SL
Limacidae		
Deroceras laeve (Müller, 1774)	15,21,27,31,69	OD,MX,UR,WT
Deroceras reticulatum (Müller, 1774)*[1,2]	21,31,69	MX,OD,UR
Ambigolimax valentianus (Férussac, 1822)*[1]	21,63	OD,UR
Limax maximus Linneaus, 1758*[1]	P2,P3	DF,UR
Lymnaeidae		
Galba Schrank 1803 sp.	21,82	MF,OD
Oxychilidae		
Oxychilus draparnaudi (Beck, 1837)*[1,2]	21,63,64,69,	MX,OD,UR
Paravitrea blarina Hubricht, 1963	24	SL
Paravitrea capsella (Gould, 1851)	29,37,45,50,79,81,101,103,104,109,116	MF,SL
Paravitrea aff. *capsella*	8,25,26,83,85,93	MF,PC,SL,WT
Paravitrea multidentata (A. Binney, 1840)[1]	4,5,8–10,115	MF,SL,WT
Paravitrea petrophila (Bland, 1883)	4,9,55,83,109,112	SL
Paravitrea placentula (Shuttleworth, 1852)	46,50,81–83,109,112,113	MF,PC,SL
Philomycidae		
Megapallifera mutabilis (Hubricht, 1951)[1]	38,39	DF,MX
Pallifera dorsalis (A. Binney, 1842)[1]	5, 91	MF
Pallifera fosteri F.C. Baker, 1939[1]	P5,9,17	OD,MF,SL
Philomycus carolinianus (Bosc, 1802)	9,29,39,79,101	MF,SL
Philomycus flexuolaris Rafinesque, 1820[1]	17,39	DF,MF

Table 1. (Continued)

Taxon	Site Numbers, Reference or Museum Collection	Habitat Codes
Philomycus togatus (Gould, 1841)[1]	9,99	MF,SL
Philomycus venustus Hubricht, 1953	P1	MX
Polygyridae		
Allogona profunda (Say, 1821)	4,74	SL
Appalachina chilhoweensis (J. Lewis, 1870)[1]	9	SL
Euchemotrema cf. *fraternum* (Say, 1824)[1]	9,42,44,50,81–83,85,	MF,PC,SL
Daedalochila plicata (Say, 1821)	9,24,33,55,91,104,109	DO,MF,SL
Daedalochila troostiana (I. Lea, 1839)	Hubricht (1985)	Unknown
Fumonelix wheatleyi (Bland, 1873)[1]	CM 62.39889	Unknown
Inflectarius downieanus (Bland, 1861)[1]	111	DF
Inflectarius inflectus (Say, 1821)	1,3,4,6,8,9,17,19,25,26,30,33–39,41,42,45–47,49–52,55,57,59, 65,67, 70–72,74–86,88–91,93,94,98–101,104,109,110,112–115	DF,DO,MF,MX,OD,PC,SL,UR,WT
Inflectarius kalmianus (Hubricht, 1965)	Hubricht (1985)	Unknown
Inflectarius rugeli (Shuttleworth, 1852)	12,29,44,109	MF,SL
Mesodon clausus (Say, 1821)	4,29,31,37,78,85,93,98,109	DF,MF,MX,OD,PC,SL,WT
Mesodon elevatus (Say, 1821)	4,8,9,34,35,37,49,55,59,74,75,77,83,93,103,105,109,112,113	DO,MF,SL
Mesodon normalis (Pilsbry, 1900)[1]	4,75	SL
Mesodon thyroidus (Say, 1816)	5–7,17,34,51,55,59,78,81,83,85,94,105,109,111,113,115	DF,DO,MF,PC,SL
Mesodon zaletus (A. Binney, 1837)	4,6,19,25,55,75	DF,SL
Neohelix albolabris (Say, 1817)	23,24,35,104,	CV,MF,SL
Patera appressa (Say,1821)	4,7,9,14,23–25,27,29,33–35,37–39,42,43,51,52,54–56,63,65–67, 70,73–78,83,95,96,98,105,109,112–114	CV,DF,DO,MF,MX,OD, SL,UR,WT
Patera perigrapta (Pilsbry, 1894)	Hubricht (1985) and Bogan *et al.* (1982)	Unknown
Polygyra cereolus (Muhlfeld, 1816)[1,2]	21	OD
Stenotrema angellum Hubricht, 1958[1]	1,4–9,19,24–26,29,31,32,34,35,37,42,47,55,59,75,79,83,87,93, 96,101–104,109,112,113	DF,MF,MX,SL,WT
Stenotrema edgarianum (I. Lea, 1841)[1]	FLMNH 502048	Unknown
Stenotrema spinosum (I. Lea, 1830)	37,44,45,49,50,55,58,59,73,74,93,103	DO,MF,SL
Stenotrema stenotrema (Pfeiffer, 1842)	1,4,9,12,22,24,26,32,33,35,38,39,42,50,51,65,71,74,75,77–79, 81–83,85–88,93–95,98,99,107,109,113–116	DF,DO,MF,MX,OD,PC,SL,UR,WT
Triodopsis complanata (Pilsbry, 1898)	34,35,74,105,115	MF,SL
Triodopsis fallax (Say, 1825)	CM 62.18256, CM 98025, and Bogan *et al.* (1982)	Unknown
Triodopsis hopetonensis (Shuttleworth, 1852)[1]	3,13–15,20,21,27,31,33,38,39,52,53,82,94,97,100,111,113	DF,DO,MF,MX.OD,SL,WT
Triodopsis tennesseensis (Walker and Pilsbry, 1902)	95	SL
Triodopsis tridentata (Say, 1816)	1,4,5,7,9,12,19,23–26,29,101–104,114,116	CV,DF,MF,SL
Triodopsis vulgata Pilsbry, 1940	1,9,25,26,29,32,39,44,45,50,55,57,59,81,91,115,	MF,SL
Xolotrema caroliniense (I. Lea, 1834)[1]	1	MF
Xolotrema denotatum (Ferussac, 1821)	4,7,9,10,29,37,75,105	MF,SL,WT
Pomatiopsidae		
Pomatiopsis lapidaria (Say, 1817)	3,4,10–12,22,25,26,51,52,79,84,86,88,89,93,98	DF,MF,PC,SL,WT
Pristilomatidae		
Hawaiia alachuana (Dall, 1885)[1]	35	SL

Table 1. (Continued)

Taxon	Site Numbers, Reference or Museum Collection	Habitat Codes
Hawaiia minuscula (A. Binney, 1841)[1]	3,7,15,17,18,20,24,28,31,34,37,47,56,61,65,66,74–77,80,82,83, 102,109,113	DF,DO,MF,MX,OD,PC,SL,WT
Punctidae		
Punctum blandianum Pilsbry, 1900	1–10,12,19,22,24–26,28–30,34–36,38,45,48–50,54,55,57,60,62, 74,75,77–79,81,83,88,91–95,101–105,109,112,116	DF,DO,MF,MX,OD,SL,WT
Punctum minutissimum (I. Lea, 1841)	4,9–11,14,18,19,24,25,29,33,35,42,46,47,59,64,69,73,74,79, 81–83,87–89,91,93,96,99,103,104,106,109,112	DF,DO,MF,MX,PC,SL,UR,WT
Punctum smithi Morrison, 1935[1]	1,32,34,74,109	MF,SL
Punctum vitreum (H.B. Baker, 1930)[1]	3,12,14,22,30,34,35,37,38,42,43,45,47,51,52,64,75–81, 83,84,88, 91,93,96,105,109	DF,DO,MF,MX,OD,PC,SL,WT
Pupillidae		
Pupoides albilabris (C.B. Adams, 1841)	20,21,52,53,56,63,65,71,76,84	DO,MF,OD,PC,UR,WT,
Strobilopsidae		
Strobilops aeneus Pilsbry, 1926	1,3,5–7,9,19,24,29,34,36,45,55,57–59,70,74,75,89,94,99,109,115	DF,DO,MF,SL,WT
Strobilops labyrinthicus (Say, 1817)[1]	9,18,24,103,104	MF,PC,SL
Strobilops texasianus (Pilsbry and Ferriss, 1906)[1]	24,103,104,	MF,SL
Subulinidae		
Allopeas cf. *clavulinum* (Potiez and Michaud, 1838)*[1,2]	65	UR
Opeas pyrgula Schmacker & Boettger, 1891*[1,2]	21,31,56,63,65,66	DO,MX,OD,UR
Succineidae		
Catinella oklahomarum (Webb, 1953)[1]	15,21	OD,WT
Novisuccinea ovalis (Say, 1817)[1]	1,12,21,47,61	MF,OD
Oxyloma retusum (I. Lea, 1834)[1,2]	21	OD
Succinea forsheyi I. Lea, 1864	Hubricht (1985)	Unknown
Testacellidae		
Testacella haliotidea Draparnaud, 1801*[1]	54,64,68	DF,MX,OD
Valloniidae		
Vallonia costata (Müller, 1774)[1,2]	63	UR
Vallonia excentrica Sterki, 1893	15,21,31,52,53,56,64	DO,MX,OD,WT
Vallonia perspectiva Sterki, 1893	4,7,34,35,37,55,69,109	SL,UR
Vallonia pulchella (Müller, 1774)[1,2]	21,56,63,67–69,76	OD,F,DO
Vertiginidae		
Columella simplex (Gould, 1840)[1]	1,3,4,12,21,35,38,51,55,75,83,92,93,99,102,103	MF,MX,OD,SL,WT
Vertigo gouldii (A. Binney, 1843)[1]	4,8,9,18,21,26,30,33–35,37,39,55,56,64,74,77–79,83, 89,95,96, 99,103,109,112	DF,DO,MF,MX,OD,PC,SL,WT
Vertigo milium (Gould, 1840)	11,15,43,52,86,100	WT
Vertigo oscariana (Sterki, 1890)[1]	3,4,9,12,19,24,35,38,45–48,50,55,88,96,99,102–105,109,112	DF,MF,MX,PC,SL,WT
Vertigo ovata Say, 1822[1]	15,43,108	WT
Vertigo parvula (Sterki, 1890)[1]	35,103,104	MF,SL
Vertigo pygmaea (Draparnaud, 1801)*[1]	3,15,28,55,67	DF,DO,SL,WT,
Vertigo tridentata Wolf, 1870[1]	43,67,75,109	DO,SL,WT

sites (Sites 1, 4, 37, 101, 103, 109, 112, 113), all of which were mature hardwood forest or sandstone/limestone bluff. *Anguispira* cf. *jessica* was found only at McAnnaly Ridge (Site 99), a mature hardwood forest. In general, both species were associated with decomposing wood.

Arion fasciatus Nilsson, 1923: This non-native species is wide ranging in North America and is found in a variety of habitats including grasses, shrubs, hedgerows and forests of maple/ash/elm (Chichester and Getz 1973). Its distribution stretches across Canada and it is well established in the northeastern U.S.A. and California. Elsewhere, *A. fasciatus* has been reported from maize fields in Ohio and Kentucky, and the Great Smoky Mountain National Park in North Carolina (Burch 1962, Hammond and Byers 2002, Dourson 2010, 2013). We found this species at Maxwell Spring (Site 38), a mature forested area near a busy road.

Arion hortensis Férussac, 1816: In North America, *A. hortensis* has been reported from Canada and a number of eastern states including Delaware, Kentucky, Pennsylvania and Virginia (Burch 1962, Pearce and Bayne 2003, Dourson 2010, Hotopp *et al.* 2013). In Virginia it has been found in counties adjacent to Tennessee. Its preferred habitat includes cultivated areas as well as deciduous and coniferous forest (Chichester and Getz 1973). We found this species in shaded brushy habitat of a residential area (Site 21). This non-native species is very similar to another invasive species, *Arion distinctus* Mabille, 1868. The identification of *A. hortensis* was verified by F. Borrero of APHIS.

Arion intermedius (Normand 1852): Reported from Canada, New York, California and as far south as Kentucky and Virginia, this non-native species is found primarily in disturbed habitats (Burch 1962, Forsyth 2004, Dourson 2010, Hotopp *et al.* 2013). We found *A. intermedius* in second-growth floodplain forests and a former pasture at the edge of a spring (Sites 3, 13, 27).

Arion subfuscus (Draparnaud, 1805): This invasive species was found on a forested slope adjacent to the Third Creek Greenway within the city limits of Knoxville (Site 51). *Arion subfuscus* has been introduced throughout northeastern U.S.A, where it thrives in natural woodlands as well as developed areas (Chichester and Getz 1973, Blanchard and Getz 1979). It appears to be increasing its southern range as there are records in Virginia and North Carolina (Grimm *et al.* 2009, Hotopp *et al.* 2013). It has been noted as a pest of maize and soybeans in Ohio (Hammand and Byers 2002). Previous to this survey, it had not been reported in Tennessee. The success of this species in woodland areas of the Third Creek Greenway may be a threat to local native slugs. Although this site is surrounded by disturbed/residential areas, the occurrence of *A. subfuscus* in a mature hardwood forest is cause for concern. *Arion subfuscus* is an important predator of *Pinus sylvestris* (Linnaeus, 1753) seedlings in northern Sweden (Nystrand and Granström 1997). It also was the dominant slug found in recently burned black spruce forest in Newfoundland and has the ability to affect forest regeneration and biodiversity (Moss and Hermanutz 2010). We have observed this species in remote forests of northern Minnesota and southern Ontario, where it was the only slug species encountered.

Bradybaena similaris (Férussac, 1821): This species is known from the Gulf coastal states and is a native of southeastern Asia (White-McLean 2011). It has invaded Australia, Europe, and North and South America. Numerous live individuals were found in May at a landscape nursery business in Knoxville outside the greenhouses (Site P6). Because they were found during a warm season, we are unsure if the species is surviving year-round. Besides being an important agricultural pest, *B. similaris* can be carrier of *Angiostrongylus cantonensis*, a parasitic nematode that causes a disease called human eosinophilic meningoencephalitis (Carvalho *et al*. 2012). This disease typically occurs in Asia but there are documented cases in Florida, Louisiana, and Texas (Iwanowicz *et al.* 2015, Stockdale Walden *et al*. 2017). At least five other species we found in Knox County, *Ventridens demissus* (A. Binney, 1843), *Zonitoides arboreus*, *Limax maximus* (Linneaus, 1758), *Ambigolimax valentianus* (Férussac, 1822) and *Deroceras laeve* (Müller, 1774) also have the ability to carry this parasite (Senanayake *et al*. 2003, Asata *et al*. 2004, Lv *et al*. 2008, Stockdale Walden *et al*. 2017).

Cochlicopa lubricella (Porro, 1838): This European species has colonized southeastern Canada and northeastern U.S.A., and has been reported in Virginia (Hotopp *et al*. 2013). It is generally found in disturbed areas. In Knox County, we found specimens adjacent to a landscape nursery business in Powell (Site 21) and in three park-like habitats in Knoxville (Sites 53, 66, 69). There is disagreement among specialists over the separation of this species from *Cochlicopa lubrica* (Müller, 1774), another species introduced from Europe (Welter-Schultes 2012). We found both species in Knox County and followed Pearce and Drescher (2017) in separating the two using shell size (>2.29 mm diameter = *C. lubrica*, <2.19 mm diameter = *C. lubricella*).

Deroceras laeve (Müller, 1774): Although thought by many to be the only native *Deroceras* in North America, some researchers believe the species originated in Europe (Dourson 2013, D. Robinson pers. comm.). It is a widely distributed garden pest throughout the eastern U.S.A. (Burch 1962) and was previously known to occur in Knox County (McCracken and Selander 1980). We found this slug in residential and urban areas (Sites 15, 21, 27, 31, 69).

Deroceras reticulatum (Müller, 1774): This European slug is an important agricultural pest throughout North America and in many places worldwide (Burch 1962), however we found no published records of this species in Tennessee.

In Knox County, this slug is common in floodplains and residential and urban areas (Sites 21, 31, 69).

Dryachloa dauca Thompson and Lee, 1980: Described from Florida, this distinctive snail has also been found in Alabama, and within the last few years has been collected in the southern Piedmont of North Carolina where it occurs in degraded habitats along railroads and in relatively undisturbed, species-rich areas (A. Van Devender, pers. comm.). It is unlikely this species has been overlooked by earlier collectors in the eastern U.S.A. and it's rapidly expanding range suggests it may not be native to North America (H. Lee, pers. comm.). We found one individual in a second growth forest in Knoxville (Site 39).

Galba Schrank 1803 sp.: Four species of *Galba* are known to occur in Tennessee (Johnson *et al.* 2013). *Galba* typically occurs on the edges of ditches and ponds and can be semi-aquatic, as long as the area is moist or flooded sporadically (P. Johnson, pers. comm.). It can survive dry periods for more than a year in aestivation (Kendall, 1949). Although it is not typically included in a list of terrestrial snails, we found *Galba* sp. on a mature forested slope approximately 25 m from a small stream and on the edge of an ephemeral creek (both in Site 82). Other specimens were found on the edge of a landscape nursery (Site 21).

Gastrocopta holzingeri (Sterki, 1889): This species was found on Saltpeter Bluff, a limestone/sandstone bluff overlooking the Tennessee River (Site 34). It has been found in limestone of the same geological origin in the Shenandoah Valley of western Virginia (J. Nekola, pers. comm.). The only previous record of this species in Tennessee is a fossil from Jackson County near the Kentucky border (Hubricht 1985).

Glyphyalinia cryptomphala (G. H. Clapp, 1915) and *Glyphyalinia solida* (H. B. Baker, 1930): For these two similar species, Hubricht (1985) reported that shell and anatomical differences do not overlap. Our survey produced specimens clearly matching each description. To differentiate between immature shells, the diameter was measured at 4.5 whorls; immature shells with a diameter of 4.5 mm or less were recorded as *G. cryptomphala*, and immature shells measuring 5.5 mm or more were reported as *G. solida*.

Hawaiia alachuana (Dall, 1885): Hubricht (1985) considered this to be a calciphile, and his distribution map showed sporadic occurrence over much of the eastern and midwestern U.S.A. Three main clusters are apparent: 1) Tennessee, Virginia, Maryland and West Virginia; 2) eastern Oklahoma and nearby Arkansas; 3) peninsular Florida. We found *H. alachuana* only at Site 35 on Saltpeter Bluff, a limestone cliff complex adjacent to the Tennessee River.

Inflectarius downieanus (Bland, 1861): This species is usually found on flat-topped mountains where the soil is slightly acidic (Hubricht 1985). A single specimen was collected at Seven Islands State Park near the French Broad River in a low, scrubby area (Site 111). We separated it from *Mesodon clausus* (Say, 1821) using shell characteristics.

Limax maximus Linneaus, 1758: This species is now found on every continent except Antarctica (Grimm *et al.* 2009). In North America, it is distributed widely in Canada, has been reported from Mexico, and resides in much of the U.S.A. including Alaska, Oklahoma and Hawaii. In Tennessee, it has been reported around old homestead sites in the Great Smoky Mountains National Park (Dourson 2013) and our discussions with other malacologists indicate it has resided in urban and residential environments of Knox County for many years. *Limax maximus* is a large, yellowish-grey slug readily recognized by having distinct black spots on the mantle and spots often coalescing into two or three lines on the body. A total of three individuals were found in two urban/residential areas (Sites P2, P3). Both specimens at Site P3 (a parking lot) were pale, uniformly yellowish grey, and devoid of black markings. Pilsbry (1948) refers to a rare form of *L. maximus* that matches our specimens. Our identification was made based on internal anatomy and confirmed by F. Borrero (APHIS).

Opeas pyrgula Schmacker and Boettger, 1891: An introduced species common in urban areas, it is known from Pennsylvania, Virginia, and most of the Atlantic and Gulf Coast states of the eastern U.S.A. (Dundee 1971, Hotopp *et al.* 2013). We found *O. pyrgula* in six urban locations (Sites 21, 31, 56, 63, 65, 66). A literature search produced no previous Tennessee records.

Pallifera dorsalis (A. Binney, 1842): This species ranges from eastern Canada and the northeastern U.S.A. to Tennessee (Chichester and Getz 1973, Dourson 2013). At Site 91, a mature forest on a karst ridgetop, individuals we encountered had a rusty or brownish foot margin along its entire length. Because this color pattern was subtle, we identified them as *P. dorsalis* rather than *Pallifera ohioensis* (Sterki, 1908) which is rare and has been reported from only Ohio, Indiana and one county in North Carolina (Dourson 2013). Chichester and Getz (1973) described a similar color form for *P. dorsalis* in their treatment of terrestrial slugs of northeastern North America, but did not discuss *P. ohioensis*. We found specimens without a rusty foot margin at Site 5, a karst forested slope on Copper Ridge.

Paravitrea capsella (Gould, 1851): We found individuals that clearly were *Paravitrea capsella* and at least three unnamed forms. Hubricht (1985) considered *P. capsella* to be a complex of species that share a similar shell form but with distinct anatomical differences. The three unnamed forms conchologically resembled *P. capsella*, but each uniquely varied morphologically from the species description. These differences included size, presence of teeth in juveniles and adults, and genital structure. We lumped these forms into a group we call *Paravitrea* aff. *capsella*. As they did not co-occur with *P. capsella*, we listed *Paravitrea* aff. *capsella* separately.

Polygyra cereolus (Mühlfeld, 1816): Native to Florida, this species has extended its range to all the Gulf States, the Carolinas, Oklahoma, Kentucky and Hawaii (Pilsbry 1940, Perez and Cordeiro 2008, Bergey *et al*. 2014). It can be a pest species on legumes and possibly other crops (Kalmbacher *et al.* 1979). We found this species near the periphery of a landscape plant nursery (Site 21).

Stenotrema angellum Hubricht, 1958: Hubricht (1985) reported *S. angellum* in three north-central Tennessee counties: Fentress, Clay and Jackson. It has now been found in eight additional Tennessee counties, including three in the Valley and Ridge physiographic region of East Tennessee: Hancock, Hawkins, and Cocke (H. Lee, pers. comm.). We found this species to be common in Knox County (33 sites in various habitats). Specimens we encountered were smaller than the typical diameter described by Hubricht (1958) (9.5–10.0 vs. 10.0–11.0mm). In a few of the UMMZ lots cataloged as *Stenotrema stenotrema* (Pfeiffer, 1842) we also found *S. angellum*. We suspect this may be typical of other collections, as these two species are often syntopic in Knox County.

Stenotrema edgarianum (Lea, 1841): The sole Knox County record for this species is an undated specimen at FLMNH collected by Mrs. G. Andrews who actively collected in the late 1800's and early 1900's (Pilsbry 1900) and was a resident of Knox County. Only state and county of origin are provided for the Knox County specimen in FLMNH. All other records for this species are restricted to the Cumberland Plateau, the physiographic region west of the Valley and Ridge. Given this, we question the locality attributed to the Knox County specimen in the FLMNH collection.

Striatura meridionalis (Pilsbry and Ferriss, 1906): This was the most commonly encountered species in Knox County (66 sites). *Striatura meridionalis* is a microsnail that inhabits leaf litter in a broad range of habitats. Coney *et al*. (1982) found this to be the most abundant snail in a survey of the Hiawasee River Basin.

Strobilops labyrinthicus (Say 1817) and *Strobilops texasianus* (Pilsbry and Ferriss, 1906): These species can be difficult to separate. According to Dourson (2015), *S. labyrinthicus* is separated from *S. texasianus* by having weaker ribs that fade as they pass into the basal area and a smaller shell height (1.8 mm vs 2 mm). Rib counts, placement of the five basal lamellae, and the number of ribs on the last whirl (*i.e.,* > 50 ribs on the last whirl = *S. labyrinthicus*) also are useful features (T. Pearce, pers. comm). We found both species in Knox County. *Strobilops labyrinthicus* occurred at five sites (Sites 9, 18, 24, 103, 104) and *S. texasianus* occurred at three of those sites (Sites 24, 103, 104). Significant variation was present in position of the basal lamellae, but shell condition often made this character difficult to discern. Specimens we identified as *S. texasianus* were generally taller but this was not consistent. Other diagnostic characters, such as width of the umbilicus and number and strength of ribs as they pass into the basal area, showed a clear distinction. Both species were found in sites associated with rocky boulders or outcrops.

Triodopsis fallax (Say, 1825): Several lots of this species were collected in Knox County in the late 1800s and early 1900s by G. H. Clapp and V. Sterki and cataloged at CMNH; we verified two of these lots. This species was also reported in Knox County by Bogan *et al.* (1982). Hubricht (1985) reported *T. fallax* from three east Tennessee counties: Blount, Hamilton and Monroe. We did not find *T. fallax* in our study.

Triodopsis hopetonensis (Shuttleworth, 1852): This is a common snail of urban, residential and disturbed habitats. According to Hubricht (1985) this species has been introduced in eastern Tennessee, Alabama, and Mississippi. We have frequently encountered this species at interstate rest areas in Virginia, North Carolina, and South Carolina. In Knox County it was common in 19 urban or otherwise disturbed sites, often with *Ventridens demissus* (Binney, 1843).

Ventridens coelaxis (Pilsbry, 1899): This species is characterized as a narrow endemic occurring in 13 counties at the convergence of Tennessee, Virginia, and North Carolina (Dourson 2013, Hotopp *et al*., 2013). Some of these counties occur wholly or partially in the Valley and Ridge, Blue Ridge, or the Cumberland Mountain physiographic provinces. Hubricht (1985) reported *V. coelaxis* is usually found on mountainsides at higher elevations, which would imply the species is generally in areas within the Blue Ridge or Cumberland Mountains. Our Knox County record of *V. coelaxis* is from an undated lot in the CMNH collection. This lot was donated to CMNH in the early 1900's. No specific locality within Knox County was given. This record is interesting, maybe questionable, considering the absence of high elevation habitats in Knox County.

Vertigo pygmaea (Draparnaud, 1801): This species has a spotty distribution mainly in the northeastern U.S.A. It is a non-native species from western Eurasia (Welter-Schultes 2012). In Tennessee it had previously been recorded in Cumberland County (Nekola and Coles 2010). We found this species in a wide range of habitats, including wetland, limestone river bluff, and an urban rubble slope (Sites 3, 15, 28, 55, 67).

DISCUSSION

Of the 15 new state records we documented in Knox County, only four are species native to North America: *Oxyloma retusum* (I. Lea, 1834), *Polygyra cereolus* (Muhlfeld, 1816), *Vallonia costata* (Müller, 1774) and *Vallonia pulchella* (Müller, 1774). All four were found in urban/residential areas, suggesting they were introduced to Tennessee by anthropogenic means. *Vallonia costata* and *V. pulchella* are generally more northern in distribution, although *V. pulchella* is also distributed in many western states (Pilsbry 1949, Hubricht 1985). *Polygyra cereolus* appears to be increasing its distribution in a northerly direction. Pilsbry (1940) presented numerous records of *P. cereolus* from Florida but in no other states. More recently it has been found in several states including Hawaii.

Eleven percent of the Knox County snail fauna are not native to North America. Many of the non-native species we documented in Knox County are considered widespread in the U.S.A. and likely have been present in Tennessee for decades, but there has been no account of their occurrence in the published literature. The spread of non-native land snails is of concern because they have the potential to cause harm to agriculturally important crops and to native species (Robinson and Slapcinski 2005). Several of the non-native species we found in Knox County: *Bradybaena similaris* (Férussac, 1821), *Cochlicopa lubricella*, *Cochlicopa lubrica*, *Deroceras reticulatum* and *Oxychilus draparnaudi* (Beck, 1837), as well as Florida native *P. cereolus* were found on or adjacent to landscape plant nurseries. Plant nurseries appear to play a role in the spread of non-native land snail species (Bergey *et al.* 2014). With the exception of *Arion subfuscus*, all non-native species we found were in urban, residential or disturbed areas. *Arion subfuscus* has been invading forests in Canada and the northern U.S.; its appearance in a mature woodland in Knox County is troubling because of the potential for competition with native land snail species.

Microsnails (<5mm at greatest dimension) comprised 38% of the Knox County land snail fauna; 46% of our microsnail species represent new records for Knox County. Dourson (2007) suggested this component of the southeastern land snail fauna is under reported, and he pointed out that in Hubricht's 1985 distributional atlas, larger snail species were better represented. Hubricht (1985) also commented on gaps in the distribution for many species, which he attributed to differences in collecting effort. This strongly suggests some of the previous collecting efforts in the eastern U.S.A. did not include sampling of soil and leaf litter, or perhaps only minor attention was given to this microhabitat. This may explain why one of the most widespread species we found, *Gastrocopta contracta* (Say, 1822), a snail 2.2–2.5 mm long, had not previously been recorded in Knox County.

Compared to the remainder of the U.S.A. the Southeast supports a high diversity of land snails. A variety of factors are associated with this diversity, including topography, geology and geological history, soil chemistry, and climate. In central Kentucky, Dourson (2007) found a 2 ha site supported at least 86 species of land snails. This relatively small site encompassed the junction of three physiographic regions rich in limestone outcrops and calcareous soil. Within the lower Hiwassee River basin in southeastern Tennessee, in an area that includes the Valley and Ridge and the Blue Ridge physiographic regions, Coney *et al.* (1982) reported 86 species. With 151 species, Knox County has a land snail fauna that is diverse even for the southeastern U.S.A; in fact Knox County has more species than has been reported for the entire state of Louisiana (140 species) (Minton and Perez 2005). Although a number of species we found are not native to North America, we report 136 native species. Much of this diversity was found on high bluffs along rivers and creeks and in relatively undisturbed forested slopes. While this was a non-quantitative study, our survey results indicate that steep slopes and rock bluffs may be an important predictor of high snail diversity (see Appendix 1). Similarly, Coney *et al.* (1982) found slope and snail diversity were positively correlated and suggested slope effect may be indirect; physical characteristics associated with slope, such as moisture levels, forest and rock types, and higher calcium availability, may be more influential. One of the more interesting areas we surveyed was Saltpeter Bluff, a high and nearly inaccessible cliff overlooking the Tennessee River on the southeast edge of Knox County. Two sites on this bluff (Sites 34 and 35, with a combined approximate area of 2.5 ha) produced a total of 40 species, including several of the rarest species in this survey. Three species were found only on this cliff: *Hawaiia alachuana*, *Lucilla scintilla* (H.B. Baker, 1929), and *Gastrocopta holzingeri*. Three other Saltpeter Bluff species, *Vertigo parvula* Sterki, 1890, *Gastrocopta lewisiana* (G.H. Clapp, 1908) and *Punctum smithi* Morrison, 1935, were found at only a few other locations. The most speciose area was a forested cove that included three sites in the northeast corner of the county (Sites 9, 10, 11; N = 48 species). This area (approximately 5 ha) included a mature forest and adjacent emergent wetland in the vicinity of an undisturbed chert gravel spring issuing from the base of a sandstone/limestone cliff.

A review of the published historical land snail fauna in the eight counties adjacent to Knox County produced the following number of species (in brackets) by county: Blount [120], Sevier [105], Roane [54], Anderson [54], Grainger [43], Union [30], Loudon [17], Jefferson [11] (Hubricht 1985, Nekola and Coles 2010, Dourson 2013). It is not surprising that Blount and Sevier Counties have the greatest putative diversity because about one-third of both counties have been subject to recent land snail surveys as part of the All Taxa Biodiversity Inventory in the Great Smoky Mountains National Park (Dourson 2013, Douglas et al. 2014). Further, Blount and Sevier Counties are in the Valley and Ridge and the Blue Ridge physiographic regions, and areas where multiple physiographic regions merge have been shown to provide habitat characteristics, geology, forest structure, and availability of various other resources required to generate high land snail diversity (Dourson 2007, Dourson and Beverly 2008, Douglas *et al.* 2014). Most of Jefferson County is in the

Valley and Ridge physiographic region, and a small part of the southeast corner of the county is in the Blue Ridge (Soil Survey Staff 2002a). This information suggests the known land snail fauna for Jefferson County is wildly underreported, and to a lesser degree the same may be true of the other counties adjacent to Knox County, especially those spanning multiple physiographic provinces, e.g., Anderson and Roane – both are mainly in the Valley and Ridge with a small portion on their western side in the Cumberland Plateau (Soil Survey Staff 1978, 2002b).

This study revealed Knox County's land snail fauna is remarkably more diverse than was previously known. The earliest records of land snails in Knox County date to the late 1800's, but by that time period, all old-growth forest in the county had been cleared. Loss of old growth habitat may have affected the land snail community. Thus, Knox County's complete historical record may never be known. To address this question future research could compare the land snails of old-growth forests in nearby Great Smoky Mountains National Park to adjacent forest communities similar in elevation, geology and physiography to those found in Knox County.

Over the last several years, the municipal governments of Knoxville and Knox County, in collaboration with non-governmental organizations, have actively promoted the preservation and use of urban wilderness for outdoor recreation. We applaud this effort and hope areas set aside for protection will serve as refugia for native flora and fauna in the face of the county's increasing human population.

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Appendix 1. Description of land snail survey sites in Knox County, Tennessee, including habitat (HAB), aspect (ASP), canopy coverage (CC), elevation (ELV), and number of species (No. Sp.). Canopy designations are abbreviated as follows: Full (F) = 60–100% canopy, Medium (M) = 40–60% canopy, Open (O) = 0–40% canopy, C = cave. Sites P1 through P6 represent opportunistic collections. Habitat designations are as follows: CV = Caves, DF = Disturbed second growth forest, DO = Disturbed sandstone/limestone outcrops, MF = Mature hardwood forest, MX = Mixed habitats, OD = Open disturbed, PC = Pine forest/cedar groves, SL = Sandstone//limestone outcrops and river bluffs, UR = Urban/residential, WT = Seeps/wetlands/floodplains. Aspect abbreviated by direction: if blank, area was level, mixed or in a cave. Location: LDB = Left descending river bank, RDB = right descending river bank. Soil information is from Roberts *et al.* (1955).

Site	Date	Location	Habitat	HAB	ASP	CC	ELV (m)	Latitude/ Longitude (decimal degrees)	No.Sp.
1	6NOV2016	Bull Run Ridge, Diggs Gap	Steep slope; mixed hardwood forest, maple/oak; fine sandy loam from acidic sandstone	MF	NE	F	305	36.0975 -84.0220	27
2	6NOV2016	Bull Run Ridge, W of Diggs Gap	Steep ravine in a seep mixed hardwood forest, oak/hickory; mesic; fine sandy loam	WT	SSE	F	335	36.0955 -84.0220	4
3	30MAR2016	Bull Run Valley, E of Stillhouse Hollow,	Floodplain; mixed hardwoods, sycamore/oak; alluvial silt loam	WT		M	256	36.0850 -84.0220	24
4	30MAR2016	Copper Ridge, E of Stillhouse Hollow	Limestone cliff facing creek; mixed hardwoods, beech/sycamore	SL	NW	M	268	36.0861 -84.0202	38
5	30MAR2016	Copper Ridge, E of Stillhouse Hollow	Steep slope; karst, mixed hardwood forest, hemlock/oak; silty clay loam	MF	SE	F	305	36.0854 -84.0204	13
6	30MAR2016	Copper Ridge, W of Stillhouse Hollow	Moderate slope; karst; mixed hardwood forest, beech/sycamore; silty clay loam	SL	NE	F	268	36.0839 -84.0220	14
7	6FEB2017	Bull Run Valley, S of Hill Rd	Limestone cliff facing creek; mixed hardwoods, beech/oak; silty clay loam	SL	NE	F	311	36.1489 -83.9550	23
8	6FEB2017	Bull Run Valley, S of Hill Rd	Moderate slope; mixed hardwood forest, beech/oak; karst; silty clay loam	MF		F	293	36.1481 -83.9544	20
9	21MAY2016	Copper Ridge, Texas Valley Rd	Steep wooded karst slope; mixed hardwoods, beech/maple/oak; cherty silty loam	SL	NW	F	433	36.1671 -83.8648	44
10	21MAY2016	Copper Ridge, Texas Valley Rd	Edge of woodland spring with chert gravel; mixed hardwoods, oak/beech; cherty silty loam	WT	NW	F	360	36.1666 -83.8669	13
11	21MAY2016	Copper Ridge, Texas Valley Rd	Edge of pond; mesic; cattails/grasses; silt loam	WT		O	348	36.1673 -83.8675	7
12	22JAN2017	Black Oak Ridge, 2 km E of SR 441,	Moderate slope; mixed hardwoods; limestone outcrops; English ivy; cherty silt loam,	MF	N	F	366	36.0670 -83.9009	16
13	4OCT2015	Beaver Valley, Emory Rd, Blue Hole Spring	In grasses near spring and under walnut/cedar; recently pasture; alluvial silt loam	WT		O	311	36.0701 -83.9638	6

Appendix 1. (Continued)

Site	Date	Location	Habitat	HAB	ASP	CC	ELV (m)	Latitude/ Longitude (decimal degrees)	No.Sp.
14	4OCT2015	Beaver Valley, Emory Rd. near Blue Hole Spring	Second growth on recent pasture; karst; clay loam	DF		M	311	36.0701 -83.9642	8
15	26MAR2016	Beaver Valley, Old Powell Airfield	Edges of wetland; mixed hardwoods, grasses; alluvial silt loam	WT		M	299	36.0455 -83.9995	15
16	12MAR2016	Beaver Ridge, NW base	Woodland spring, mixed hardwoods, oak/hickory/poplar; mesic silty clay loam	WT		F	311	36.0203 -84.0179	6
17	14MAR2016	Beaver Ridge, NW slope	Moderately steep slope; mixed hardwood forest, oak/poplar; silty clay loam	MF	NW	F	317	36.0206 -84.0175	14
18	1APR2015	Beaver Ridge, NW base	Mixed pine forest, cedar, few hardwoods; karst; silty clay loam	PC	NW	F	317	36.0213 -84.0163	13
19	22APR2015	Beaver Ridge, along power line	Open area along power line; fine sandy loam from acidic sandstone	DF	NW	O	357	36.0179 -84.0175	16
20	22APR2015	Beaver Ridge, NW base	Open field; grasses; limestone/mudstone outcrops; silty clay loam	DO		O	357	36.0212 -84.0186	6
21	5NOV2016	West Beaver Creek Dr, 150 m W of Clinton Hwy	Residential lawn, near landscape business; around debris, under plastic	OD		M	305	36.0160 -84.0492	24
22	23DEC2015	Copper Ridge, 600 m E of Bell Campground Rd	Low swale; mesic mixed hardwood forest; alluvial silt loam	WT		F	308	36.0473 -84.0562	14
23	27MAR2016	Copper Ridge, Brushy Valley Cave	Cave; twilight section and in first full dark room	CV		C	360	36.0491 -84.0599	9
24	19SEP2015	Copper Ridge; 650 m E of Bell Campground Rd	Mature mixed hardwood; karst, near cave opening; silty clay loam	SL	W	F	329	36.0478 -84.0601	32
25	30MAR2016	Copper Ridge, Fowler Spring, Bell Campground Rd	Limestone bluff over forested spring; mixed hardwoods, beech/sycamore	SL	N	F	294	36.0449 -84.0595	18
26	30MAR2016	Copper Ridge, Fowler Spring, Bell Campground Rd	Mesic soils around spring; karst; mixed hardwood forest, beech/ sycamore; silt loam	WT		F	274	36.0450 -84.0595	20
27	19SEP2015	Beaver Valley floodplain, Emory and Karns Valley Rds	Floodplain; recent pasture, second growth forest; mixed alluvium	WT		F	287	35.9816 -84.1231	10
28	5JUN2015	Hardin Valley Rd, 1.5 km E of Pellissippi Pkwy	Moderate slope; disturbed second growth forest; eroding cherty silt loam	DF	N	F	299	35.9548 -84.1418	5
29	1OCT2015	Beaver Valley, Couch Mill Rd	Steep karst slope facing Beaver Creek; mixed hardwood maple/oak; cherty silt loam	MF	SEE	F	262	35.9469 -84.2045	26
30	3AUG2015	Hickory Creek Rd, along creek	Scrubby forest in floodplain; alluvial silt loam	WT		F	244	35.8898 -84.2463	13
31	17APR2016	Hines Valley, I 75 Watt Rd Exit, around the truck stops	Highly disturbed area; mixed samples; forest edges, fence rows; mixed soils	MX		O	274	35.8800 -84.2300	13

Appendix 1. (Continued)

Site	Date	Location	Habitat	HAB	ASP	CC	ELV (m)	Latitude/ Longitude (decimal degrees)	No.Sp.
32	10OCT2016	Blackoak Ridge, at Watt Rd	Steep slope; mixed hardwood forest, hickory/oak; low limestone outcrops; cherty silt loam	MF	NW	F	305	35.8753 -84.2336	9
33	12FEB2017	Webb School of Knoxville	Disturbed area in a sinkhole; karst; mixed hardwoods, oak/sycamore	DO		F	287	35.9243 -84.1162	14
34	17NOV2015	Saltpeter Bluff, RDB of Tennessee R Mile 610	Limestone cliff; some mature hardwoods, oak/cedar	SL	S	M	274	35.8076 -84.1655	25
35	8DEC2015	Salt Peter Bluff, RDB of Tennessee R. Mile 610	Very steep slope; mixed hardwoods; some sandstone outcrops; cherty silt loam	SL	S	F	244	35.8073 -84.1649	38
36	8DEC2015	Above Saltpeter Bluff, near Tennessee R. mile 610	Ridgetop; mixed hardwood forest, oak/ hickory; silty clay loam	MF		F	305	35.8077 -84.1636	10
37	7NOV2016	Keller Bend of Tennessee R.	Steep forested slope; large limestone boulders; mixed hardwoods	SL	NNW	F	274	35.8502 -84.0641	25
38	8JUN2015	Maxwell Spring, Northshore Rd	Karst; mixed hardwood forest near spring; mixed samples; mesic and dry soils	MX		F	274	35.8851 -84.0386	24
39	8NOV2015	Rudder Oaks Way and Rudder Ln	Moderate slope; karst; mixed hardwood forest, hickory/oak	DF	E	F	311	35.8989 -84.0214	18
40	17MAY2015	Tennessee R. Mile 635, RDB	Moderate slope; open grassy field; clay loam	WT	S	0	250	35.8871 -83.9935	2
41	17MAY2015	Tennessee R Mile 636, RDB	Moderate slope; mixed hardwood forest; calcareous sandstone present; clay loam	DF	S	F	287	35.8885 -83.9928	7
42	2AUG2015	S of Duncan Rd and Duncan Br	Steep slope; mixed hardwood forest, beech/maple; calcareous sandstone present; clay loam	MF	N	F	262	35.8893 -83.9925	15
43	2AUG2015	S of Duncan Rd; along Duncan Br	Grassy floodplain, some low vegetation; clay loam	WT		O	262	35.8898 -83.9931	13
44	4SEP2015	Brown Mtn., I.C.King Park, near S entrance	Steep slope; mixed hardwood forest, oak/ hickory; calcareous sandstone; loam	MF	N	F	262	35.8926 -83.9524	11
45	12SEP2015	Brown Mtn., I.C. King Park, S of Knob Cr.	Steep slope; mixed hardwood forest, oak/ hickory; calcareous sandstone; loam	MF	NE	F	276	35.8945 -83.9470	27
46	7OCT2015	Brown Mtn., I.C.King Park, N side	Cedar grove; limestone/shale outcrops; silty clay loam	PC	W	M	250	35.8975 -83.9506	12
47	24DEC2015	Brown Mtn., I.C.King Park, E side	Moderate slope; mixed hardwood forest, oak/hickory; karst; loam	MF	N	F	262	35.8985 -83.9395	20
48	12MAR2016	Brown Mtn., I.C. King Park, E side	Mixed hardwood forest along stream bank; beech/oak; limestone rocks; silty clay loam	WT		F	256	35.8925 -83.9491	7
49	30MAR2016	Brown Mtn., I.C. King Park, S of Knob Cr.	Mesic bluff of layered calcareous sandstone; mixed hardwoods, beech/hickory/oak; loam	SL	N	F	280	35.8978 -83.9403	11
50	24MAY2016	Brown Mtn., S of Hendrix Ln	Steep slope; mixed hardwoods, beech/maple; sandstone outcrops; sandy clay loam	MF	NE	F	34	35.8968 -83.9216	26

Appendix 1. (Continued)

Site	Date	Location	Habitat	HAB	ASP	CC	ELV (m)	Latitude/ Longitude (decimal degrees)	No.Sp.
51	12SEP2015	Third Creek Greenway	Moderate slope; mixed hardwood forest; limestone sinkhole; cherty silt loam	MF	NW	F	280	35.9484 -83.9635	20
52	12SEP2015	Third Creek Greenway	Bamboo stand in floodplain with mixed hardwoods, sycamore; mesic alluvial silt loam	WT		F	287	35.9513 -83.9572	21
53	5MAY2015	Third Creek Greenway	Open grassy slope along roadway	OD	E	O	250	35.9529 -83.9413	9
54	5MAY2015	Third Creek Greenway	Mixed samples in urban park, waste area around dumps and buildings; exotic vegetation	DF	NE	F	250	35.9505 -83.9423	6
55	26JUL2015	Tennessee R. Mile 646, LDB	Limestone cliff; mixed hardwoods and weeds, beech/privot	SL	N	M	259	35.9408 -83.9363	30
56	14MAR2017	Neyland Dr , TN R. Mile 646	Open, exposed limestone outcrops next to a busy road; exotic vegetation	DO		M	259	35.9443 -83.9311	15
57	24OCT2015	Forested area S of Tennessee R. Mile 646, LDB,	Moderate slope; mixed hardwood forest, beech/maple; calcareous sandstone; loam	MF	SW	F	290	35.9413 -83.9299	13
58	24OCT201	Forested area S of Tennessee R. Mile 646, LDB	Moderate slope; mixed hardwood forest, maple/oak; disturbed; trashy; calcareous sandstone outcrops; loam	DO	N	F	244	35.9414 -83.9280	10
59	22AUG2015	High Ground Park	Moderate slope; mixed hardwood forest, oak/hickory; clay loam	MF	NE	F	320	35.9399 -83.9232	21
60	22AUG2015	High Ground Park	Along a small wooded stream; beech/ hemlock; alluvial loam	WT		F	268	35.9393 -83.9210	6
61	22AUG2015	High Ground Park	Open meadow occasional trees; native wildflowers, grasses; loam	OD		O	329	35.9409 -83.9211	6
62	2JUN2015	Woodlawn Pike, Graystone Church	Second growth forest; gullied eroded soils; some loam	DF	S	F	307	35.9457 -83.9098	3
63	15MAR2016	Block around the RR track and Grand St, Knoxville	Urban; trashy; shrubs; grasses	UR	NW	M	274	35.9626 -83.9334	13
64	7MAY2015	Second Creek Greenway	Mixed sample; wooded floodplain and limestone bluff; cherty silt loam; close to urban area	MX		F	276	35.9575 -83.9229	15
65	21NOV2016	Neyland Dr, under RR bridge near Second Cr.	Urban, degraded; weedy	UR	S	M	256	35.9567 -83.9215	13
66	15MAR2016	Old Grey Cemetery, Tyson St	Parklike with some trees; along stone wall; silty clay loam	OD		M	274	35.9750 -83.9253	13
67	15MAR2016	Jackson Ave and Gay St	Urban; steep, trashy, rocky outcrop next to a parking lot	DO	N	M	293	35.9679 -83.9215	7
68	15MAR2016	First Presbyterian Cemetery	Urban, parklike; large trees	OD		M	293	35.9647 -83.9168	5
69	15MAR2016	Blount Mansion, Knoxville	Lawn and shrubs; grasses	UR		M	305	35.9631 -83.9122	12

Appendix 1. (Continued)

Site	Date	Location	Habitat	HAB	ASP	CC	ELV (m)	Latitude/ Longitude (decimal degrees)	No.Sp.
70	6SEP2015	Sharp Ridge Mem. Park, SW side	Moderate slope; mixed hardwood forest, oak/maple; acidic sandstone; fine sandy loam	MF	NW	F	388	36.0012 -83.9491	12
71	6SEP2015	Sharp Ridge Mem. Park, NE side	Moderate slope, mixed hardwood forest, oak/maple; acidic sandstone, fine sandy loam	MF	E	F	388	36.0082 -83.9355	7
72	10OCT2015	Sharp Ridge Mem. Park, middle of park	Steep forested slope, mixed hardwoods oak/maple; acidic sandstone; fine sandy loam	MF	N	F	341	36.0039 -83.9411	9
73	29MAR2015	Holston R Park	Mixed hardwood forest; karst; silty clay loam	SL		M	250	35.9739 -83.8603	10
74	26OCT2016	Holston R Park, Holston R, RDB	Limestone boulders and sandstone ledges; mixed hardwoods	SL	NE	F	244	35.9733 -83.8596	21
75	17NOV2015	Ijams Nature Center, TN River mile 651, LDB	Limestone bluff and steep hardwood forested slope, oak/sycamore	SL	NE	F	262	35.9557 -83.8626	24
76	17NOV2015	Ijams Nature Center, Meades Quarry	Limestone/marble outcrops facing quarry pond; disturbed area	DO		M	259	35.9511 -83.8677	15
77	17NOV2015	Ijams Nature Center, Ross Quarry	Old marble quarry; mesic; limestone/ marble blocks	DO	SE	F	290	35.9464 -83.8741	25
78	17NOV2015	Ijams Nature Center	Dry alkaline valley; historic location of a lime-making operation; dominated by cedar	OD		O	293	35.9451 -83.8752	21
79	21OCT2015	Marie Myers Park	Moderate slope; mixed hardwoods, maple/hickory, *Vinca* sp.; exposed limestone	MF	NE	F	287	35.9371 -83.8731	26
80	21OCT2015	Marie Myers Park	Moderate slope; cedar and mixed hardwoods; sandstone/limestone rocks; *Vinca* sp.	PC	NE	F	287	35.9394 -83.8762	8
81	23MAY2015	Hastie Park	Hilly mixed hardwood forest, oak/hickory; limestone boulders	MF		F	274	35.9330 -83.8780	27
82	15AUG2015	Burnett Creek Rd and Burnett Creek	Moderate slope; mixed hardwoods with cedar, invasive *Vinca* sp.; some limestone	MF	SE	F	256	35.9374 -83.8492	21
83	9MAY2016	Forks of the River NWA, French Broad R Mile 1.5, LDB	Limestone/sandstone cliff; mixed hardwoods oak/sycamore	SL	NE	M	248	35.9438 -83.8442	28
84	9MAY2016	Forks of the River NWA	Open cedar grove; moss covered rocky soil with limestone	PC		O	248	35.9409 -83.8470	11
85	16AUG2015	On trail S of Burnett Ck Rd	Open cedar grove; moss covered rocky soil with limestone	PC	E	O	287	35.9329 -83.8561	13
86	16AUG2015	S of Burnett Ck Rd, unnamed tributary to Tennessee R.	Mixed hardwood forest, hickory/maple; stream bank, limestone; alluvial silt loam	WT		M	256	35.9311 -83.8497	14
87	16AUG2015	S of Burnett Ck Rd	Mixed hardwood forest, hickory/maple; limestone outcrops	MF	W	F	262	35.9303 -83.8491	9

Appendix 1. (Continued)

Site	Date	Location	Habitat	HAB	ASP	CC	ELV (m)	Latitude/ Longitude (decimal degrees)	No.Sp.
88	20NOV2016	Sevierville Pike	Moderate slope; mixed hardwood forest, oak/hackberry; limestone, silty clay loam	MF	E	F	274	35.9241 -83.8529	14
89	20NOV2016	Sevierville Pike	Mixed hardwood forest, hickory/ maple; stream bank; limestone; alluvial silt loam	WT	Flat	M	274	35.9244 -83.8526	13
90	9MAY2016	Burnett Ck Rd, N of Fordtown Rd	Second growth forest; entire slope covered with an unidentified herbaceous ground cover	DF	NEE	F	259	35.9295 -83.8287	3
91	9MAY2016	Brown Mtn, NE of Burnett Ck Rd	Karst ridgetop; mixed hardwood forest, oak/hickory; loam	MF	SW	F	335	35.9317 -83.8251	19
92	15MAY2016	Brown Mtn, base at Fordtown Rd	Steep ravine; in a seep; mixed hardwood forest, oak/maple; alluvial clay loam	WT		F	280	35.9269 -83.8334	6
93	15MAY2016	Brown Mtn, base at Fordtown Rd	Shaded ravine; mixed hardwood forest, oak/ maple; loam	MF	S	F	274	35.9269 -83.8311	27
94	2APR2016	Thorn Grove Pike and Kennedy Rds	Sandstone boulder forest, oak/cedar; 40% canopy	DO		M	274	35.9660 -83.7975	18
95	9MAY2015	Holston R Mile 3, LDB	Limestone cliff; some mixed hardwoods, oak	SL	SW	F	259	35.9894 -83.8365	10
96	9MAY2015	Holston R Mile 4, LDB	Limestone cliff; some mixed hardwoods, sycamore	SL	SW	M	268	35.9972 -83.8278	14
97	9MAY2015	Holston R Mile 5, LDB	Disturbed second growth forest; eroded alluvial loam	DF	SW	M	262	36.0145 -83.8296	2
98	11FEB2017	Love Ck Rd	Moderate slope; limestone boulders; disturbed hardwood forest	DF	SW	F	274	36.0223 -83.8592	5
99	12NOV2016	McAnnally Ridge, E of Ellistown Rd	Steep slope; mixed hardwood forest, oak/hickory; acid sandstone; fine sandy loam	MF	NE	F	366	36.0633 -83.8203	28
100	12NOV2016	McAnnally Ridge, E of Ellistown Rd	Floodplain and edge of creek, open, wet pasture; mesic silt loam	WT		O	305	36.0653 -83.8198	7
101	5MAR2016	House Mountain State Natural Area, 1km E of Idumea Rd	Moderate slope; mixed hardwood forest, oak/hickory; sandstone; fine sandy loam	MF		M	354	36.1051 -83.7624	15
102	19MAR2016	House Mountain State Natural Area, SE base	Mature mixed hardwood forest; mesic, standing water; sandstone; fine sandy loam	WT	SE	F	372	36.1055 -83.7647	19
103	19MAR2016	House Mountain State Natural Area, NW side	Steep slope; mixed hardwood forest, oak/hickory; sandstone boulder; fine sandy loam	MF	NW	F	518	36.1088 -83.7725	30
104	19MAR2016	House Mountain State Natural Area, SE side	Steep slope; mixed hardwood forest, oak/ hickory; sandstone boulder; fine sandy loam	MF	SE	F	518	36.1064 -83.7710	27

Appendix 1. (Continued)

Site	Date	Location	Habitat	HAB	ASP	CC	ELV (m)	Latitude/ Longitude (decimal degrees)	No.Sp.
105	11FEB2017	Holston R mile 16, RDB	Limestone bluff; mixed hardwood forest, oak/beech	SL	SEE	M	274	36.0556 -83.7232	18
106	11FEB2017	Saylor Ford Rd	Wetland/flood plain; weedy, open, mesic; alluvial silt loam	WT		M	259	36.0548 -83.7264	5
107	2APR2016	Midway Rd and Tuckahoe Ck	At a road cut into a shaly bank; shaly clay loam	DO		O	274	35.9781 -83.6898	2
108	2APR2016	Seven Islands State Park	Edge of pond; grasses, scrubby trees; open; silt loam	WT		O	317	35.9543 -83.6915	1
109	15OCT2015	Seven Islands State Park, French Broad R. mile 15, RDB	Limestone cliff; mixed hardwoods, beech/oak/hickory	SL	S	F	262	35.9515 -83.6970	40
110	2APR2016	Seven Islands State Park	Edge of pond/wetland; grasses; open; alluvial silt loam from micaceous material	WT		O	207	35.9504 -83.6950	3
111	15OCT2015	Seven Islands State Park	Disturbed, scrubby floodplain; alluvial silt loam from micaceous material	DF		M	262	35.9499 -83.6938	7
112	2APR2016	Seven Islands State Park, French Broad R Mile 17.5, RDB	Steep mixed hardwood slope, oak/ maple; sandstone river bluff; fine sandy loam	SL	E	F	290	35.9492 -83.6878	18
113	3APR2016	Bays Mtn, French Broad R Mile 15, RDB	Limestone/sand stone bluff; mixed hardwoods; fine sandy loam from acid sandstone	SL	NE	M	274	35.9435 -83.6961	20
114	3APR2016	Bays Mtn, Porterfield Gap, E side	Steep mixed hardwood slope, beech/ hickory; acid sandstone outcrops; fine sandy loam	SL	W	F	305	35.9218 -83.7441	13
115	3APR2016	Bays Mtn, Porterfield Gap, W side	Steep mixed hardwood slope, beech/ hickory; acid sandstone, fine sandy loam	MF	E	F	290	35.9215 -83.7447	19
116	12FEB2017	Bays Mtn, Finger Ridge, N of Dry Hollow Rd	Steep mixed hardwood slope, oaks; acid sandstone; fine sandy loam	MF	NW	F	415	35.9072 -83.7792	18
P1	8NOV2017	Powell Blvd	Sidewalk next to mixed hardwood forest	MX		O	293	36.0193 -84.0414	1
P2	14MAR2016	West Beaver Creek Dr,	Mixed hardwood forest at edge of a residential yard under a board; silty clay loam	DF	NW	F	323	36.0206 -84.0175	1
P3	12SEP2015	W Beaver Creek Dr and Bayless Ln	Parking lot in the rain	UR		O	317	36.0262 -84.0203	1
P4	20MAY2016	Mud Flat Cave	Cave; limestone	CV		C	262	35.8875 -84.0917	1
P5	13MAR2016	Fort Dickerson Park,	Parklike; mixed hardwoods; loam from calcareous sandstone	OD		M	335	35.9488 -83.9160	1
P6	26MAR2017	Davenport Rd,	Open, disturbed grassy bank; near a greenhouse.	UR		O	274	35.9493 -83.9006	1