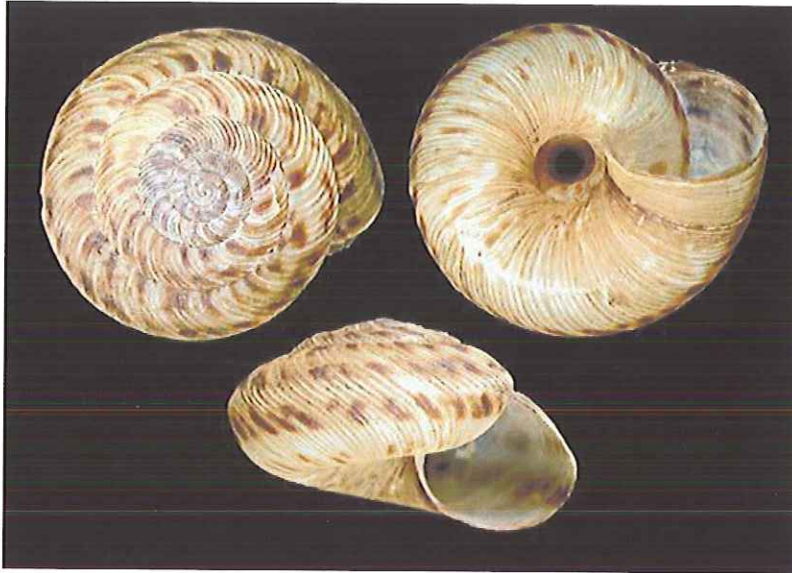


Land Snails of selected Pennsylvania Natural Areas

May, 2003



Anguispira alternata (3X), found at four natural areas

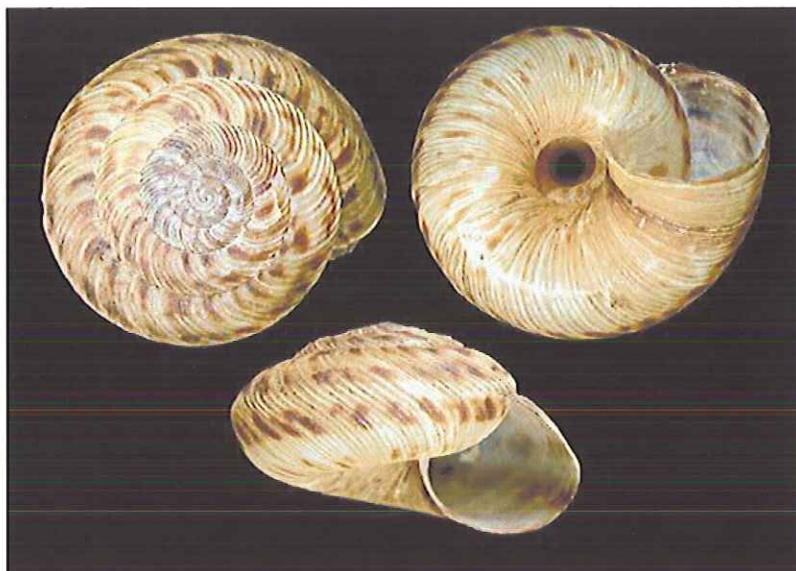
Larry Watrous photo

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USA

supported by: DCNR Grant Agreement ME#380141

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APPALACHIAN CONSERVATION BIOLOGY

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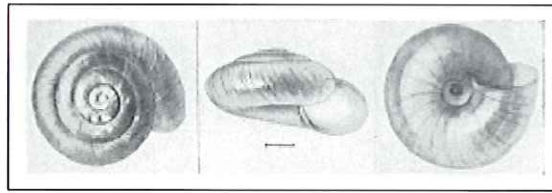
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Zonitoides arboreus was the snail most frequently found.
Illustration from Pilsbry (1948). Line = 1mm.

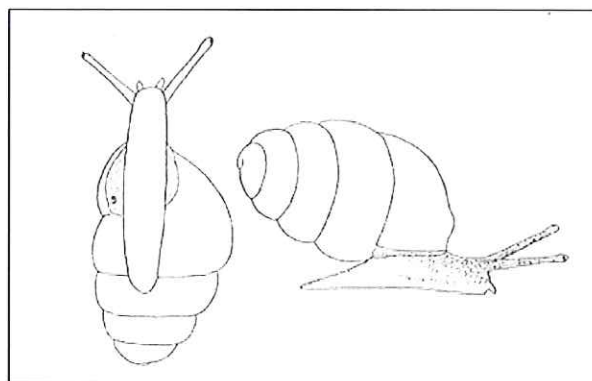
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Gastrocopta pentodon, a snail of Beartown Woods.
Illustration from Pilsbry (1948).



East side of Sharp Mt. ridge top at State Game Lands 211

ABSTRACT

Land snails were collected at eight natural areas across Pennsylvania in the summer of 2001. Four of these natural areas included old growth forest stands. A total of 42 land snail species were found, representing about 40% of the state's native species, using both quantitative and random search methods at each natural area. Thirty-six county geographic distribution records representing 21 species were discovered, and three state geographic distribution records representing one species (found at each of three sites). At Tionesta National Scenic Area in Warren County, nine of the 12 land snail species found had not been previously reported for that county. Identification of an atypical *Vertigo* sp. population at Beartown Woods in Franklin County remains outstanding. Quantitative sampling sites were established to allow repeatable temporal sampling and inventory of specific habitats. Results from quantitative sampling demonstrated correlations between land snail abundance and extractable calcium in the upper soil horizons. Six land snail species of interest are profiled here, including four of potential conservation interest: *Columella* sp., *Punctum vitreum* (H.B. Baker, 1930), *Striatura exigua* (Stimpson, 1850), and *Vertigo* sp.

INTRODUCTION

In the eastern United States there are at least 500 native species of land snails (Mollusca: Gastropoda), with at least 100 in Pennsylvania (derived from Hubricht 1985; taxonomic discrepancies do not allow an exact count). Identification and distribution information about this diverse but little-studied group is generally sparse, but there are important summaries of land snail distributions in Pennsylvania by Brooks (1931) and Wurtz (1940).

Land snails usually live among leaf litter, rocks, woody debris, and at the base of plants in the uppermost soil horizons. Many land snails feed upon plant matter including live vegetation, rotting leaves, wood, sap, algae and fungi (e.g. Pilsbry 1939-40, 1946-48, Grime and Blythe 1969). A few also feed opportunistically upon animal scats and carcasses, or upon other snails or other invertebrates, such as nematodes.

Snails concentrate calcium (Ca), which they ingest from their food, in the calcium carbonate of their shells. In fact, land snail abundance and diversity in forest sites in the central Appalachian Mountains is correlated with Ca in upper soil horizons (Hotopp, 2002). This important nutrient moves up the “food chain” as predators consume snails. Land snails are preyed upon by a variety of animals, especially certain ground beetles (Carabidae) (e.g. Digweed 1993), and shrews (Soricidae) (e.g. Ingram 1942), though it is the larger predators that consume whole shells. Snail shells can be an important source of Ca for some Passerine birds (e.g. Graveland et al 1992).

Pennsylvania is a state of 28.7 million acres, with three major river drainages – the Susquehanna and Delaware drain most of the state to the Chesapeake and Delaware bays, respectively, and the Allegheny River drains most of the remainder into the Ohio River. Elevations range from near sea level on the eastern rivers to 3,213’ above sea level in the southwestern part of the state, at Mount Davis in Somerset County.

The physiographic regions of Pennsylvania are Allegheny Plateau to the north and west, Valley and Ridge, and Blue Ridge in the east-central, and Piedmont in the southeastern corner. The Allegheny Plateau of Pennsylvania is the state’s high ground, composed of Devonian and Mississippian rock. The Valley and Ridge consists of long,

steep sandstone ridges of Cambrian to Devonian rock trending southwest-northeast. The Blue Ridge is older, more distressed rock of Proterozoic to early Cambrian origin. And the Piedmont is a rolling plain of richer soils over mixed Proterozoic to Ordovician-aged rock. The biota of Pennsylvania was profoundly influenced by three glaciations during the last glacial age. The final, Wisconsin Glaciation, peaked at 18,000 years BP and covered the northern and western two-thirds of the state.

Fifty-nine percent of Pennsylvania, or 17 million acres, are forested (Alerich 1993). Oak-hickory is the dominant forest type, at 47%, and northern hardwoods cover 38%. Red maple (*Acer rubrum*) is the most common tree species by volume and by number (4.5 million cubic feet; 1.7 billion stems), followed by northern red oak (*Quercus rubra*) and black cherry (*Prunus serotina*). Red maple is also the most rapidly increasing species (interestingly, this tree species can be negatively associated with land snail abundance and species richness; Hotopp 2002).

STUDY SITES

Because of Pennsylvania's relatively large size (for an eastern state) and extensive public lands, there are a great number of potential land snail study sites. A subset of eight study areas around Pennsylvania were selected (Table 1), mostly from larger tracts of old growth forest stands on state land reported in a document by the Center for Rural Pennsylvania (1995). However, they also include an area on federal land, and two tracts of second-growth state land, one being the focus of a comprehensive "bioblitz" inventory by the Pennsylvania Department of Conservation and Natural Resources and cooperators. An overview of the natural areas, derived mostly from The Center for Rural Pennsylvania (1995) and a Pennsylvania Bureau of Forestry publication (undated), follows.

Beartown Woods Natural Area, Michaux State Forest, Franklin Co.

This small natural area at the intersection of the Appalachian Trail and Rt. 30 is mixed northern hardwood-eastern hemlock forest on a small stream near Waynesboro, just east of Black Gap. The natural area recognizes eleven hectares (27 acres) of riparian forest identified as old growth. Elevations are in the 1,100' to 1,200' asl range.

Forrest H. Dutlinger Natural Area, Suquehannock State Forest, Clinton Co.

This 1,500-acre natural area comprises hemlock, oak, aspen and northern hardwood forest stands on steep slopes rising to a small plateau north of Kettle Creek and west of Hammersly Fork Run. Elevations of this natural area, on the Hammersly Fork USGS quadrangle, range from 1,050 to 2,000' asl. Forest Dutlinger's highlight is a 64 hectare (158-acre) old-growth eastern hemlock-northern hardwood forest on the upper reaches of Beech Bottom Hollow.

Lehigh Gorge State Park, Carbon Co.

This 4,500-acre state park conserves 26 miles of an historic railroad grade and riparian habitat on the Lehigh River, from Francis E. Walter dam to the town of Jim Thorpe. A variety of riparian hardwood, oak, hemlock, northern hardwood and pine forest stands comprise this large park, with adjacent state parks and state game lands more than doubling the conserved forest area. Elevations range from approximately 600' to 1,700' asl. Approximately 360 hectares (900 acres) of mixed eastern hemlock-hardwood on gorge slopes are reported. Relevant USGS quadrangles are several, with parts of the White Haven and Hickory Run maps at the focus of this study.



Hell Run at McConnell's Mill State Park.

McConnell's Mill State Park, Lawrence Co.

On Slippery Rock Creek Gorge west of Portersville, this 2,529-acre park consists primarily of mixed eastern hemlock-northern hardwood and oak stands on steep slopes and a narrow riparian zone, with upland fields above. Elevations range from approximately 850' to 1,300' asl. Approximately 400 hectares (1,000 acres) of mixed eastern hemlock-northern hardwood old growth are reported here. The park, which also conserves an historic mill site, lies on the Portersville USGS 7.5' quadrangle.

Quebec Run Wild Forest, Forbes State Forest, Fayette Co.

This wild area is 4,765 acres on the Quebec Run and Tebolt Run tributaries of the Big Sandy River. Mature forests are oak, northern hardwood and eastern hemlock, though there are reportedly large areas of third-growth pole timber. Elevations range from 1,500' to 2,500' asl on the Bruceton Mills USGS quadrangle.

State Game Lands 211 (St. Anthony's Wilderness), Lebanon Co.

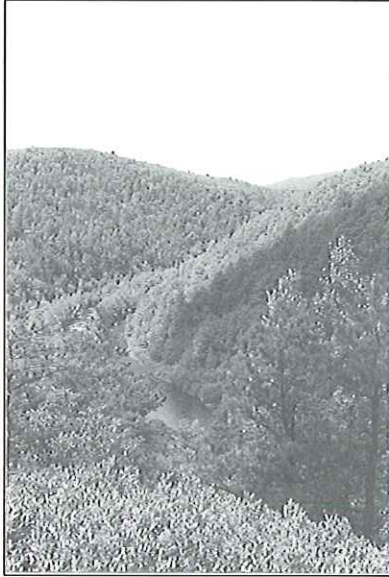
This is a biological inventory ("bioblitz") area (J. Hassinger, pers. comm., 2000) on State Game Lands north of Harrisburg. This area is within a large tract of contiguous forest in excess of 2,000 hectares (5,000 acres). Elevations range from 900' to 1,500' asl on the Grantville Quad.

Snyder-Middleswarth Natural Area, Bald Eagle State Forest, Snyder Co.

More than 100 hectares (250 acres) of old-growth white pine (*Pinus strobus*), eastern hemlock, pitch pine (*Pinus rigida*) and oak (*Quercus* spp) forest along Swift Run, northwest of Troxelville near the center of the state. Elevations are in the 1,350' - 2,000' asl range on the Weikert USGS quadrangle.

Tionesta National Scenic Area, Allegheny National Forest, Warren Co.

Tionesta Scenic and Research Natural Area is Pennsylvania's largest old-growth forest tract, covering approximately 1,600 hectares (4,000 acres), but also including natural gas pipeline right-of-ways and access roads. It straddles the Warren-McKean county line on the headwaters of the Tionesta Creek in northwestern Pennsylvania. Hough (1936) described the area as dominated by eastern hemlock and American beech (*Fagus grandifolia*) and including other northern mixed wood species. Kane USGS quadrangle elevations are in the 1,500' - 2,000' asl range.



Lehigh Gorge State Park

METHODS

Each of eight selected natural areas in Pennsylvania was visited once between June and August 2001. Land snails were collected both by random search and quantitatively. Random search explored leaf litter, the bases of plants, moss hummocks, tree trunks, woody debris, and rock features. This search covered no fixed area, but included places along trails, near streams, at the foot of steep slopes or on side-slope benches, at bedrock outcrops and among rock screes, and rarely, the edge of old fields or building foundations.

Quantitative methods consisting of timed search and sieved litter techniques were conducted upon a single 10m x 20m site at each natural area. Quantitative sites were selected for homogeneous vegetation, topography, and aspect. These sites necessarily focused upon one habitat type where often several were available, so they should not be considered representative of an entire natural area. A ten-minute timed search of the leaf litter surface, rocks, woody debris and live plant stems was conducted across the 200m²-sample plot. At each of four 0.25m² sample locations (a square 0.5m on each side) dispersed within the plot, litter from the Oa and Oe horizons was gathered, placed on a 10mm sieve, shaken 50 times, turned over, and shaken 50 more times. This litter (with

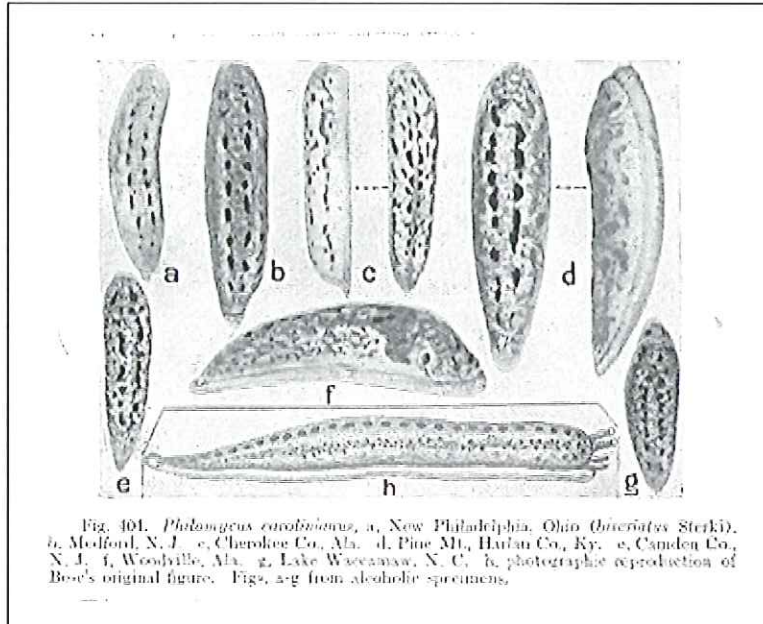
snails) was stored in plastic bags until the snails could be removed, sorted and identified. Live snails collected were drowned in tap water for 24 hours, then placed in 70 % ethanol. Characteristics recorded at each plot included slope, aspect, the diameter at breast height (dbh) of all trees (>5 cm dbh), and smaller shrubs, vines and herbaceous plants. At each site half a liter of material from each of the Oe and Oa soil horizons was removed from each of four pits, one each within each quadrant of the site. Site location latitude and longitude was determined using a Garmin 12CX global positioning system unit, map datum WGS 84.

In the laboratory, snails were removed from the sieved litter by spreading out a thin layer of litter and examining it with the aid of a magnifying visor. Snails collected in this study were identified based primarily upon external characteristics using a dissecting microscope and Pilsbry (1939-40; 1946-48), Burch (1962), and Emberton (1988; 1991). F. Wayne Grimm, Eastern Ontario Biodiversity Museum, and Timothy A. Pearce, Carnegie Museum of Natural History, reviewed identification of some difficult species. Pearce dissected two Arionid slugs from Lehigh Gorge make a determination based upon internal genitalia.

Soils were analyzed by the Maryland State Soil Testing Laboratory (University of Maryland, College Park, MD), and some samples were re-tested for corroboration at the West Virginia University Soil Testing Laboratory (Morgantown, WV). Extractable Ca was measured with a flame photometer (Technicon version 4) after extracting with Mehlich I Double Acid Extract for two hours (Mehlich 1953, Flannery and Markus 1980). Measurements of pH were made electrometrically using a 1:1 volume of sample to water (McLean 1982). Organic matter was determined by ashing at 350 C° (Storer 1984). Results are expressed on an oven-dried basis.

County or state geographic distribution records are reported as those species not reported in Hubricht (1985), Brooks (1931) or Wurtz (1940). Species of potential conservation interest were determined by somewhat subjective criteria. They include species that are globally rare, with a global rank of G1-G3; or globally restricted, such as uncommon Appalachian Mountain endemics; or peripheral – that is, species located near the edge of their range.

Correlation analysis was used to test associations between land snail abundance, species richness, and soil chemistry measurements and tree species basal area. To determine land snail and extractable soil Ca correlations, the soil horizon with the highest pH at each sample point (either Oe or Oa) was used.



Philomycus carolinianus illustration from Pilsbry (1948).

RESULTS

land snail distribution

Land snail species are reported by family for each of eight selected natural areas (Tables 1-8), and also reported alphabetically for all sites (Table 9). Areas searched for land snails are mapped on 7.5' USGS topographic maps (Appendix 1). Collected specimens were added to the Mollusk Collection at the Carnegie Museum of Natural History in Pittsburgh, PA (CMNH #64755-64875, 64890).

A total of 42 land snail species are reported from the eight surveyed natural areas. These represent approximately 40% of Pennsylvania's native land snail species richness. Each natural area lies in a different county, and each area had at least two county geographic distribution records. Tionesta in Warren County had the most geographic

distribution records – nine - and the highest proportion of new records - 75% of those species found.

In all, 36 county geographic distribution records were discovered, representing 21 different species (some newly reported species were found at more than one site; Table 9). These records include a *Vertigo* sp. found at Beartown Woods, Franklin County, whose identity is still under investigation. Three state geographic distribution records were discovered as well, for *Helicodiscus notius* Hubricht, 1962 (found at each of three sites).

quantitative sampling

Land snail densities per m² were calculated for quantitative sampling sites by combining the results of the four 0.25m² collections made at each site. Densities ranged from 1 snail/m² at Snyder-Middleswarth to 447 snails/m² at Beartown Woods (Table 10).

In soil samples, average extractable soil Ca in the Oe horizon ranged from 2.23 g/kg soil at Tionesta to 30.8 g/kg soil at Beartown Woods (Table 11). Average extractable soil Ca in the Oa horizon ranged from 0.35 g/kg soil at Tionesta to 18.3 g/kg soil at Beartown Woods. For pH, values in the Oe horizon ranged from 4.4 at Snyder-Middleswarth to 5.6 at Beartown Woods, and in the Oa, pH values ranged from 3.75 at Snyder-Middleswarth to 5.1 at Beartown Woods. Organic matter in the Oe horizon ranged from 63% at McConnell's Mill to 84% at Lehigh Gorge, and in the Oa horizon ranged from 34% at McConnell's Mill to 83% at Lehigh Gorge (it should be noted that at 34% organic matter, the McConnell's Mill sample should technically be considered A horizon material).

Fourteen tree species were identified at quantitative sites. Eastern hemlock (*Tsuga canadensis*) was the most frequently encountered tree species, present at 7 of 8 sites.

Correlations were found between numbers of land snails in sieved, timed and combined searches and extractable Ca in the upper soil horizons. Land snail species richness in sieved litter samples was also correlated with extractable Ca in the upper soil

horizons. Significant correlations were found within Ca, organic matter and pH parameters in adjacent soil horizons.

other findings

Although old-growth forest stands were anticipated for six natural areas, such stands were located at only four sites. Old growth was not found at Lehigh Gorge State Park or McConnell's Mill State Park, nor were available park staff aware of old growth forest areas. These two parks did have large areas of mature, second-growth forest and perhaps occasional residual trees. However, intact stands with the appearance of exceeding 100 years, as might be indicated by age structure, certain branching or bark patterns, snags or woody debris, were not found.

Despite the lack of old growth in two natural areas, two new potential old-growth areas were located elsewhere. In the Bald Eagle State Forest, in the vicinity of the Snyder-Middleswarth Natural Area, an apparently old chestnut oak (*Quercus prinus*) slope was observed. This stand was on the west side of Locust Ridge on the downslope side of Locust Ridge Road, west of its intersection with Ulsh Gap Trail. At State Game Lands 211 there appeared to be scattered, gnarled residual trees, both to the west and east of the Sharp Mountain ridge top (though not on the crest), in the vicinity of the Appalachian Trail and an unnamed connecting trail to the ridge. However, each of these two areas will require examination to determine whether they are old growth forest.

DISCUSSION

land snail distribution

This inventory of natural areas found a number of new geographic distribution records for land snails in Pennsylvania. These findings are not surprising considering the dearth of extensive snail inventory across large parts of North America, the sporadic nature of snail inventories, and the lack of taxonomic experts. Some counties, such as Warren, are mostly unexplored.

Further inventory should be expected to reveal additional land snail species at all of these natural areas. Some land snails may be present at very low densities, highly localized, or found only at certain times of year or under certain weather conditions not sampled during this study. Among those species that might be discovered are those common snails that were obviously missed, such as *Zonitoides arboreus* (Say, 1816) at Lehigh Gorge, those occurring patchily, such as several of the larger Polygyrids, and small snails occurring at low density, such as vertigos and glyphs.

The anomalous population of *Vertigo* sp. at Beartown Woods is undergoing an intensive examination. It is most like *Vertigo gouldi* (A. Binney, 1843) and may be simply an atypical population of this species.

Although there may appear to be differences in species richness between these Pennsylvania natural areas, these inventory numbers are not valid for drawing comparisons between the areas. Each natural area is of a different size and includes different habitats, and each received different collecting effort, except at quantitative sampling plots.

quantitative sampling

The successful establishment of quantitative sampling sites enables changes in land snails and soil chemistry to be compared over time (although no specific return date is planned at present). These quantitative sites are not useful for comparisons between natural areas, because they sample such a small portion they are not representative of an entire natural area. However, temporal comparisons can be used to explore widespread environmental change, or local changes in site quality.

The correlation between land snail abundance and extractable Ca in the upper soil horizons for these Pennsylvania sites supports previous work in the central Appalachian Mountains (Hotopp 2002) and elsewhere (Burch 1955, Graveland et. al. 1994) . For these correlations, the soil horizon with the highest extractable Ca (either Oe or Oa) was employed, rather than conducting parallel comparisons of horizons Oe and Oa, because some soil profiles, especially at Beartown Woods followed a Ca trend with soil depth that was opposite of most sample locations. Particularly at Beartown Woods, Ca values in the Oa horizon were greater than those in the Oe horizon, while other sites generally had greater extractable Ca values in the Oe horizon. Because both horizons are near the surface and readily accessible to land snails, the highest extractable Ca value was considered a more important parameter for correlation testing than extractable Ca in the particular horizon. However, it should be noted that without making this adjustment, several significant correlations would not be demonstrated. It is also important to note that because Ca is a critical and sometimes limited nutrient in land snail physiology, the relationship between snail community metrics and extractable soil Ca can be considered a functional relationship.

other findings

Lehigh Gorge and McConnell's Mill State Parks are reported as having extensive old growth acreage - 900 for Lehigh Gorge and 197-1,200 for McConnell's Mill (*in* The Center for Rural Pennsylvania 1995). However, because old forest was not located, the source of this information may need to be re-examined. Although The Center for Rural Pennsylvania (1995) report is derived mostly from Haney and Schaadt (1994), it cites three articles as the source of its summary table "Location and Description of old-growth forest sites in Pennsylvania." I was able to check one of these - Davis (1996). Although Davis mentions both sites as old growth, this is a review, and unlike several other Pennsylvania sites noted by Davis, no original source is provided.

The recognition of two potential old-growth sites at State Game Lands 211 and near Snyder-Middleswarth is not surprising, as Pennsylvania has not completely inventoried old growth sites, and many sites are not easily identified. However, neither of these areas exhibit trees of great size, so they may represent stands partly cutover in the past or merely younger trees on harsh growing sites.



Forrest H. Dutlinger Natural Area understory showing deer overbrowsing

conservation

Conservation of the land snail fauna at each of the eight natural areas has great potential under the stewardship of their various state and federal agency owners, but some important challenges will need to be undertaken. White-tailed deer (*Odocoileus virginianus*) overbrowsing is a widespread and often under-appreciated impact to forests throughout Pennsylvania. Overbrowsing impacts were observed at every natural area visited in this study, and these typically consisted of understory species composition shifts toward plants less preferred by deer, reduction of understory vegetation indicated by open forest floors and browse lines, and in some areas abundant deer sign. Deer browsing has been shown to affect ground-nesting birds (DeCalesta 1994), although its effect upon land snails has not been examined. The apparent reduction in land snail food and cover related to overbrowsing would be expected to have some influence. Additional

impacts might include reduced humidity levels and forest floor drying related to the loss of understory, which should also be expected to reduce snails.

Direct loss of habitat due to development is generally a lesser risk on public lands. However, Beartown Woods has seen some past and recent infrastructure encroachments. At this natural area, highway maintenance or widening, right-of-way maintenance or widening, and further parking and trail development will need to be carefully planned to avoid further impacts to both old forest and the habitat of the enigmatic *Vertigo* sp. at the site. Beartown Woods may also be suffering from the indirect, edge effects of development as parts this stand appear to be in decline.

Loss of calcium from the leaf litter and upper soil horizons related to acid rain and timber harvest may also influence land snail populations, though these effects are presently unclear for Northeastern forests (Yanai, et al. 1999). Extractable soil calcium is correlated with land snail abundance and species richness in central Appalachian Mountain forests (Hotopp 2002), and acid rain is occurring on sensitive soils in Pennsylvania, including of course the natural areas in this study. A link between acid rain and land snail reductions as found in Europe (Wäreborn 1992) has not yet been detailed in North America. However, the effects of acid rain impacts to populations of birds that prey upon land snails have been established (Graveland et al 1994, Hames et al 2002)

Other land snail conservation issues may include impacts from non-native plants and animals, and global climate change. Some natural areas are adjacent to, or were previously disturbed by intensive human activities such as road building, development and mining, and one result is the presence of non-native land snails. Arionid slugs, generally believed to be introduced from Europe, are widespread in eastern North America and found at three (and probably more) of the natural areas: Beartown Woods, Forrest Dutlinger and Lehigh Gorge. In addition, *Oxychilus alliarius* (J.S. Miller, 1822), a Zonitid snail from Europe, was also found at Beartown Woods. Non-native snail interactions with, or influences upon, native snails are mostly unknown. Field observations suggest that there are also species shifts in native land snails related to the presence of some non-native invasive plants, but these effects are unstudied.

Global climate change will have profound changes upon natural systems in this century, so effects upon land snails are expected. Snails can be extirpated by increasing summer maximum temperatures as Baur and Baur (1993) demonstrated for a European species. However, specific influences upon most species are unknown. Presumably, land snail species restricted to higher elevations are among those most at risk, as their distribution may be limited by climate.

In general, continuing conservation of old-growth forest stands, and restoration of native vegetation and natural disturbance regimes (or their simulation) are expected to benefit most native snail species. However, because fire does kill land snails in the leaf litter, the reintroduction of fire through prescribed burning or prescribed natural burns should recognize the potential need for snail refuges where rare snail species can persist and recolonize.



Sugar maple at Tionesta National Scenic Area.

SPECIES of INTEREST

Five land snail species of special interest are profiled below - either because they are new Pennsylvania state geographic distribution records or because they are of potential taxonomic or conservation interest. Each description includes some identifying characteristics of the animal, its general habitats, and its overall range. These are followed by detailed description of its occurrences and habitat as found in this project, and recommendations for conservation.

Columella sp. undescribed column

Columns are generally small, parallel-sided, toothless pupillids, approximately 2mm long. Although the high-spire column *Columella simplex* (Gould, 1841), is presently the sole recognized Appalachian Mountain species in this genus, Hubricht (1985) comments that *C. simplex* is probably a complex of two or three species, and Grimm agrees (pers. comm., 1999).

The ecology and conservation needs of the species in this complex are almost completely unknown, though they appear to be calciphilic. In general, members of this complex are rarely encountered (e.g. see Hubricht 1985).

Columella sp. was found in damp leaf litter at Beartown Woods - co-occurring with other pupillids in a boulder scree - and at Quebec Run. Retaining canopy cover at both locations will aid in maintaining damp site conditions and leaf litter. Large openings in the vicinity could indirectly increase sites temperatures and reduce humidity, possibly eliminating this species. Specific habitat or buffer zone requirements are unknown, but extensive logging, or road construction and widening, may pose a threat to this species. Acid rain may also pose a threat to this calciphilic species where it occurs on sensitive soils (e.g. Quebec Run).

Helicodiscus notius Hubricht 1962 tight coil (state record)

This blind, litter-dwelling snail has a shell shaped somewhat like a tiny car tire, as others of its genus. Heliciform, with five whorls and spiral lirae (the “treads”), its diameter is approximately 3.5mm. It is a look alike of its congener *H. parallelus* (Say, 1817), and is relatively recently described (Hubricht 1962), which accounts for the lack of previous reports. In other words, this possible state record is a matter of taxonomy rather than geography, and not all of the taxonomic questions have been resolved.

F. Wayne Grimm helped to determine this species, using as a diagnostic characteristic the lirae that extend to the beginning of the embryonic whorl. Tim Pearce notes that this lirae characteristic is not explicitly included in the species description. However, Hubricht states that the lirae of *notius* are “stronger.” Based upon measurements from shell drawings in Hubricht and Pilsbry (1948), Pearce (pers comm. 3/18/02) explains that *notius* and *parallelus* are not easily distinguished, in part because because:

- 1) The *H. notius* species description notes an additional whorl, but both species have the same number of whorls in the illustrations.
- 2) The *H. notius* species description notes a broader umbilicus, but both species have the same width umbilicus in the illustrations.

However, Grimm (pers. comm.) believes that Pilsbry may have drawn an *H. notius* specimen for the illustration of *H. parallelus*, as, of course, these species were not separated at the time.

Helicodiscus notius was found in leaf litter at McConnell’s Mill, Quebec Run and Tionesta. Specific habitat or buffer zone requirements are unknown, but maintaining forest cover is presumably necessary for conservation of this species.

Punctum vitreum (H.B. Baker, 1930) glass spot

This animal’s shell is approximately 1.3mm in diameter, umbilicate, nearly colorless and with widely spaced riblets. It is often found in leaf litter with its very similar but common congener, the small spot, *P. minutissimum* (I. Lea, 1841).

Punctum vitreum occurs sparsely from New Jersey to Illinois, and southwest to Texas (Hubricht 1985). Although it can be easily overlooked, it is certainly not as common as *P. minutissimum*. Coney et al (1982) found the glass spot associated with limestone and late stages of succession. In this project it was found in sieved leaf litter samples at Beartown Woods and Quebec Run. Both were mesic stands of hardwoods and eastern hemlock, dominated by tulip poplar (*Liriodendron tulipifera*) at Quebec Run and by sugar maple (*Acer saccharum*) at Beartown Woods.

Conservation of this species is presumed to depend upon the maintenance of older forest on rich soils. Logging, road construction or widening, and other direct impacts may eliminate or at least reduce this species through habitat destruction. Acid rain may also pose a threat to this calciphilic species where it occurs on sensitive soils (Quebec Run).

Megapallifera mutabilis (Hubricht, 1951) changeable mantleslug

The changeable mantleslug is a sizeable mottled native slug, with a diagnostic gray or dull green foot-edge. In the Northeast it is often associated with large logs in mesic, relatively acid forest. This slug is reported from adjacent New York and Maryland by Hubricht (1985), and incidentally reported in York County, Pennsylvania by Fairbanks (1987).

In the present study, *M. mutabilis* was found at Forrest Dutlinger, State Games Lands 211, Snyder-Middleswarth and Tionesta natural areas. At Tionesta it was found in an eastern hemlock, American beech (*Fagus grandifolia*), sweet birch (*Betula lenta*) stand among sandstone features, near the top of a slope. At Snyder-Middleswarth it was found on an eastern hemlock low on a slope, and at Forrest Dutlinger was beneath the bark of a basswood (*Tilia americana*) log. At State Game Lands 211 the slug was found in a mixed stand of hemlock, white pine (*Pinus strobus*), white oak (*Quercus alba*), chestnut oak, and red maple.

This species was only recently described, which probably accounts for the dearth of previous reports from Pennsylvania. Retaining coarse woody debris, a critical habitat

component for many of the Philomycid slugs, is presumably necessary for this species' conservation.

***Striatura exigua* (Stimpson, 1850) ribbed striate**

This animal has a 2.3mm-diameter shell recognized by its unique sculpture - widely-spaced riblets with dense spiral grooves between. In the north it occurs in swampy woods, but in the Appalachian Mountains is also found in moist leaf litter (Hubricht 1985).

Striatura exigua occurs sparsely south of New England, New York and Michigan, down into the mountain counties of West Virginia and Virginia. In this study, it was located at Forest Dutlinger and Quebec Run. At Forest Dutlinger it was found along Beech Bottom Trail, a mid-slope mesic site of mixed northern hardwoods-hemlock, and at Quebec Run in a mesic tulip poplar, eastern hemlock, sweet birch stand. Elevations were roughly 1,500' and 1,900' asl, respectively.

Because this is generally a high-elevation species in the central Appalachian Mountains, temperature and humidity are presumed to be important factors in its persistence. Impacts that would open its habitat, causing drying and warming, such as logging or fire, could result in impacts to this snail. Other possible threats to the ribbed striate include acid rain, which can reduce the calcium available for snails on poor soil (Wäreborn, 1992), and global climate change, which may lead to a warmer local climate. Snails can be extirpated by increasing summer maximum temperatures as Baur and Baur (1993) demonstrated for a European species.

***Vertigo* sp. unknown vertigo (county record)**

This animal shares several shell characteristics with *Vertigo gouldi*, but whether this species or a congener, it is undoubtedly a geographic distribution record for Franklin County.

At Beartown Woods, high densities of *Vertigo* sp. were found in a forested, low-relief rock talus, within 50 meters of a small stream. Co-occurring snails were *Gastrocopta pentodon* (Say, 1821) and *Columella* sp. Overstory trees were dominated by tulip poplar and sugar maple, with eastern hemlock and northern red oak. Understory

cover was nearly half exposed rock, with Virginia creeper (*Parthenocissus quinquefolia*), common polypody (*Polypodium virginianum*) and a wide variety of other herbaceous species.

Local habitat conservation is strongly recommended, including avoidance of site impacts from Appalachian Trail re-routing, logging, road building, or infrastructure improvements.

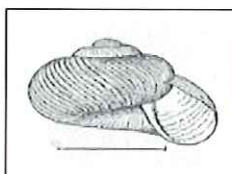


Beartown Woods is near Rt. 30 and the AT.

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Striatura meridionalis

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Table 1. Land snails of Beartown Woods Natural Area, Michaux State Forest, Franklin Co., PA.

Family	species	common name	Franklin Co. record	spp. of interest	det. FWG
<u>Basommatophora</u>					
Carychiidae					
	<i>Carychium exile</i> (I. Lea, 1842)	ice thorn	c		✓
<u>Stylommatophora</u>					
Pupillidae					
	<i>Columella</i> sp. (species complex)	column		✓	
✓	<i>Gastrocopta pentodon</i> (Say, 1821)	comb snaggletooth	c		✓
	<i>Vertigo</i> sp.	undescribed vertigo	c		
Punctidae					
	<i>Punctum minutissimum</i> (I. Lea, 1841)	small spot			
	<i>P. vitreum</i> (H.B. Baker, 1930)	glass spot	c	✓	
Discidae					
	<i>Anguispira alternata</i> (Say, 1816)	flamed disc			
Arionidae					
	<i>Arion subfuscus</i> (Draparnaud, 1805) (non-native)	dusky arion			
Philomycidae					
	<i>Philomycus</i> sp. (immature)	mantleslug			
	<i>Pallifera cf dorsalis</i> (A. Binney, 1842)	pale mantleslug			
Helicarionidae					
	<i>Euconulus cf fulvus</i> (Müller, 1774)	brown hive	c		✓
Zonitidae					
	<i>Mesomphix inornatus</i> (Say, 1821)	plain button			
	<i>Oxychilus alliarius</i> (J.S. Miller, 1822) (non-native)	garlic glass-snail			✓
	<i>S. ferrea</i> E.S. Morse, 1864	black striate	c		
	<i>Striatura meridionalis</i> (Pilsby & Ferriss, 1906)	median striate			
	<i>S. milium</i> (E.S. Morse, 1859)	fine-ribbed striate		c	
	<i>Ventridens supressus</i> (Say, 1829)	flat dome			
	<i>Zonitoides arboreus</i> (Say, 1816)	quick gloss			
Polygyridae					
	<i>Euchemotrema fraternum</i> (Say, 1824)	upland pillsnail			
	<i>Neohelix albolabris</i> (Say, 1816)	whitelip			
	<i>Triodopsis tridentata</i> (Say, 1816)	northern threetooth	c		

c, county geographic distribution record; s, state geographic distribution record; g, global record

Table 2. Land snails of Forrest H. Dutlinger Natural Area, Susquehannock State Forest, Clinton Co., PA.

Family	species	common name	Clinton Co. record	spp. of interest	det. FWG
Discidae					
	<i>Anguispira alternata</i> (Say, 1816)	flamed disc			
	<i>Discus catskillensis</i> (Pilsbry, 1896)	angular disc	c		
Arionidae					
	<i>Arion subfuscus</i> (Draparnaud, 1805) (non-native)	dusky arion			
Philomycidae					
	<i>Pallifera dorsalis</i> (A. Binney, 1842)	pale mantleslug			
	<i>Megapallifera mutabilis</i> (Hubricht, 1951)	winding mantleslug	c	✓	
Zonitidae					
	<i>Striatura exigua</i> (Stimpson, 1850)	ribbed striate	c	✓	
	<i>S. ferrea</i> E.S. Morse, 1864	black striate	c		
	<i>S. milium</i> (E.S. Morse, 1859)	fine-ribbed striate		c	
	<i>Zonitoides arboreus</i> (Say, 1816)	quick gloss			
Polygyridae					
	unknown (immature)				

c, county geographic distribution record; s, state geographic distribution record

Table 3. Land snails of Lehigh Gorge State Park, Carbon Co., PA

Family	species	common name	Carbon Co. record	spp. of interest	det. FWG
Arionidae					
	<i>A. subfuscus</i> (Draparnaud, 1805) (non-native)	dusky arion			
Philomycidae					
	<i>Pallifera dorsalis</i> (A. Binney, 1842)	pale mantleslug			
Helicarionidae					
	<i>Euconulus cf fulvus</i> (Müller, 1774)	brown hive	c		
Zonitidae					
	<i>Striatura meridionalis</i> (Pilsby & Ferriss, 1906)	median striate	c		

c, county geographic distribution record; s, state geographic distribution record

Table 4. Land snails of McConnell's Mill State Park, Lawrence Co., PA.

Family	species	common name	Lawrence Co. record	spp. of interest	det. FWG
Helicodiscidae					
	<i>Helicodiscus notius</i> Hubricht, 1962	tight coil		s	✓
Discidae					
	<i>Anguispira alternata</i> (Say, 1816)	flamed disc			
	<i>Discus patulus</i> (Deshayes, 1830)	domed disc			
Philomycidae					
	<i>Pallifera dorsalis</i> (A. Binney, 1842)	pale mantleslug	c		
	<i>Philomycus carolinianus</i> (Bosc, 1802)	Carolina mantleslug	c		
Helicarionidae					
	<i>Euconulus cf fulvus</i> (Müller, 1774)	brown hive	c		
Zonitidae					
	<i>Mesomphix cupreus</i> (Rafinesque, 1831)	copper button			
	<i>Mesomphix inornatus</i> (Say, 1821)	plain button			
	<i>Paravitrea multidentata</i> (A. Binney, 1840)	dentate supercoil	c		
	<i>Ventridens intertextus</i> (A. Binney, 1841)	pyramid dome			✓
	<i>Zonitoides arboreus</i> (Say, 1816)	quick gloss			
Polygyridae					
	<i>Mesodon zaletus</i> (A. Binney, 1837)	toothed globe			
	<i>Neohelix dentifera</i> (A. Binney, 1837)	big-tooth whitelip			
	<i>Triodopsis tridentata</i> (Say, 1816)	northern threetooth			
	<i>Xolotrema denotata</i> (Férussac, 1821)	velvet wedge			

c, county geographic distribution record; s, state geographic distribution record



Typical mature forest searched for land snails at McConnell's Mill State Park.

Table 5. Land snails of Quebec Run Wild Area, Forbes State Forest, Fayette Co., PA.

Family	species	common name	Fayette Co. record	spp. of interest	det. FWG
Pupillidae	<i>Columella</i> sp. (species complex)	high-spire column			✓
Punctidae	<i>Punctum vitreum</i> (H.B. Baker, 1930)	glass spot	c	✓	
Helicodiscidae	<i>Helicodiscus notius</i> Hubricht, 1962	tight coil		s	
✓	<i>H. parallelus</i> (Say, 1817)	compound coil			
Philomycidae	<i>Philomycus carolinianus</i> (Bosc, 1802)	Carolina mantleslug	c		
	<i>P. togatus</i> (Gould, 1841)	toga mantleslug			
Zonitidae	<i>Mesomphix inornatus</i> (Say, 1821)	plain button			
	<i>Striatura exigua</i> (Stimpson, 1850)	ribbed striate	c	✓	
	<i>S. ferrea</i> E.S. Morse, 1864	black striate			
	<i>S. milium</i> (E.S. Morse, 1859)	fine-ribbed striate			
	<i>V. ligera</i> (Say, 1821)	globose dome			
	<i>Zonitoides arboreus</i> (Say, 1816)	quick gloss			
Polygyridae	<i>Triodopsis tridentata</i> (Say, 1816)	northern threetooth			

c, county geographic distribution record; s, state geographic distribution record

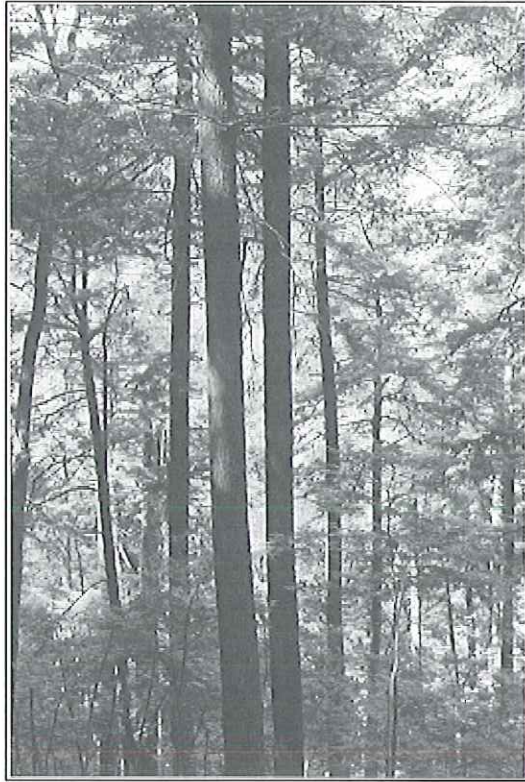
p, occurrence of potential conservation interest

Table 6. Land snails State Game Lands 211 (St. Anthony's Wilderness), Lebanon Co., PA.

Family	species	common name	Lebanon Co. record	spp. of interest	det. FWG
Philomycidae	<i>Megapallifera mutabilis</i> (Hubricht, 1951)	changeable mantleslug	c	✓	
	<i>Pallifera dorsalis</i> (A. Binney, 1842)	pale mantleslug			
	<i>Philomycus togatus</i> (Gould, 1841)	toga mantleslug	c		
Succineidae	<i>Succinea ovalis</i> Say, 1817	oval ambersnail			
Zonitidae	<i>Glyphyalinia indentata</i> (Say, 1823)	carved glyph			
	(species complex)				
	<i>G. rhoadsi</i> (Pilsbry, 1899)	sculpted glyph			✓
	<i>Zonitoides arboreus</i> (Say, 1816)	quick gloss			
	<i>Z. nitidus</i> (Müller, 1774)	black gloss	c		
Polygyridae	<i>Neohelix albolabris</i> (Say, 1816)	whitelip			
	<i>N. dentifera</i> (A. Binney, 1837)	big-tooth whitelip			

c, county geographic distribution record; s, state geographic distribution record

p, occurrence of potential conservation interest



Snyder-Middleswarth ancient forest

Table 7. Land snails of Snyder-Middleswarth Natural Area, Bald Eagle State Forest, Snyder Co., PA.

Family	species	common name	Snyder Co. record	spp. of interest	det. FWG
Philomycidae					
	<i>Megapallifera mutabilis</i> (Hubricht, 1951)	changeable mantleslug	c	✓	
	<i>Philomycus togatus</i> (Gould, 1841)	toga mantleslug	c		
Zonitidae					
	<i>Zonitoides arboreus</i> (Say, 1816)	quick gloss	c		
Polygyridae					
	<i>N. dentifera</i> (A. Binney, 1837)	big-tooth whitelip			

c, county geographic distribution record; s, state geographic distribution record
p, occurrence of potential conservation interest

Table 8. Land snails of Tionesta National Scenic Area, Allegheny National Forest, Warren Co., PA

Family	species	common name	Warren Co. record	spp. of interest	det. FWG
Helicodiscidae					
	<i>Helicodiscus notius</i> Hubricht, 1962	tight coil		s	✓
Discidae					
	<i>Anguispira alternata</i> (Say, 1816)	flamed disc	c		
	<i>Discus patulus</i> (Deshayes, 1830)	domed disc	c		
Philomycidae					
	<i>Megapallifera mutabilis</i> (Hubricht, 1951)	changeable mantleslug	c	✓	
Zonitidae					
	<i>Striatura ferrea</i> E.S. Morse, 1864	black striate	c		
	<i>S. milium</i> (E.S. Morse, 1859)	fine-ribbed striate		c	
	<i>Ventridens intertextus</i> (A. Binney, 1841)	pyramid dome			
	<i>Zonitoides arboreus</i> (Say, 1816)	quick gloss	c		
	<i>Z. nitidus</i> (Müller, 1774)	black gloss	c		
Polygyridae					
	<i>Neohelix albolabris</i> (Say, 1816)	whitelip			
	<i>Stenotrema barbatum</i> (G.H. Clapp, 1904)	bristled slitmouth	c		
	<i>Triodopsis tridentata</i> (Say, 1816)	northern threetooth			

c, county geographic distribution record; s, state geographic distribution record
p, occurrence of potential conservation interest

Table 9. Master list of land snails from eight selected natural areas in Pennsylvania.

species	Bear- town Woods	Forrest Dutlin- ger	Lehigh Gorge	McCon- nell's Mill	Quebec Run	SGL 211	Snyder - Middles warth	Tio- nesta
<i>Anguispira alternata</i>	✓	✓		✓				c
<i>Arion subfuscus</i>	✓	✓	✓					
<i>Carychium exile</i>	c							
<i>Columella</i> sp. (complex)	✓				✓			
<i>Discus catskillensis</i>		c						
<i>D. patulus</i>				✓				c
<i>Euchemotrema fraternum</i>	✓							
<i>Euconulus fulvus</i>	c		c	c				
<i>Gastrocopta pentodon</i>	c							
<i>Glyphyalinia indentata</i> (complex)						✓		
<i>G. rhoadsi</i>						✓		
<i>Helicodiscus notius</i>				s	s			s
<i>H. parallelus</i>					✓			
<i>Megapallifera mutabilis</i>		c				c	c	c
<i>Mesodon zaletus</i>				✓				
<i>Mesomphix cupreus</i>	✓			✓				
<i>M. inornatus</i>				✓	✓			
<i>Neohelix albolabris</i>	✓					✓		✓
<i>N. dentifera</i>				✓		✓	✓	
<i>Oxychilus alliarius</i>	✓							
<i>Pallifera</i> cf <i>dorsalis</i>	✓	✓	✓	c		✓		
<i>Paravitrea multidentata</i>				c				
<i>Philomycus carolinianus</i>				c	c			
<i>P. togatus</i>					✓	c	c	
<i>Philomycus</i> sp.	✓							
<i>Polygyrid</i> (imm)		✓						
<i>Punctum minutissimum</i>	✓							
<i>P. vitreum</i>	c				c			
<i>Stenotrema barbatum</i>								c
<i>Striatura exigua</i>		c			c			
<i>S. ferrea</i>	c	c			✓			c
<i>S. meridionalis</i>	✓		c					
<i>S. milium</i>	c	c			✓			c
<i>Succinea</i> cf <i>ovalis</i>						✓		
<i>Triodopsis tridentata</i>	c			✓	✓			✓
<i>V. intertextus</i>				✓				✓
<i>V. ligera</i>					✓			
<i>V. suppressus</i>	✓							
<i>Vertigo</i> sp.	c							
<i>Xolotrema denotata</i>				✓				
<i>Zonitoides arboreus</i>	✓	✓		✓	✓	✓	c	c
<i>Z. nitidus</i>						c		c

c, county geographic distribution record; s, state geographic distribution record.

Table 10. Numbers of snails and snail species at eight Pennsylvania quantitative sampling sites.

site	# snails litter	# snails sieved	# snail spp sieved litter	# snails timed search	# species timed search	total # snails	total # species*
Beartown Woods	447	8	8	18	2	465	8
Forrest Dutlinger	2	2	2	6	2	9	4
Lehigh Gorge	7	1	1	0	0	7	1
McConnell's Mill	7	4	4	3	3	10	6
Quebec Run	28	7	7	4	3	32	9
Snyder-Middleswarth	1	1	1	4	2	5	3
SGL 211	4	3	3	0	0	4	3
Tionesta	2	2	2	3	1	5	2

* total # species is not the sum of # snails in sieved litter and timed search because the same species may be found with both techniques.

Table 11. Soil parameter averages of two upper soil horizons for eight Pennsylvania sites. Ca in g/kg oven-dried soil.

site	extractable Ca (g/kg soil)		Ca (g/kg soil)		pHOe	pH	organic matter (%)	
	Oe		Oe	Oa			Oe	Oa
Beartown Woods	30.8		18.3		5.6	5.1	75	72
Forrest Dutlinger	6.33		4.33		4.65	4.23	82	76
Lehigh Gorge	8.78		5.6		5	4.18	84	83
McConnell's Mill	15.4		10.9		4.33	3.98	63	34*
Quebec Run	11.1		4.53		5.35	4.5	82	79
Snyder-Middleswarth	7.35		6.5		4.4	3.75	83	82
SGL 211	14.3		8.25		5.35	4.9	81	74
Tionesta	2.23		0.35		4.6	4.25	80	67

* such a low proportion of organic matter means this soil horizon would be properly assigned to the "A" horizon.

Table 12. Correlation Coefficients of land snail community metrics and soil parameters from eight Pennsylvania sites.

	#snails sieved litter	#snails timed search	#snails	#spp sieved litter	#spp timed search	#spp	extract- able Ca	pH Oe	organic matter Oe	pH Oa	organic matter Oa
#snails sieved litter	1.000										
#snails timed search	0.935	1.000									
# snails	1.000	0.940	1.000								
#spp sieved litter	0.716	0.681	0.716	1.000							
#spp timed search	0.153	0.383	0.162	0.518	1.000						
#spp extractable Ca	0.530	0.598	0.534	0.928	0.773	1.000					
pH Oe	0.878	0.750	0.875	0.765	0.196	0.620	1.000				
organic matter Oe	0.617	0.424	0.611	0.675	-0.216	0.439	0.629	1.000			
	-0.217	-0.222	-0.217	-0.347	-0.499	-0.394	-0.448	0.250	1.000		
pH Oa	0.671	0.503	0.666	0.672	-0.225	0.408	0.686	0.913	0.036	1.000	
organic matter Oa	0.034	0.009	0.033	-0.157	-0.421	-0.224	-0.193	0.415	0.957	0.169	1.000

.707 P = .05

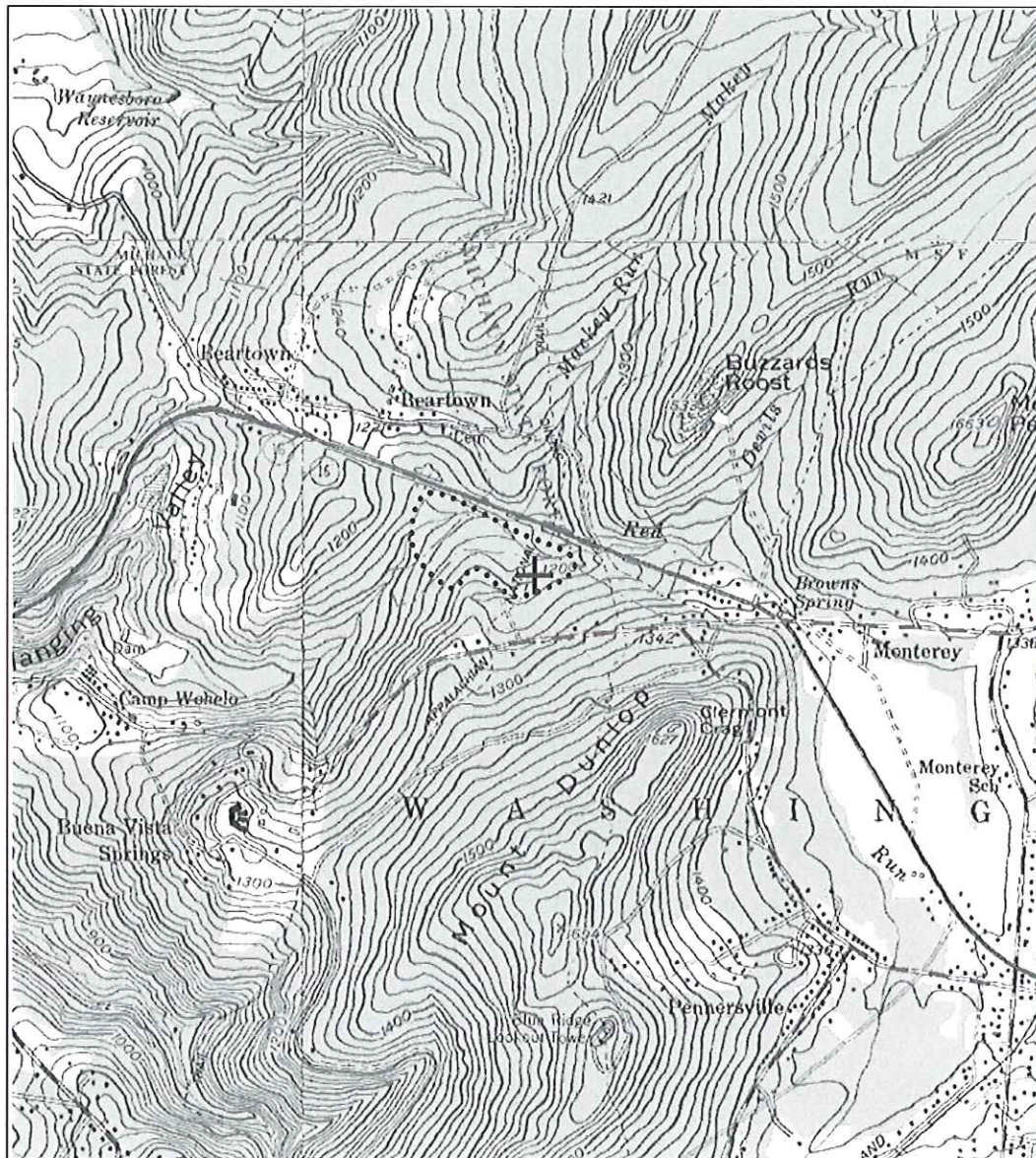
Table 13. Basal areas of tree species at quantitative sampling sites.

site	Amel. arborea	Acer pennsyl.	Acer sacch.	Acer rubrum	Betula alleghe.	Betula lenta	Nyssa sylvatica	Fagus grand.	Liriod. tulip.	Pinus rigida	Quercus alba	Quercus prinus	Quercus rubra	Tsuga can.
Beartown			4.84						5.47				2.45	2.14
Woods														
Forrest				6.03		1.57		0.69						5.66
Dutlinger														
Lehigh Gorge										5.47		2.07		
McConnell's Mill			2.95					6.54					4.08	2.51
Quebec Run				1.19					13.32					3.58
Snyder-														6.79
Middleswarth														
SGL 211	0.38			6.66		4.08	1.89				1.13	3.90		0.25
Tionesta		0.69	4.15		1.38			8.11						1.38

Table 14. Quantitative sampling site coordinates and characteristics. Site location latitude and longitude was determined using a Garmin 12CX global positioning system unit, map datum WGS 84.

site	latitude	longitude	aspect°	slope°
Beartown Woods	N39° 44.383'	W077° 29.430'	345	20
Forrest Dutlinger	N41° 28.042'	W077° 53.844'	0	0
Lehigh Gorge	N40° 58.088'	W075° 44.700'	-	5
McConnell's Mill	N40° 55.038'	W080° 12.992'	60	20
Quebec Run	N39° 45.214'	W079° 41.137'	75	10
Snyder-Middleswarth	N40° 48.362'	W 077° 18.140'	10	30
SGL 211	N40° 28.891'	W076° 37.717'	140	5
Tionesta	N41° 38.836'	W078° 57.690'	325	5

Figures. Maps of Pennsylvania Natural Areas searched for land snails.

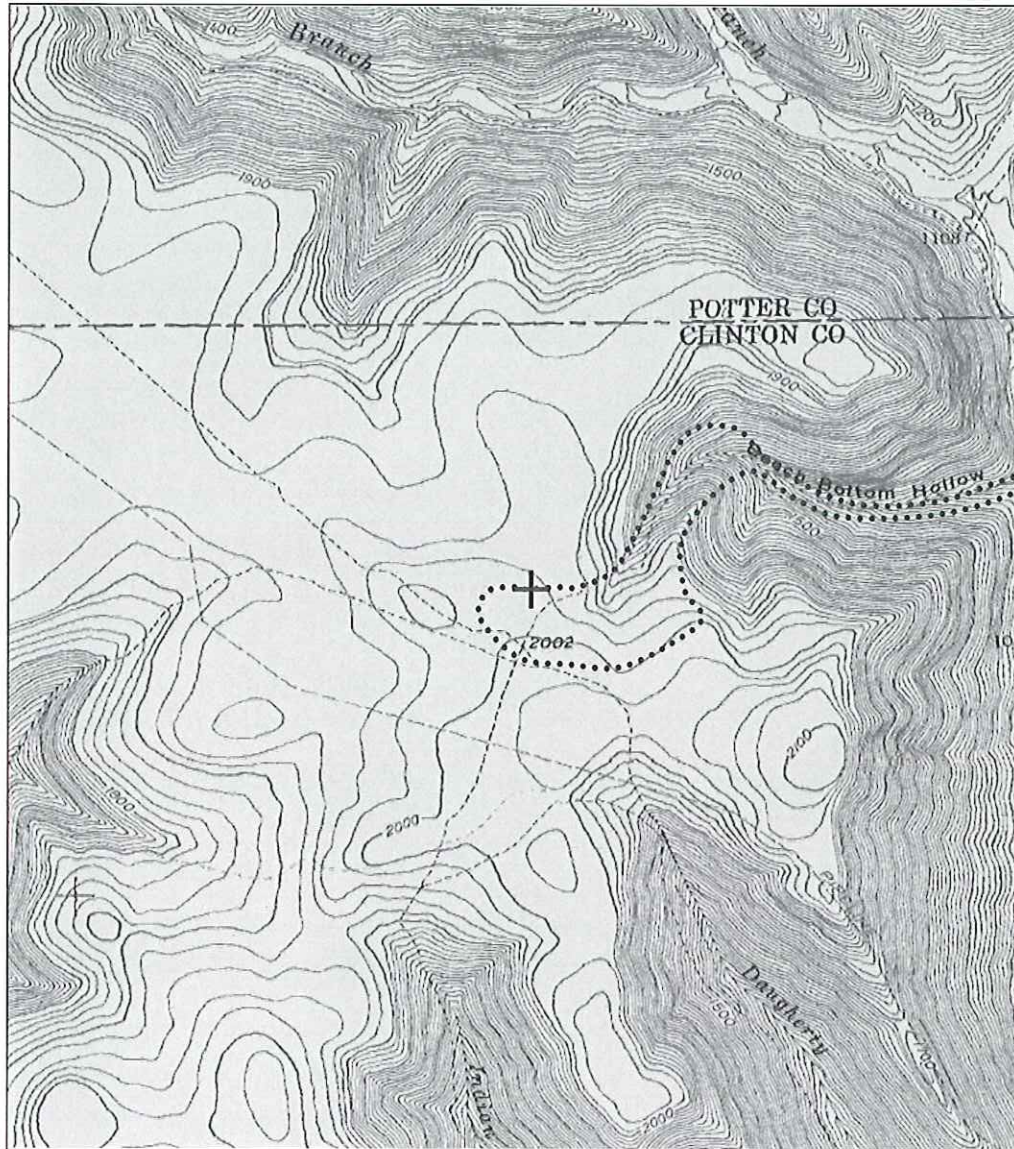


Beartown Woods

Quantitative sampling coordinates: N39.7397, W077.4905

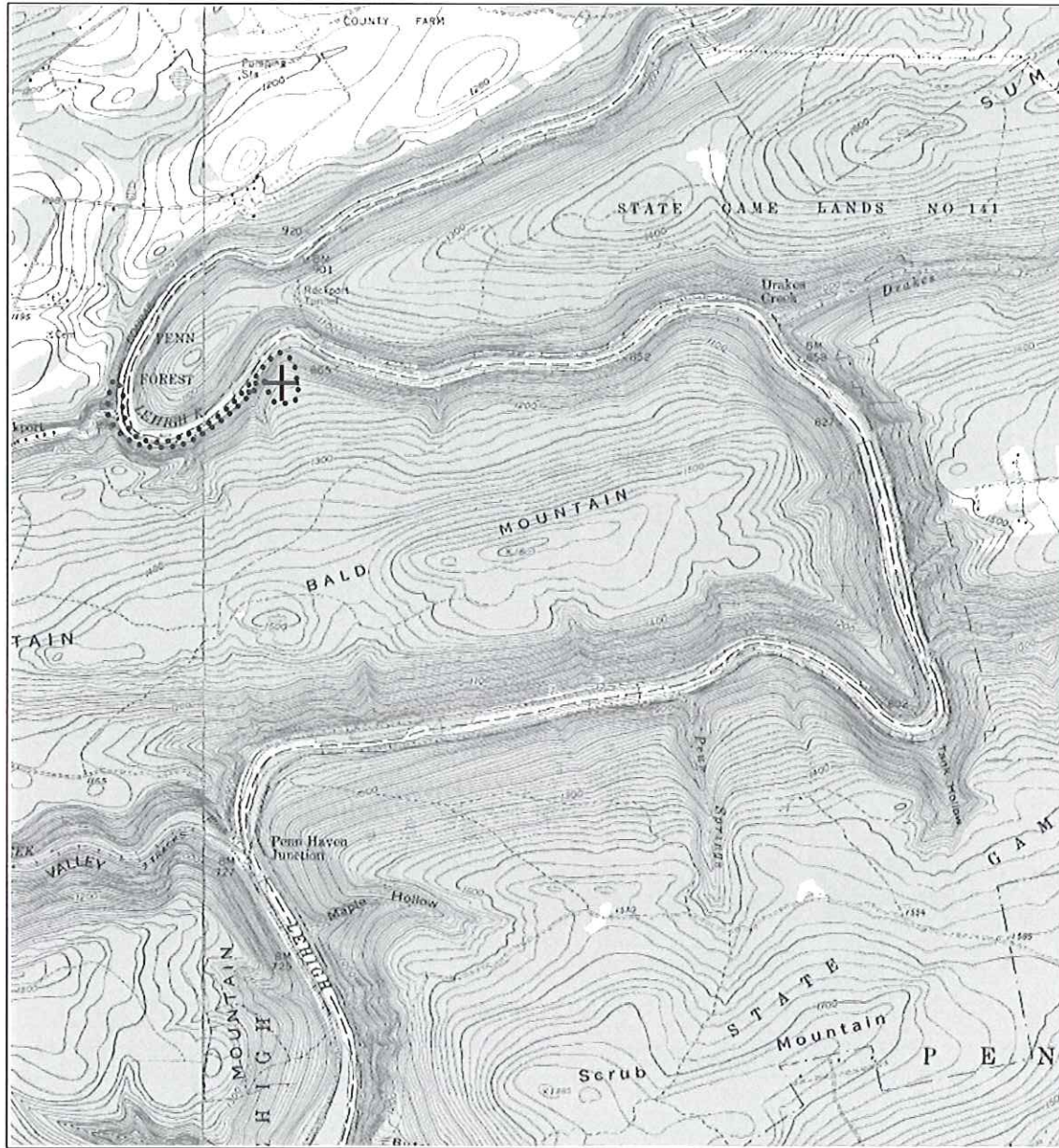
dotted line = general search area

cross = quantitative sampling site



Forest Dutlinger

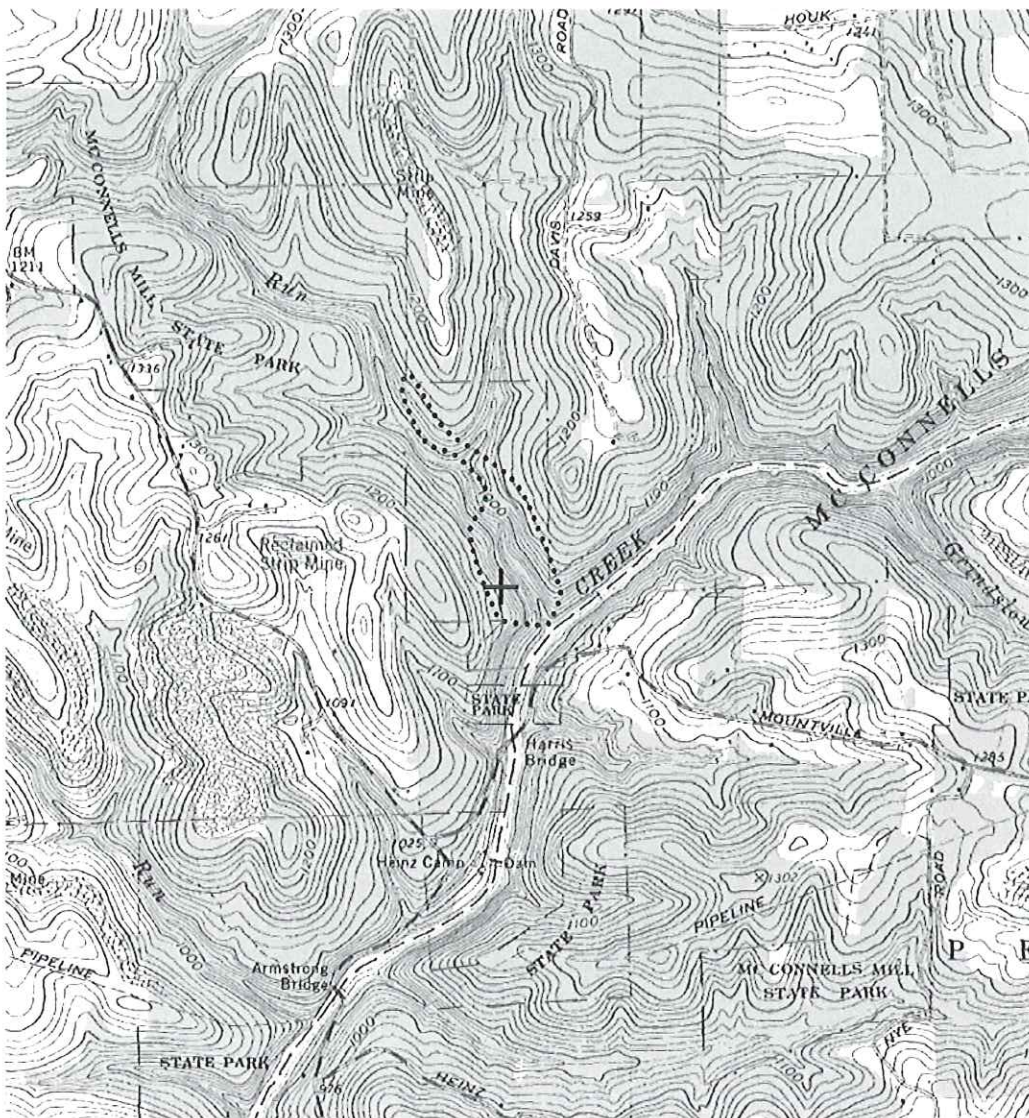
Quantitative sampling coordinates: N41.4674, W077.8974



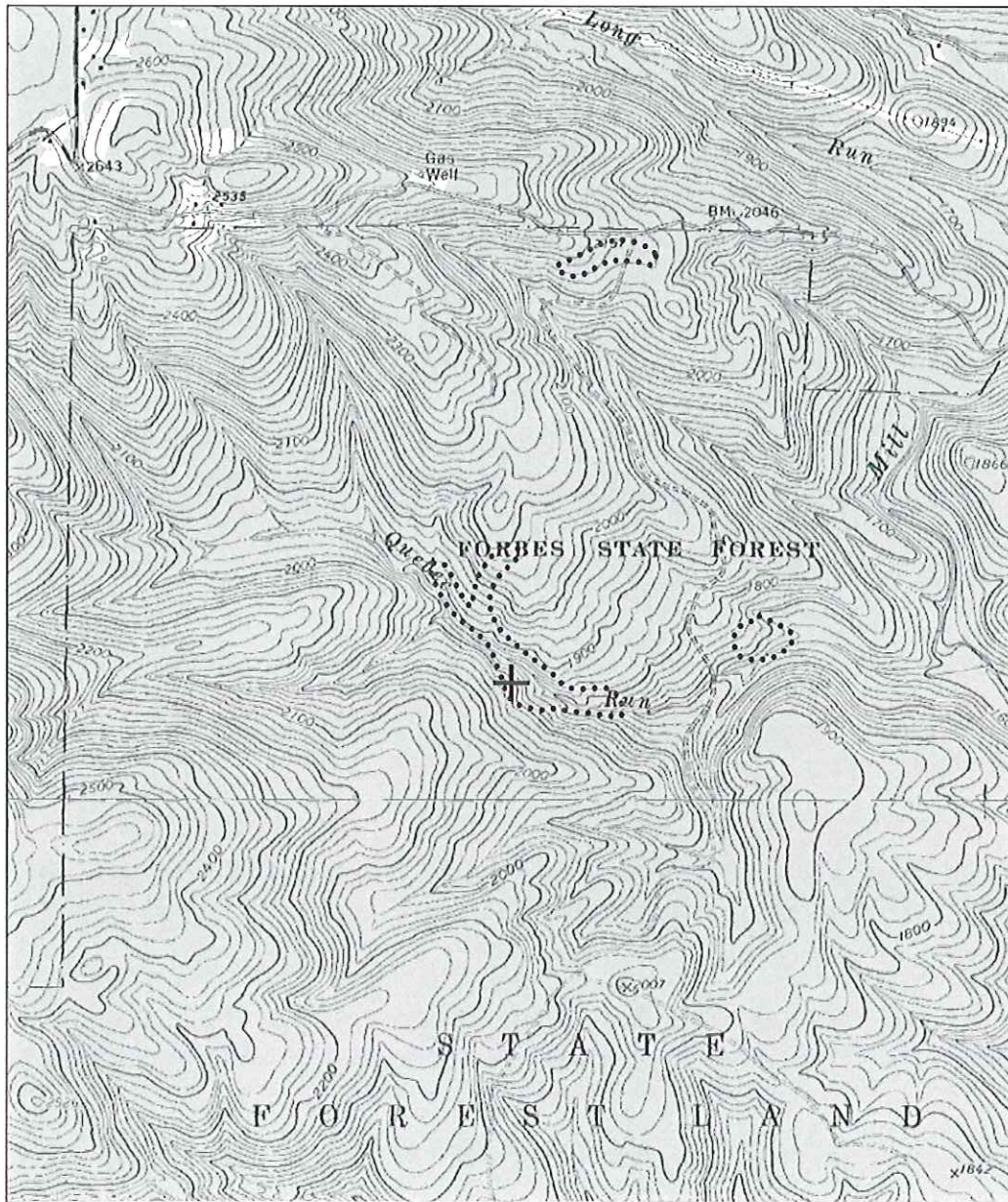
Lehigh Gorge

Quantitative sampling coordinates: N40.9681, W075.7450

Note: first mile of trail and river downstream of the Tannery access point also searched.

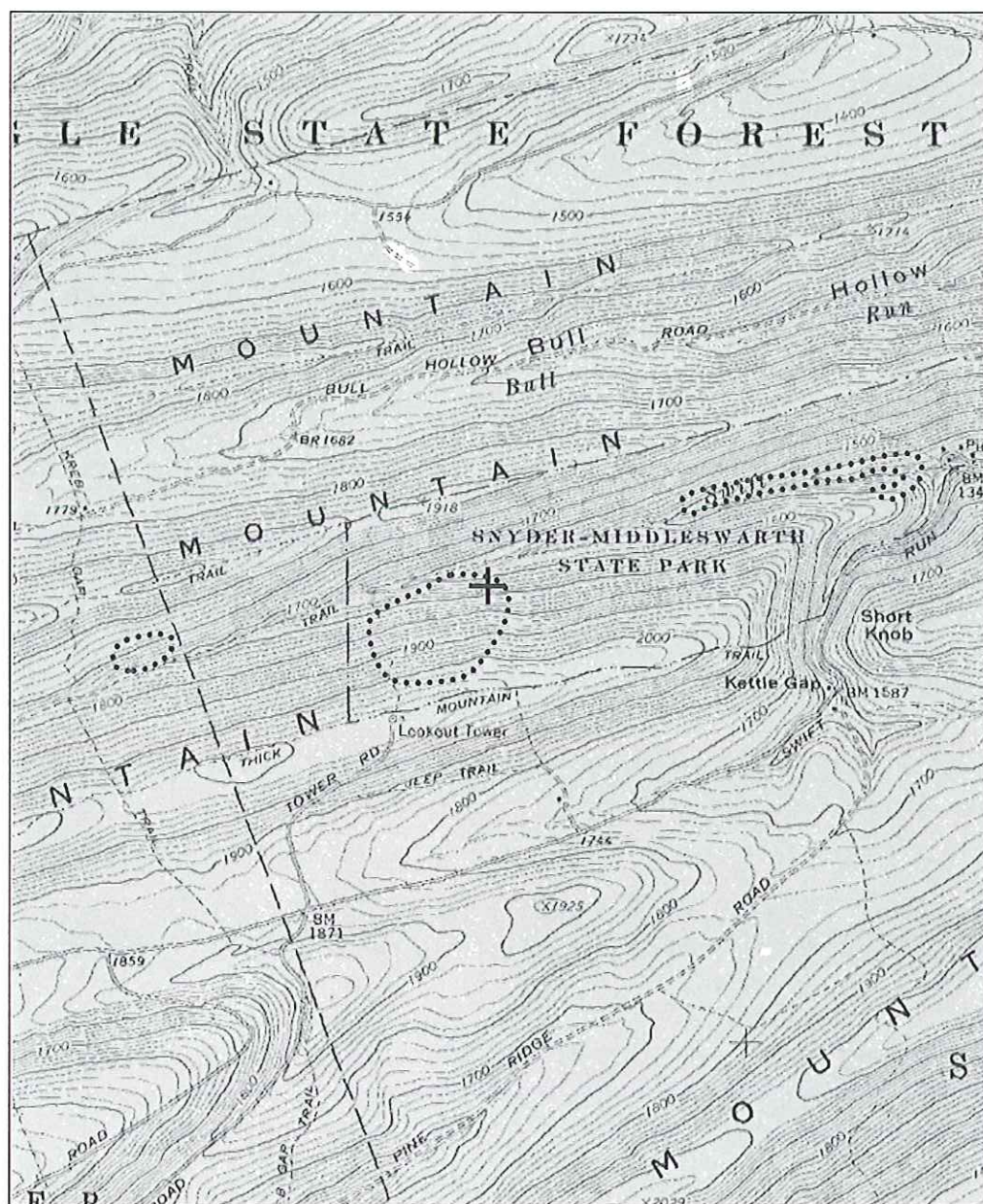


McConnell's Mill
Quantitative sampling coordinates: N40.9173, W080.2165

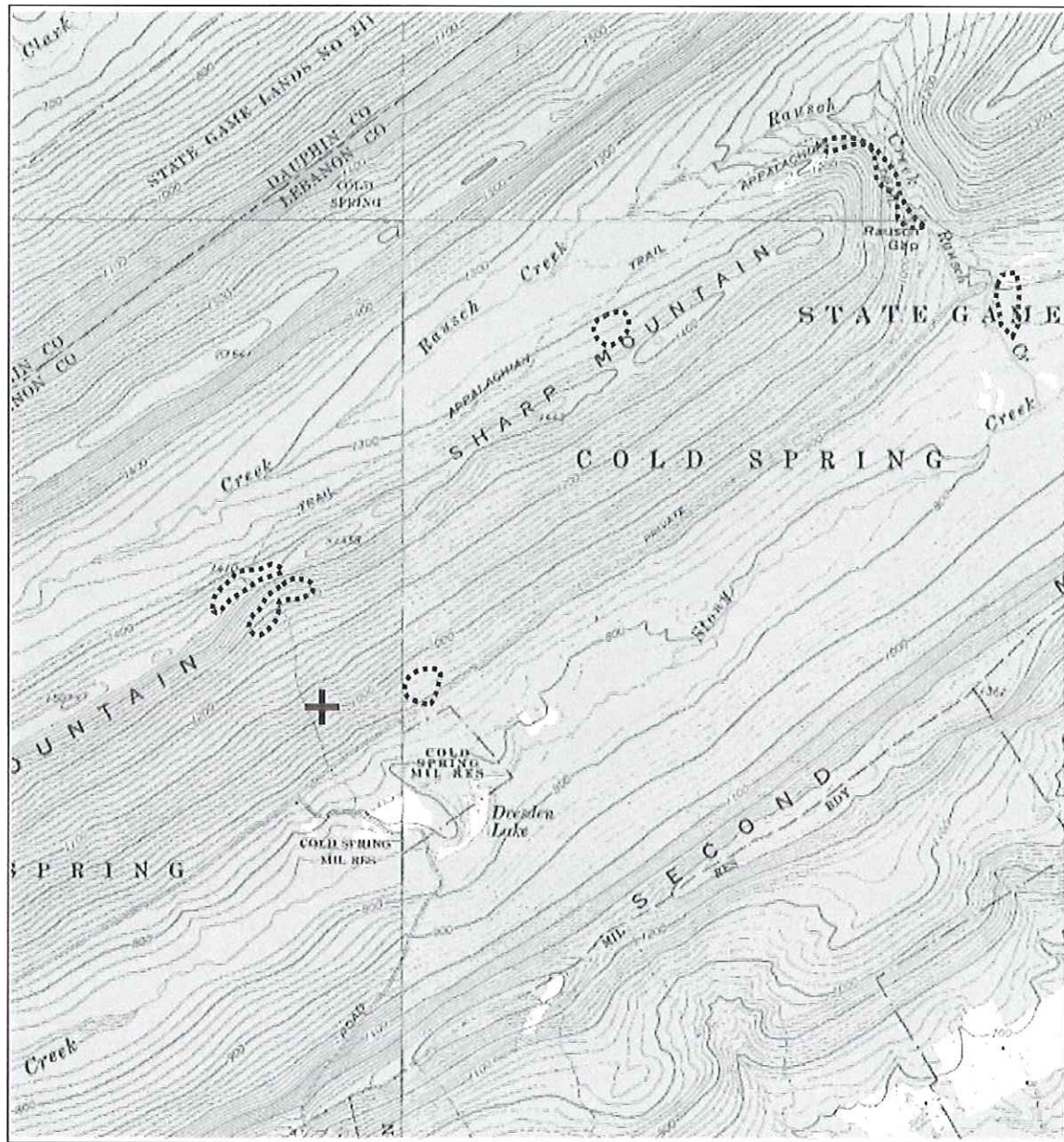


Quebec Run

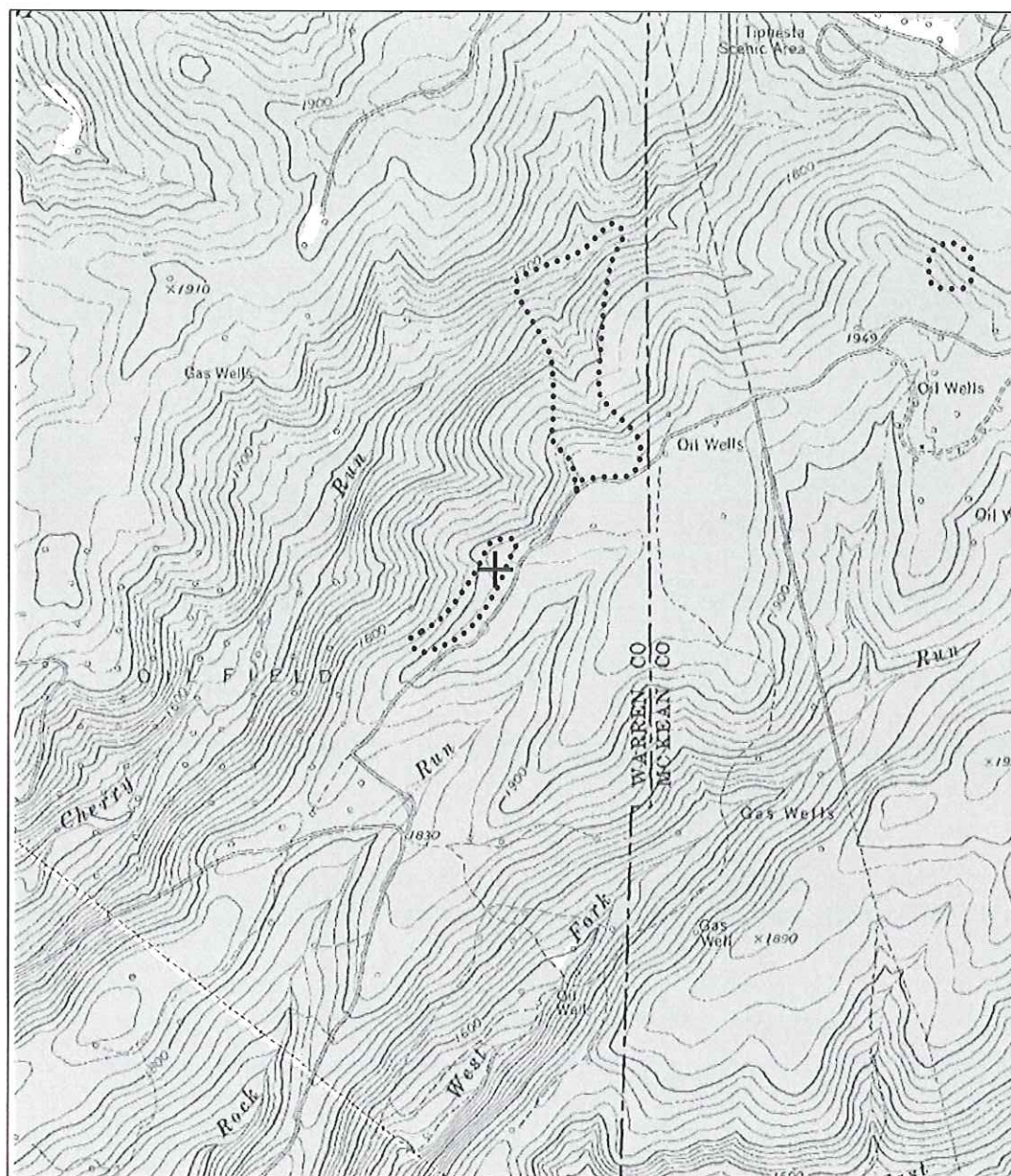
Quantitative sampling coordinates: N39.7536, W079.6856



Snyder-Middleswarth
Quantitative sampling coordinates: N40.8060, W077.3023



State Game Lands 211 (St. Anthony's Wilderness)
Quantitative sampling coordinates:



Tionesta

Quantitative sampling coordinates: N41.6473, W078.9615