

LAND MOLLUSCA OF NORRIS DAM STATE PARK WITH NOTES ON CUMBERLAND PLATEAU AND BLUE RIDGE AFFINITIES

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ABSTRACT—This study examined the biodiversity of the land mollusks of Norris Dam State Park near Norris, Tennessee. Biodiversity was examined in randomly selected areas within the park. One-hundred-meter transects were utilized with five sampling stations, each 20 m from adjacent stations, established along each transect. Macro (> 5 mm) and micro (< 5 mm) snails were collected using person-minute searches and leaf-litter samples. A total of 782 specimens were collected representing 9 families, 23 genera, and 43 species. From this collection, 28 new county records were established for Anderson and Campbell counties. Among these county records, six species previously known to occur on the Cumberland Plateau and/or in the Blue Ridge mountains were discovered. The presence of these 6 disjunct populations suggests that the Ridge and Valley physiographic province has been a region of dispersion for some elements of the Cumberland Plateau and Blue Ridge Mountains. This also suggests that the Ridge and Valley of East Tennessee may serve as a refuge for relict populations with Cumberland Plateau and Blue Ridge affinities. These findings weaken the belief that the broad Ridge and Valley of eastern Tennessee was a barrier to intermingling between the Cumberland Plateau and Blue Ridge snail fauna.

The distribution of terrestrial gastropods is poorly studied and, therefore, ranges of many species are inadequately illustrated in today's literature. In terms of land snails and their composition and diversity, the Ridge and Valley region of East Tennessee is severely understudied. This is especially true with regard to micro snails and is represented by the numerous gaps found in the distribution records in Hubricht (1985). The current investigation was initiated as part of the Tennessee Department of Environment and Conservation's all taxa biological inventory of state parks. The purpose of this study was to examine land mollusk species diversity within different physical communities found at Norris Dam State Park near Norris, Tennessee.

Land snails are crucial for the proper functioning and overall health of forest ecosystems (Caldwell, 1993). They break down organic matter and enhance nutrient cycling (Wareborn, 1992). Through ingestion and defecation, snails also play an important role in the movement of certain soil fungi that help capture nutrients for many plants, including economically important plants like hardwood trees and grains (Caldwell, 1993).

No studies examining land mollusks have been conducted within Norris Dam State Park. However, a few terrestrial gastropod surveys have been conducted within Tennessee. A study was conducted statewide on the distribution of the family Polygyridae in which 76 new county records were found for 27 of the 75 species of that family known from Tennessee (Bogan *et al.*, 1982). Lutz (1950a; b) surveyed Claiborne County and established a list of the land mollusks present including the description of a new species of *Triodopsis*. Coney *et al.* (1982) conducted an ecological study of land mollusks in the Hiwassee River basin and found greater species diversity occurred on steep slopes when compared to moderate slopes.

Drastic elevation changes and gradient extremes are indicative of the Ridge and Valley of eastern Tennessee.

As noted by Burch (1969), the land mollusks of the Southern Appalachians have unique distributions. Binney (1885), as well as Burch (1962), designated the Southern Appalachians as the Cumberland Molluscan Province in regard to terrestrial gastropod faunas. This recognition was due to high levels of endemism of terrestrial gastropods throughout the region. Pilsbry (1900) further divided the region into an eastern division, which includes the Great Smoky Mountains and Blue Ridge Region (BR), and a western division containing the Cumberland Plateau (CP). These two divisions are separated in Tennessee by the Ridge and Valley physiographic province (RV). Pilsbry (1900) believed that river systems in the RV presented a geophysical barrier that prevented the passive movement and intermingling of the Cumberland Molluscan Province's east and west division species. All species that belong to the order Stylommatophora, encompassing most species in the study area, breathe air and lack an operculum to seal off their apertures and to protect themselves from the outside environment (Luchtel and Deyrup-Olsen, 2001). As a result, they are not adapted to life in totally aquatic environments. Therefore, large bodies of water would present a formidable barrier to movement and dispersal.

MATERIALS AND METHODS

Study Area—Norris Dam State Park was purchased by the state of Tennessee in 1953 from the Tennessee Valley Authority (Kohl, 2002). Located on Norris Lake, the park is split into two sections, one on the eastern shore of Norris Lake and one on the western shore (Fig. 1), and encompasses

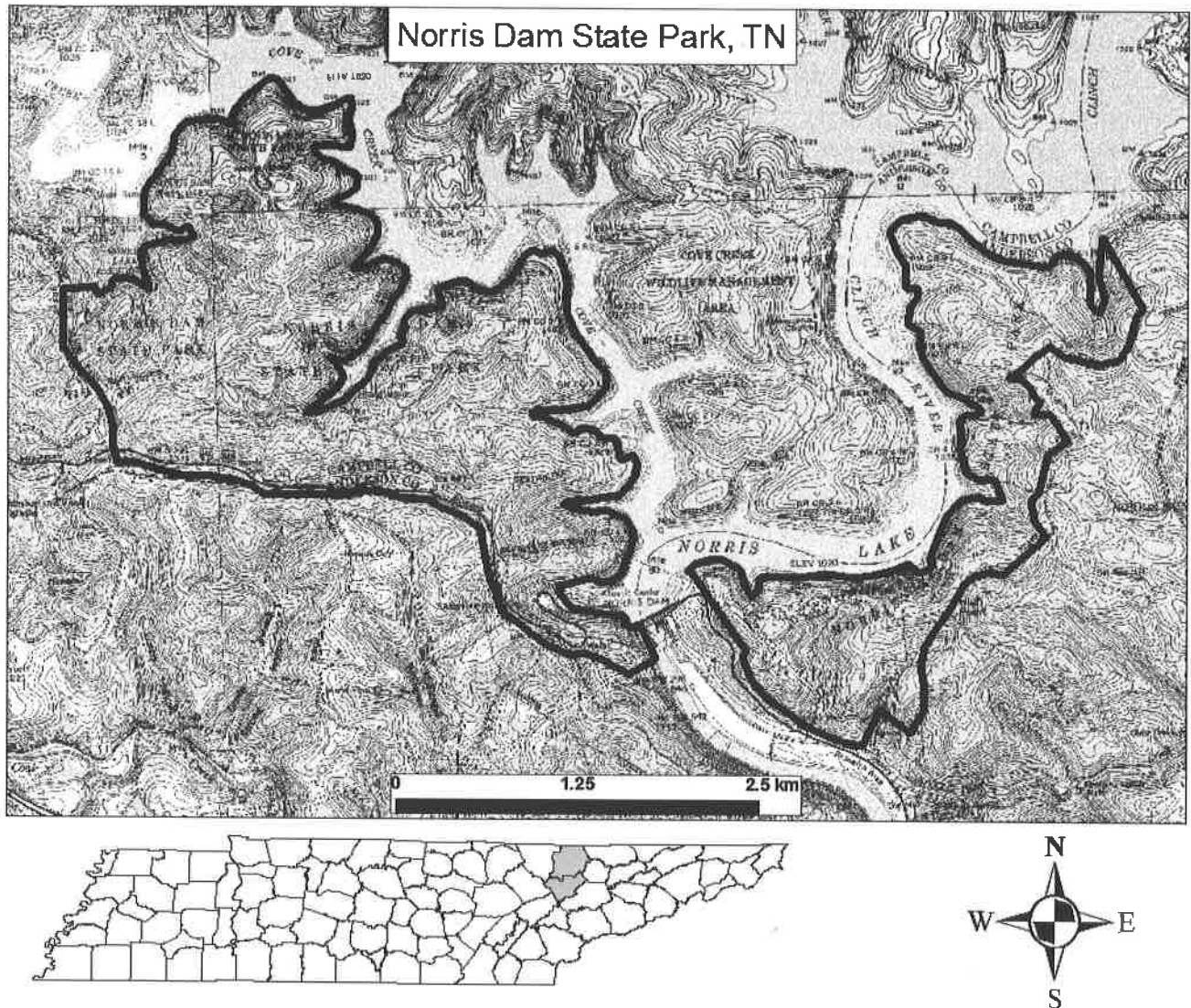


FIG. 1. Map showing the boundaries of Norris Dam State Park (heavy dark line). The inset map of Tennessee highlights Anderson and Campbell counties where the park is located.

approximately 1133 ha. The park is situated in the RV of Tennessee (Fenneman, 1938) 32.8 km north of Knoxville, Tennessee. Elevation ranges from 274 m above sea level near US Highway 441 to 448 m at its highest point. The area is drained by the Clinch and Powell rivers with a major tributary being Cove Creek. The geology of the area is mainly limestone and dolomite with a few outcrops of chert, sandstone, and shale (Kohl, 2002). Copper Ridge Dolomite is the dominant strata in the area and all sites sampled were underlain by this formation. The topography of Norris Dam State Park is one of dry ridges separated by moist ravines and hollows. The forest community is characterized by having *Quercus velutina*, *Quercus montana*, *Carya* spp., *Acer rubrum*, *Fagus grandifolia*, and *Liriodendron tulipifera* as dominant tree species. Saplings of these species, *Vaccinium* spp., and *Gaylussacia* spp. are dominants within the shrub layer. Historically, *Pinus* spp. were an important component of this forest. However, the southern pine beetle, *Dendroctonus frontalis*, has been very detrimental.

Most reproducing-sized pines have been killed, leading to a large amount of decaying coarse woody debris on the forest floor in some areas of the park.

Sampling Techniques—Sampling occurred September 2006–January 2008. Eight visits to the park were made during this period with the majority of collection taking place during spring and fall 2007. Stratified random sampling was used to obtain data regarding land snail composition and diversity. Eight 100-m line transects were established, two within each strata sampled. The park was stratified by physical communities which included ridge top communities, cove communities, north-facing slopes, and south-facing slopes. Five sampling stations were established along each transect and spaced 20 m apart. A total of 40 stations were sampled, each being divided into four quadrants. One 17 cm × 31 cm leaf litter bag was collected in each quadrant, totaling four bags per point. Each bag was filled with litter from a 0.25 m² sampling frame. Litter bags were taken back to the lab, dried, and sifted

using numbers 4, 10, 14, and 18 soil sieves to search for micro snails (< 5 mm) (Coney *et al.*, 1981). Macro snails (> 5 mm) were collected through raking and walk-through surveys of the transect areas. Raking and walk-through surveys were conducted for a minimum of twenty person minutes. If larger quantities of live specimens and empty shells were found, more time was taken for these surveys. After collection, live mollusks were euthanized in water for a 24-h period. Specimens were then placed in a solution of 85% (or higher) ethyl alcohol for another 24 h to kill any bacteria that may have been living on the organism. The tissue was then removed, and the shells were identified to species based on shell morphology.

Taxonomy—Keys provided by Pilsbry (1940; 1946; and 1948) and Burch (1962) were used to identify all shells collected. State and county records as well as range extensions were determined using Hubricht (1985). Taxonomy was based on Turgeon *et al.* (1998).

RESULTS

This study yielded 782 specimens representing 9 families, 23 genera, and 43 species. Twenty-eight new county records for Anderson and Campbell counties were collected (Table 1). Of these, six species were previously known from the BR and CP physiographic provinces. These discoveries represent significant range extensions for these six species (Table 2). One species, *Mesomphix rugeli*, had a 161-km range extension from its nearest known location on Big Black Mountain in Harlan County, Kentucky (Hubricht, 1985).

DISCUSSION

The CP and BR share many species of land snails (Hubricht, 1985). The RV acts as a barrier to movement and dispersal where movement is impeded by some type of landform, such as a river, mountain, ridge or by some type of unsuitable habitat. The upper Tennessee River system eroded the area between the CP and BR provinces, separating populations and creating relict populations of certain species, such as those shown (Table 2), on the CP. The discovery of sympatric occupation between CP and BR faunas at Norris Dam suggests that the RV was not a barrier for some species and is also holding pockets of isolated populations of these relict species.

A possible explanation for the presence of these species may be the merging of multiple physiographic regions. Dourson (2007) reported similar patterns of species diversity and range extensions from Furnace Mountain in Powell County, Kentucky, where multiple physiographic regions unite. Norris Dam State Park is located near the merging of the RV and the Cumberland Mountains. This area is sometimes considered part of the CP but is also sometimes regarded as its own physiographic/ecoregion. Dourson and Beverly (2008) suggest that large landscape edges, mixing of soil types, changes in elevation, and differences in slope gradients created by convergences of physiographic regions lead to extraordinary assemblages of species that would not normally occur in certain areas. An abundance of calcareous substrate in the RV region also bodes well for snail species diversity and abundance (Burch, 1955; Petranka, 1982; Hotopp, 2002). Snails rely on a steady supply of calcium in the development of shells (Caldwell, 1993) and the formation of eggs (Tompa, 1980). These findings also suggest that the

TABLE 1. Species collected and county records obtained during this study.

Species	Anderson County Record	Campbell County Record
<i>Anguispira alternata</i>		*
<i>Appalachina</i>		
<i>chilhoweensis</i>		
<i>Appalachina sayana</i>	*	
<i>Carychium clappi</i>		*
<i>Carychium nanmodes</i>		
<i>Cionella moreseana</i>		
<i>Discus patulus</i>		
<i>Euchemotrema fraternum</i>	*	*
<i>Gastrocopta contracta</i>		*
<i>Gastrocopta pentodon</i>		*
<i>Glyphyalinia</i>		*
<i>cryptomphala</i>		
<i>Glyphyalinia indentata</i>		*
<i>Glyphyalinia wheatleyi</i>		*
<i>Guppya sterkii</i>		*
<i>Haplotrema concavum</i>		
<i>Helicodiscus parallelus</i>		*
<i>Helicodiscus singleyanus</i>		*
<i>Inflectarius inflectus</i>		
<i>Mesodon thyroidus</i>		
<i>Mesodon zaleatus</i>	*	
<i>Mesomphix capnodes</i>		*
<i>Mesomphix cupreus</i>	*	*
<i>Mesomphix inornatus</i>		*
<i>Mesomphix perlaevis</i>		
<i>Mesomphix rugeli</i>	*	*
<i>Millerhelix fatigiata</i>	*	
<i>Neohelix albolabris</i>		
<i>Paravitrea capsella</i>		*
<i>Paravitrea multidentata</i>		*
<i>Paravitrea placentula</i>		*
<i>Patera appressa</i>		
<i>Pomatiopsis lapidaria</i>		
<i>Punctum blandianum</i>		*
<i>Stenotrema stenotrema</i>		*
<i>Striatura meridionalis</i>		*
<i>Strobilops aenea</i>	*	*
<i>Triodopsis tridentata</i>		
<i>Triodopsis vulgata</i>		
<i>Ventridens acerra</i>	*	
<i>Ventridens demissus</i>		
<i>Ventridens gularis</i>		
<i>Vertigo gouldi</i>		*
<i>Zonitoides elliotti</i>		*

populations of snails may be utilizing the RV as a conduit for dispersal between the CP and BR and that the RV may be an overlooked and understudied area of overlap between these populations.

Another possible explanation for these findings may be that many of these species were most likely more widely distributed before the Tennessee River system eroded the calcareous rock-based area of what is now the Ridge and

TABLE 2. Land snail affinities with range extensions in kilometers, status affinities, and habitats. BR = Blue Ridge, CP = Cumberland Plateau, CWD = Coarse Woody Debris, LL = Leaf Litter, and RT = Rock Talus.

Species	Extension (km)	Faunal Affinity	Habitat
<i>Appalachina chilhoweensis</i>	32	BR, CP	LL, RT
<i>Appalachina sayana</i>	96	CP	CWD, LL
<i>Mesomphix rugeli</i>	161	BR	LL
<i>Paravitrea placentula</i>	40	BR, CP	LL
<i>Vertigo gouldi</i>	80	BR, CP	LL
<i>Zonitoides elliotti</i>	97	BR, CP	CWD, LL

Valley physiographic province and made it what it is today. Throughout geologic time as this mass erosion event occurred, some populations of land snails that were located in the RV have become either extinct or isolated from the larger populations that occur in the BR and CP. The upper Tennessee River system and its tributaries may have prevented the dispersal and movement of the isolated populations. All of the snails found during this study belong to the order Stylommatophora. As previously mentioned, members of this order breathe air, lack an operculum and, therefore, lack the ability to seal themselves off completely within their shells and live in an aquatic environment.

However, land snails may have moved, and could still be moving, around aquatic environments by crossing rivers and other bodies of water on pieces of driftwood that float and provide enough of an area that is not submerged to allow for survival while crossing a river. Living on isolated islands in these meandering rivers and crossing during times of drought when water levels are low and offer enough dry areas for movement provide another possibility for a mode of dispersal and intermingling among these species within the RV, as well as dispersal from the CP and BR regions. Regardless of dispersal and movement patterns, these isolated populations have remained undiscovered throughout this period of time due to the lack of research on terrestrial gastropods.

Norris Dam State Park may also be serving as refuge for other faunal elements of the CP and BR. The recent discovery of striped maple, *Acer pensylvanicum*, within the boundaries of the park suggests other plant species normally associated with CP and BR floras could occur at Norris Dam State Park. With these floral species and communities being present in the area, it would make biological sense that their faunal obligates would be present as well.

The findings of this research indicate that further investigation of Norris Dam State Park and other areas throughout the RV is warranted. Further studies examining areas where gaps in Hubricht's distributional records are present may reveal connections and bridge gaps between disjunct populations, particularly in micro snails which may have been largely ignored by others in earlier collections. Studies such as Petranks (1982), Hubricht *et al.* (1983), and Dourson and Beverly (2008) have all documented populations of BR affinities occurring in the Pine and Big Black Mountain regions of Kentucky, which are adjacent to the CP. These areas are higher in elevation than the surrounding land masses and offer refuge to BR species. These are all range extensions which have extended across the RV, suggesting that other areas within the RV may also hold

isolated populations of CP and BR faunas. Without further studies similar to this one, these isolated populations may remain undiscovered and may even be lost due to development and urban sprawl. Climate change may also lead to the eventual loss of many of these populations. Due to the lack of research in regard to these isolated populations, the scientific community is unaware of even the basic biological and ecological needs of the species in this area.

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