APPENDIX D.
ADDITIONAL SPECIES EXPLANATIONS

The following groups were not included in the prioritization process described in Chapter 2 for reasons of jurisdictional limitations, a lack of information, and/or practicality within the time-frame for completion of the first iteration of the Wildlife Action Plan (hereafter Plan):

- Marine mammals & fish
- Pelagic birds
- Insects and arachnids
- Terrestrial gastropods

However, while severe limitations do exist in terms of data availability, overall knowledge, practicality of conservation actions, and/or jurisdictional or regulatory authority, we did not wish to simply ignore these species groups, all of which exist in, or off the coast of, North Carolina. The limitations associated with these groups point to the critical nature of partnerships and cooperative efforts among agencies and organizations to work towards improving our overall understanding of these groups.

Pelagic bird and marine species and habitat priorities were developed through review of existing publications and incorporated directly into the Plan in Chapter 5C (Marine Systems). The other groups could not be so easily organized in a common framework, as they are found across a myriad of habitats in the state. So below we have done our best, using resources currently available to us, to identify the following information for insects, arachnids, and terrestrial gastropods:

- Conservation priorities (species and/or habitats)
- Key agencies and organizations involved in the conservation of the group
- Conservation issues and needs
- Key references and additional information sources.

During future iterations of the Plan, this information should be better incorporated directly into the text where applicable.

Insects and Arachnids

Hall (1999a) presents a very good overview of general conservation issues involving insects and other invertebrates in his inventory of Lepidoptera of the Albemarle-Pamlico region of North Carolina. The following passage is from his work:

> "Conservation of insects and other invertebrates is a new, and, to some people, somewhat shocking concept. Nonetheless, preservation of native insects and other invertebrates is becoming an increasingly important concern for managers of state parks and other nature preserves. Ecosystem-oriented conservation—where the contribution of all species in maintaining ecological processes is considered—is coming to the forefront, replacing the previous focus on just a few conspicuous species, mostly vertebrates and plants. The public is also developing an appreciation for at least some groups of invertebrates. This is indicated, for example, in the growing number of butterfly counts conducted each year. There may be eventually as much demand for checklists of butterflies, dragonflies, tiger beetles, or other invertebrates as already exists for birds, other vertebrates, and wildflowers."

Insects and other arthropods are the most diverse group of any organisms, plant or animal. Over 1000 species of Lepidoptera—the best studied order of insects in North Carolina—have been recorded in the state (North Carolina Natural Heritage Program database) and at least another 1000 are expected to be eventually discovered. Equally as large, if not larger, numbers can be expected for several other insect orders. Beetles, in particular, are believed to outnumber all other taxonomic groups in terms of species.

The ecological significance of insects is great - insects play a key role in ecological processes such as primary consumption, decomposition and pollination. The majority of our plant species included on the state or federal endangered and threatened lists are dependent on insects for pollination. In some cases, specific species of insect pollinators may do most of the work and their loss, consequently, may contribute to the endangerment of the plant. *Lysimachia asperulifolia* may be one such example in North Carolina (Franklin 2001). The current low levels of seed set may indicate that a major, specialized pollinator has been lost. Insects are a primary food source for many vertebrate species groups. Game species that are largely or partly dependent on insects for food include turkey, bobwhite, ruffed grouse, and even black bear. Endangered species that rely primarily on insects include the red-cockaded woodpecker, Virginia big-eared bat, gray bat, and Indiana bat. Insects can also present considerable pest management challenges, especially introduced exotics such as the gypsy moth and Hemlock wooly adelgid. Conversely, the use of insects as biological controls may offer the best chance of combating these exotics.

However, our understanding of this group of species is far lower than almost any other animal group in the state. In recent years the North Carolina Natural Heritage Program (NC NHP) has undertaken a series of insect inventories in the coastal plain of North Carolina in order to bring understanding of the distribution, abundance, and habitat affinities for at least a few important groups of invertebrates up to the level already achieved for vascular plants and vertebrates. These surveys have uncovered not only species never before documented in North Carolina, but even species completely new to science (e.g., Apameini, New Genus 4, Species 1, Hall 1999b).

Status and Priority Species[1]

Insects and other non-crustacean arthropods are not protected by state law, nor are other groups of invertebrates except for mollusks. Yet several insects are themselves are among the most endangered of our species, primarily due to the loss of particular types of habitats. Federally-listed species in these taxa are protected under the provisions of the Endangered Species Act. In North Carolina, these include the following three insects and arachnids, all listed as Endangered Species:

- St. Francis satyr (*Neonympha mitchellii francisci*)
- American burying beetle (*Nicrophorus americanus*) (believed to be extirpated in North Carolina)
- Spruce-fir moss spider (*Microhexura montivaga*)

In addition to the American burying beetle, at least three other species are believed to have been extirpated from the state: regal fritillary (*Speyeria idalia*); grizzled skipper (*Pyrgus wyandot)*; and southern dusted skipper (*Atrytonopsis loammi*), all of which have been looked for repeatedly at sites where they were formerly known to occur. The same may also be true for the Cofaqui giant skipper (*Megathymus cofaqui*), which had previously been recorded only at a single site in North Carolina. Several other species are also known only from historic records but no real effort has been made to look for them

US Fish and Wildlife Service status surveys have been conducted on three species in collaboration with NC NHP. NC NHP recommended that the eastern Arogos skipper (*Atrytone arogos arogos*) be listed as Threatened (Hall et al.1999a), and that an undescribed species of dusted skipper (*Atrytonopsis* sp. 1) be listed as Endangered, once its taxonomic status has been resolved (Hall 2003). A status survey for the Venus flytrap moth (*Hemipachnobia subporphyrea*) is in progress, but preliminary results also indicate that this species will also be recommended for listing as Endangered (Hall and Sullivan 2000, Hall and Sullivan 2004).

Including the three species for which status surveys have been conducted, 23 species of insects and spiders occurring in North Carolina have been designated by the US Fish and Wildlife Service as Federal Species of Concern (which has no legal status). An additional 209 species of insects and spiders have been identified as Significantly Rare by the NC NHP (Table D1). This designation also carries no legal status but is used to drive conservation decisions in the state through both governmental and private initiatives.

[1]The majority of the information in this section pertains to terrestrial species.

Table D1. Rare insect and arachnid species tracked by the North Carolina Natural Heritage Program (LeGrand et al. 2004).

Group	# of Species Tracked	# of Tracked Species with Federal Protection Status
Arachnids[2]	11	1 Endangered (E); 1 Federal Species of Concern (FSC)
Mayflies[3]	16	1 FSC
Stoneflies[3]	7	0
Caddisflies[3]	14	0
Dragonflies and damselflies	37	8 FSC
Flies	1	0
Moths	70	4 FSC
Butterflies	38	1 E; 8 FSC
Grasshoppers and katydids	15	0
Beetles[3]	5	1 E (extirpated in NC); 1 Federal Species of Concern
True bugs	1	0

Including the federally listed or designated species, several species are known from only a single population in the state:

- Saint Francis' satyr (*Neonympha mitchellii francisci*) (endemic to North Carolina)
- Eastern Arogos skipper (*Atrytone arogos arogos*)
- Rare skipper (*Problema bulenta*)
- Undescribed dusted skipper (*Atrytonopsis* sp. 1) (endemic to North Carolina)

Several others are known to occur only in North Carolina and their loss here would mean total extinction of the species.

- Venus flytrap moth (*Hemipachnobia subporphyrea*)
- Carolina agrotis (*Agrotis carolina* [a newly described species formerly known as A. n. sp. nr. buchholzi])
- Sullivan's meropleon (*Meropleon diversicolor sullivani*)
- *Melanoplus decorus* (a flightless grasshopper)

Additional species that have their best known populations in North Carolina would also be strongly jeopardized if they were lost here:

- Edmund's snaketail dragonfly (*Ophiogomphus edumudo*)
- Fraser fir looper (*Macaria fraserata*)
- Appalachian crescent (*Phyciodes batesii maconensis*)
- Spruce-fir moss spider (*Microhexura montivaga*)

Still others are represented by only a handful of populations that are highly disjunct from the rest of their range. While loss of these populations might not jeopardize the entire species, they are of strong scientific interest and their loss would certainly diminish the state's natural heritage.

[2] The arachnid list is selective of cave and other montane species and is not intended to be a complete list of the rare arachnids in the state.

[3] Critically imperiled aquatic species in North Carolina (S1 or S1S2 species as ranked by NC NHP) in these groups are listed at the end of this section.

Examples include:

- *Stethophyma celatum* (a grasshopper)
- Duke's skipper (*Euphyes dukesi*)
- Bell's sandragon (*Progomphus bellei*)
- *Papaipema eryngii* (a moth)
- Berry's skipper (*Euphyes berryi*)
- Aaron's skipper (*Poanes aaroni aaroni*)
- *Spartiniphaga carterae* (a moth)
- Grisatra underwing moth (*Catocala grisatra*)
- Sundew moth (*Hemipachnobia monochromatea*)
- *Lemmeria digitalis* (a moth)

Finally, there are a large number of species that are still too poorly known to estimate their conservation significance, including several that have yet to be scientifically described. Examples (all moths) include:

- Apameini, New Genus 4, Species 1
- Apameini, New Genus 2, Species 3
- *Macrochilo* n. sp. 1 nr. *absorptalis*
- Apantesis n. sp. 1 nr. carlotta
- Noctuidae, New Genus nr. *Oligia*
- *Pangrapta* n. sp. 2
- *Cyclophora* n. sp.

Critically imperiled aquatic insects in North Carolina (S1 or S1S2 species as ranked by NC NHP, 2004) include species in the caddisfly, stonefly, mayfly, and beetle families[4]:

Mayflies

- *Baetisca becki* (a mayfly)
- *Baetisca obesa* (a mayfly)
- *Baetopus trishae* (a mayfly)
- Benfield's bearded small minnow mayfly (*Barbaetis benfieldi*)
- Cahaba sand-filtering mayfly (*Homoeoneuria cahabensis*)
- Spiculose serratellan mayfly (*Serratella spiculosa*)
- *Tortopus puella* (a mayfly)

Stoneflies

- Williams' rare winter stonefly (*Megaleuctra williamsae*)
- *Zapada chila* (a stonefly)

Caddisflies

- *Ceraclea cancellata* (a caddisfly)
- *Diplectrona metaqui* (a diplectronan caddisfly)
- Mount Mitchell caddisfly (*Manophylax altus*)
- *Rhyacophila vibox* (a rhyacophilan caddisfly)

Beetles

- Gammon's stenelmis riffle beetle (*Stenelmis gammoni*)

[4]Maps created and maintained by Eric Fleek, North Carolina Division of Water Quality (NC DWQ) identify distribution patterns of mayfly, stonfly, and caddisfly species based on NC DWQ sampling, though some are in need of update (David Lenat, pers. comm.).

Key Organizations

Only two state agencies are actively involved in conducting insect surveys and applying this information to conservation.

The **NC Division of Water Quality, Biological Assessment Unit** conducts aquatic invertebrate sampling as part of widespread monitoring of biological integrity in North Carolina waters. The Biological Assessment Unit uses stream insects (i.e., caddisflies, mayflies, stoneflies, beetles) for monitoring water quality; they conduct stream surveys across the state on a regular basis. The Unit does not attempt to determine the conservation concern for any of these species, nor does it seek protection for insects per se. Nonetheless, at least some stream reaches identified as High Quality Water or Outstanding Resource Waters through this process receive a significant amount of protection.

The **NC Natural Heritage Program** (NC NHP) is the only state agency involved in directly determining the conservation status of individual insect species and other invertebrates and using this information to help guide ecosystem conservation. NC NHP itself conducts surveys for a few selected groups including moths, butterflies, grasshoppers, and dragonflies (the results of several of these surveys are available as NC NHP reports). They also collaborate with the Biological Assessment Unit of the Division of Water Quality in making use of their survey data to identify rare species of aquatic insects. They work in partnership with USFWS to conduct status surveys on several species of rare insects (e.g., in addition to the ones listed above, NC NHP conducted surveys on the Saint Francis' Satyr that led to its being listed as Endangered). They use occurrence records for rare species of insects, along with similar records for other taxonomic groups, to assess ecosystem integrity and conservation priority of individual natural areas. NC NHP uses information provided by habitat-specialist insects, along with other animals, to assess landscape integrity at a regional level. Examples of this use can be found in the Conservation Assessment of the Southeast Coastal Plain of North Carolina (Hall and Schafale 1999) and in the Assessment of Terrestrial Habitat Quality and Landscape Integrity in the Albemarle-Pamlico Estuarine Study Area (Hall 2004; revision in progress). NC NHP staff have authored many other critical reports regarding insect conservation in North Carolina (Hall and Sullivan 2000, Hall 1999a, Hall 2003, Hall et al. 1999a, Hall et al. 1999b).

Hall's "Rules of Thumb"

While recognizing that insects and other invertebrates may never be studied as fully as other species groups by preserve managers, Hall (1999a) makes the point that some attention must be given towards their proper management if an ecosystem-based approach is the desired outcome. He presents five rules of thumb, generalizations that may be a first-step towards more comprehensive management of natural areas and ecological preserves in North Carolina. The following passages are taken directly from his work:

"The first of these rules follows a general principle of ecosystem conservation by Aldo Leopold (1953):

> *If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.*

Rule of Thumb 1. Management actions that significantly alter some aspect of an ecosystem are likely to have major effects on insects and other invertebrates. The responses of these species to the management actions may be very different than those of plants or vertebrates, the usual intended beneficiaries of the action. In the worst case, a large number of the unknown but important "cogs and wheels" of the ecosystem may be lost as a result of the action.

Keeping this in mind, additional rules of thumb will be described below that can help reduce the likelihood of a dire outcome.

Role of state parks and nature preserves in the conservation of insects and invertebrates

Nature preserves, including most state parks, are usually established where high quality examples of native ecosystems exist, as indicated by vegetative communities or the presence of rare species of plants or vertebrates. Although few preserves have yet been created specifically with insects or other invertebrates in mind, areas of high quality native habitats usually contain significant faunas of invertebrates as well. There are, in fact, several reasons why invertebrates frequently turn out to be among the rarest species in a given preserve:

- Invertebrates often have highly specific habitat requirements, much more so than is typical for vertebrates. Many insects, for instance, feed only on a particular host plant. Habitat requirements for these species include those for its host plant as well as additional ones of their own.
- Invertebrate populations often undergo extreme fluctuations in numbers, resulting from vagaries in weather or cyclical changes in abundance of their predators or parasites. They are much more prone to local extirpation than either vertebrates or plants. As discussed below, they often survive only where there are enough well-dispersed habitat patches to support a metapopulation.
- Despite their vulnerability to local extirpation, some species can survive in long-lasting, relict populations, as long as natural ecosystem processes are continuous through time. For example, a population of the brown elfin (*Incisalia augustinus*) found on the summit of Occoneechee Mountain, a State Natural Area along the Eno River, may have existed there since the end of the Ice Age approximately 10,000 years ago, just as have several rare plants with similar montane or boreal distributions (no other populations of this species are known from fifty miles around). Their presence on this monadnock is indicative not only of the high quality of the habitats that currently exist, but on the continuity of those habitats and the ecological processes maintaining them throughout that immense span of time. This ability to maintain relict populations is shared with many rare plant species but is less typical for vertebrates.

For all these reasons, the presence of healthy populations of rare or habitat specialist species of insects and other invertebrates is invariably an indication of a high degree of native ecosystem integrity. Conversely,

Rule of Thumb 2. Where high quality natural areas exist and have maintained their quality through time, a significant fauna of insects and other invertebrates—containing both rare species and a high proportion of habitat specialists—should be expected.

Role of the larger landscape in the conservation of insects and other invertebrates

Although some species of invertebrates, like some plants, can maintain small relict populations over large spans of time, most invertebrates require a distribution of habitats spread out over an entire landscape. This is especially the case for species prone to local extirpation and that depend on a metapopulation structure for survival within a region. A metapopulation is composed of a number of sub-populations, each of which may be relatively unstable, some increasing in a given year, others declining to the point of extirpation. As long as movement is possible between the sub-populations, declining populations can be "rescued" by immigration from increasing populations elsewhere within the metapopulation. A metapopulation can therefore be much more stable than its parts, at least as long as not all sub-populations are affected by the same set of events. Metapopulations are most stable, consequently, when they are spread out over a significant area of the landscape.

Conservation biologists are just beginning to realize how important metapopulations are for animals in general (for vertebrate examples, see McCullough 1996). Due to the greater fluctuations their subpopulations experience within a given year or season, invertebrates are often dependent on metapopulation structures. This is especially true of species associated with ecosystems maintained by frequent disturbances, such as fire, storms, or floods. Whereas vertebrates (and many plants) often have escape mechanisms for coping with unpredictable ecological disruptions, invertebrates typically do not. The only way many insects species survive in habitats maintained by frequent fire, for instance, is through recolonization of recently burned areas from unburned patches of habitat (Hall and Schweitzer 1993).

Habitat fragmentation – Replacement of natural landscapes with a mosaic of small patches of native habitats in a matrix of lands converted to human uses—affects all species by reducing the overall amount of available habitat, involving outright losses as well as more subtle reductions due to edge effects. The most severe effects, however, may be on species critically dependent on metapopulation structures.

By definition, habitat fragmentation is a process that increases the distances between suitable habitat patches and therefore increases the difficulties or outright danger to individuals dispersing from one habitat block to another. Since the very existence of a metapopulation depends on dispersal between suitable patches of habitat, any factor that reduces the changes of successful dispersal may doom the whole metapopulation to eventual extirpation, not just individual sub-populations as normally occurs within intact landscapes. Habitat specialists, particularly those dependent on naturally rare types of habitat or on disturbance-maintained habitats, are at greatest risk.

Rule of Thumb 3. Insects and other invertebrates should be considered at particular risk from fragmentation of native habitats. Even though invertebrate populations can be particularly high within a given sub-population during a given season, this should not be taken as a sign that, as small species, they only need a limited amount of space to maintain themselves. Their long term survival within a region may depend on as much landscape as is required to support a population (or metapopulation) of black bears, red-cockaded woodpeckers, or other species of vertebrates.

Several insects are believed, in fact, to have become critically endangered through loss of metapopulation structure, even though habitats within portions of the range of the metapopulation still appear to be high in quality. Examples in the North Carolina Coastal Plain include the Arogos skipper (*Atrytone arogos*), St Francis' satyr (*Neonympha mitchelli francsici*), and Venus flytrap moth (*Hemipachnobia subporphyrea*)[5].

Implications for management of insects and other invertebrates within state parks and nature preserves

Preserves can to some degree be regarded as islands of habitat. They are often chosen for conservation as something special in areas where the rest of the landscape has been significantly altered. All too frequently, preserves contain the only remnants of native ecosystems for miles around.

While these preserves are intended to remain "natural," active management is often needed to accomplish this goal, although management, almost by definition, involves some form of artificial disturbance. This disturbance may replace a natural form, such as wildfires, or it may be entirely new, such as spraying an entire preserve with a pesticide to control an exotic pest such as the gypsy moth.

Based on the three rules of thumb given previously, it should be clear that special precautions need to be considered in preserve management if crucial "cogs and wheels" of the ecosystem are to be retained. Given the importance of metapopulation structure to many invertebrates, particularly those most tightly associated with native habitats, preserve managers should always ask where will recolonization come from if species are lost from a given area of habitat.

Rule of Thumb 4. Wherever possible, management activities should be restricted to only a portion of a given habitat type. Other areas of the same habitat should be set aside as refuge areas (although potentially subject to treatment at a later time).

Rule of Thumb 5. In cases where a management action affects an entire preserve, as in treatment for gypsy moths, decisions about the scope, intensity, and alternative treatments should be based according to the proximity of refuge areas beyond the boundary of the preserve. Where other, untreated blocks of habitat are located close by, a wider range of management options can be considered. Even in the worst case, where species are extirpated from the preserve, recolonization from outside can still be expected. Where external refuges are located far away, however, management decisions should be based on the worst possible case: irrecoverable losses of species from the preserve."

[1]The NC NHP has conducted or is in the process of conducting status surveys for all three of these species.

Conservation Issues and Needs

Habitat loss: The greatest threat to insects comes from habitat loss, thus conservation efforts aimed at protecting native ecosystems offers the best hope for the majority of endangered insect species. However, even on lands that have been protected to maintain their natural features, management practices need to take the specific requirements of insects into account.

Consideration of insects in site management: If ecosystem-level conservation planning is to be successful, managers must include invertebrates in site management considerations. Consider Hall's rules of thumb from above (Hall 1999a).

Management practices: Insects and other invertebrates may respond to certain management practices very differently than plants or vertebrates; gauging the success of management by the effects on those species may miss significant damage being done inadvertently to insects and other non-target species. This is particularly true for prescribed burning. NC NHP has developed a set of guidelines for conducting burns in ways that minimize impacts to rare insect populations (Hall and Schwietzer 1993, Hall 1999a). Non-target impacts—particularly to rare species—also need to be carefully assessed any time pesticides (or biological control agents) are applied to natural areas.

Collection: Some species—particularly butterflies—are sought after by collectors, and over-collection can be a threat in some situations. One species, *Megathymus cofaqui*, may, in fact, have been extirpated from the state due to overcollection. Insect collecting is not regulated under state law, although permits are required in some cases for collecting on public lands (e.g., state parks, game lands, national forests).

Species control: Use of species-specific insecticides should be encouraged when possible in order to minimize non-target impacts. Key natural areas must be protected during large-scale applications of insecticides with broad non-target impacts. This is especially important in areas where native habitats are restricted in distribution (e.g., maritime and longleaf pine forests) (Hall et al. 1999b).

Outdoor lighting: Moths and other night-flying insects are particularly impacted by outdoor lighting; they become disoriented by artificial lights and can perish due to dehydration, starvation, or predators who key in on these areas. Where possible, low voltage, shielded fixtures should be used. Lighting of any kind should be avoided around habitats likely to support rare nocturnal insects (Hall 1999a). Further lighting recommendation can be found in publications of the International Dark Sky Association (www.darksky.org).

Web-based Resources

- US Fish & Wildlife Service, NC Ecological Services Office, North Carolina's Threatened and Endangered Species web site: http://nc-es.fws.gov/es/es.html
  - Recovery plan for St. Francis satyr can be found at: http://ecos.fws.gov/docs/recovery_plans/1996/960423.pdf
  - Recovery plan for Spruce-fir moss spider can be found at: http://ecos.fws.gov/docs/recovery_plans/1998/980911b.pdf
- Notes on the butterflies of North Carolina web site: (http://www.ncsparks.net/butterfly/nbnc.html) – *Contains extensive natural history information on all North Carolina butterflies, including flight phenograms, and county atlases.*
- Opler, Paul A., Harry Pavulaan, and Ray E. Stanford (coordinators). Butterflies of North America. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/distr/lepid/bflyusa/bflyusa.htm (Version 12, Dec 2003). *This site provides state by state accounts of butterfly species, including information on habitat, range, conservation, management need, Global rank, and references.*
- USGS National Water Quality Assessment Program. Invertebrate community data from North Carolina can be downloaded from the NAWQA Data Warehouse at http://water.usgs.gov/nawqa/data.
- International Dark Sky Association. www.darksky.org

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Terrestrial Gastropods

Terrestrial gastropods are protected under state law in North Carolina. However, due to extremely limited data and a scarcity of biologists who work on the taxa, little is known about the 200+ species of native terrestrial gastropods known to exist in the state or the 30+ introduced species of land snail or slugs. The North Carolina Natural Heritage (NC NHP) program collects data on 37 rare terrestrial gastropod species; their status' break down as follows:

Federally threatened:

- Noonday globe snail (*Patera clarki nantahala*)

State endangered:

- Fragile glyph (*Glyphyalinia clingmani*)

State threatened:

- Waccamaw ambersnail (*Catinella waccamawensis*)
- Big-tooth covert (*Fumonelix jonesiana*)
- Engraved covert (*Fumonelix orestes)*
- Clingman covert (*Fumonelix wheatleyi clingmanicus*)
- Smoky Mountain covert (*Inflectarius ferrissi*)
- Sculpted supercoil (*Paravitrea ternaria*)
- Roan supercoil (*Paravitrea varidens*)
- Cape Fear threetooth (*Triodopsis soelneri*)

Species of concern:

- Queen crater (*Appalachina chilhoweensis*)
- Sawtooth disc (*Discus bryanti*)
- Dark glyph (*Glyphyalania junaluskana*)
- Pink glyph (*Glyphyalinia pentadelphia*)
- Honey glyph (*Glyphyalinia vanattai*)
- Blue-footed lancetooth (*Haplotrema kendeighi*)
- Spiral coil (*Helicodiscus bonamicus*)
- Fringed coil (*Helicodiscus fimbriatus*)
- Velvet covert (*Inflectarius subpalliatus*)
- Black mantleslug (*Pallifera hemphilli*)
- High Mountain supercoil (*Paravitrea andrewsae*)
- Mirey Ridge supercoil (*Paravitrea clappi*)
- Ramp cove supercoil (*Paravitrea lacteodens*)
- Lamellate supercoil (*Paravitrea lamellidens*)
- Glossy supercoil (*Paravitrea placentula*)
- Open supercoil (*Paravitrea umbilicaris*)
- Dwarf proud globe (*Patera clarki*)
- Great Smoky slitmouth (*Stenotrema depilatum*)
- Dwarf threetooth (*Triodopsis fulciden*)
- Bidentate dome (*Ventridens coelaxis*)
- Appalachian gloss (*Zonitoides patuloides*)

Significantly rare (a NC NHP designation that does not carry any legal protection):

- Talus coil (*Helicodiscus triodus*)
- Dwarf globelet (*Inflectarius downieanus*)
- Budded threetooth (*Triodopsis tennesseensis*)
- A valvatid snail (*Valvata sincera*)
- Sculptured dome (*Ventridens collisella*)
- Hollow dome (*Ventridens lasmodon*)

Key Organizations

Collections on land snails can be found at a number of museums around the country. Review of those collections will be critical to better verifying species identifications and distributions for records pertaining to North Carolina (Art Bogan, pers. comm.).

- Field Museum of Natural History, Chicago, IL. The collections of L. Hubricht are available on the web.
- Academy of Natural Sciences, Philadelphia, PA. The collections of H. A. Pilsbry are housed here, which form the basis for the monograph of land snails of North America (see key references).
- Florida Museum of Natural History, Gainsville, FL. John Slapcinsky is conducting work on the zonitidae of western North Carolina; computerized collections.
- Carnegie Museum of Natural History, Pittsburgh, PA. Tim Pearce has a very large land snail collection which should be reviewed for North Carolina records.
- Ohio State Museum of Zoology. Tom Watters' has a computerized collection of land snails that may contain information on western North Carolina species.

Art Bogan, Curator of Aquatic Invertebrates at the North Carolina Museum of Natural Sciences, has compiled a list of land snails of North Carolina (by county) based on the Field Museum collections, though this work is very preliminary. Amy VanDevender, another North Carolina-based researcher, has begun work collecting land snails from the western part of the state (Art Bogan, pers. comm.)

Conservation Issues and Needs

The most pressing conservation issues regarding the land snails relates to the paucity of data and knowledge of this group of animals. The needs are thus the most basic: surveys, inventories, and review of existing collections. Basic systematics of most land snail fauna are very poorly known. Most of the species in family Zonitidae have never been dissected and the anatomy described, much less phylogenetic and DNA work done. Little to nothing is known about their ecology, egg laying behavior, or reproductive biology.

Specific needs include:

- A thorough state-wide survey to confirm species distributions beyond county boundaries
- Review of existing collections to verify North Carolina species records
- Basic systematics work on most fauna, especially family Zonitidae

Additional Resources

Burch, J. B. 1962. How to know the eastern land snails. Wm. C. Brown Co., Publishers, Dubuque, IA.

Hubricht, L. The distributions of the native land mollusks of the eastern United States. 1985. Fieldiana, Zoology, New Series no. 24.

Pilsbry, H. A. Land mollusca of North America (North of Mexico). 1938-1948. 4 parts. (http://www.acnatsci.org/library/scipubs/Malacology.html)

Volume 1, Part 1. 1939. Families Helicidae, Helicellidae, Helminthoglyptidae, Camaenidae.

Volume 1, Part 2. 1940. Families Polygyridae and Sagdidae.

Volume 2, Part 1. 1946. Families Bulimulidae, Urocoptidae, Cerionidae, Achatinidae, Oleacinidae, Haplotrematidae, Testacellidae, Zonitidae; and supplement to family Camaenidae, subfamily Ammonitellinae.

Volume 2, Part 2. 1948. Families Helminthoglyptidae, Limacidae, Endodontidae, Arionidae, Philomycidae, Succineidae, Strobilopsidae, Pupillidae, Valloniidae, Cionellidae, Carychiidae, Veronicellidae, Truncatellidae, Pomatiopsidae, Helicinidae.