Chapter 7. Virginia's Northern Ridge and Valley

Figure 7.1. The Northern Ridge and Valley ecoregion.

7.1. Introduction

7.1.1. Description

The Northern Ridge and Valley (Ridge and Valley, Figure 7.1) consists of parallel, northeast-to-southwest lines of mountains and valleys in western Virginia, making up a large portion of Virginia's Appalachian Mountains (Table 7.1). The soils are mostly Ultisols, Alfisols, and Inceptisols (McNab and Avers 1995). Precipitation in the ecoregion averages between 30-45in (76-114cm), with 20-30% falling as snow (McNab and Avers 1995). The average temperature ranges from 39 to 57°F (4-14°C, McNab and Avers 1995). The growing season generally lasts from 120 to 180 days, dependent on location (McNab and Avers 1995). Forest cover is largely oak (historically oak-chestnut) and oak-pine, though isolated patches of northern hardwoods and northern relict spruce-fir also occur (Woodward and Hoffman 1991). Streams are generally small, many dry up during summer, and wetlands are rare (McNab and Avers 1995). Timber production is important in the Ridge and Valley, as is farming in the valley floodplains.

Table 7.1. Names for the Northern Ridge and Valley as used in other ecoregional schemes and planning efforts. The following at least roughly correspond to the same area as Northern Ridge and Valley as used in this document.

Planning Effort/Regional Scheme	Name of Ecoregion	Reference
NABCI	BCR 28, Appalachian Mountains [1]	NABCI 2000
PIF	Mid-Atlantic Ridge and Valley (Physiographic Area 12) [2]	Rosenberg 2003
United States Shorebird Conservation	BCR 28, Appalachian Mountains [3]	Brown et al. 2001

Planning Effort/Regional Scheme	Name of Ecoregion	Reference
Waterbird Conservation for the Americas	Southeast U.S. [4]	Kushlan et al. 2002
Freshwater Ecoregions	Ecoregion 41, Chesapeake Bay; 40, South Atlantic; 34, Teays-Old Ohio [5]	Abell et al. 2000
TNC, Ecoregional Planning Units	Ecoregions 59, Central Appalachian Forest, and 50, Cumberlands and Southern Ridge and Valley [6]	Groves et al. 2000
Omernik's Ecoregions	Ecoregions 67, Ridge and Valley [7]	Omernik 1987
Bailey's Ecoregions	Section M221A, Northern Ridge and Valley	Bailey 1995

[1] BCR 28 includes all of the Appalachian Mountains, and includes what are identified in the CWCS as the Blue Ridge Mountains, Northern Ridge and Valley, and the Northern and Southern Cumberland Mountains.
[2] Physiographic Area 12 also includes most of the Blue Ridge, as well as most of the Southern Cumberlands.
[3] No regional shorebird plan exists for this BCR.
[4] Southeast U.S. is a large region including all of Virginia. The regional scheme used by Kushlan et al. (2002) is based on composites of the Bird Conservation Regions used by NABCI.
[5] The majority of the Ridge and Valley occurs within Ecoregion 41, with small areas in Ecoregion 40 (Roanoke River) and Ecoregion 34 (New River).
[6] Ecoregion 50 is mostly what is considered the Northern and Southern Cumberlands in the CWCS.
[7] Ecoregion 67 also includes most of the Southern Cumberlands as used in the CWCS.

Despite breeding and wintering habitat frequently being the subject of focus in conservation of migratory birds, stopover habitat is just as essential (Moore et al. 1995). Some concern exists that migratory habitat may be a limiting factor in some populations, rather than breeding or wintering habitat (Sherry and Holmes 1993). Habitat usage during migration is complicated by the inability of birds to search for the best site, due to time or energy restraints (Moore and Simons 1989). As a result, migration stopover habitat is likely based more on food availability to replenish fat stores than on specific plant community composition (Moore and Simons 1989). For instance, one study found a much higher than expected proportion of migrant birds in scrub-shrub habitat on a barrier island in the Gulf of Mexico (Moore et al. 1990). The crucial conservation issue here is simply that migration stopover habitat is critical, and areas identified as migration pathways must conserve these habitats. All three major bird conservation plans recognize the importance of stopover habitat, and also recognize that in many cases habitat use during migration is poorly understood (Brown et al. 2001; Kushlan et al 2002; Rich et al. 2004).

Due to its position in the center of the Appalachians, Virginia's mountains are critical to hundreds of species of migrant birds, especially diurnal raptors (Hill 1984). The mountains provide updrafts that make migration energetically efficient for raptors (Johnsgard 1990). This makes the mountains of VIrginia an important flyway for raptor migration. For example, in 1997, 35% of the raptors observed during the fall migration hawk watch were in the mountains (with the remaining 65% occurring coastally, Holt 1998). Although many raptors migrate through the mountains and along the coast, it is rare for birds to switch routes: birds banded in the mountains are generally only recovered in the mountains, and vice versa (Hill 1984). Raptor migrants in the mountainous ecoregions include many species that breed in Virginia, such as the Tier I peregrine falcon *Falco peregrinus*, as well as many that do not, such as the northern goshawk *Accipiter gentilis* and golden eagle *Aquila chrysaetos.*

Several species of bats that occur in Virginia are also migratory. These include the Tier I Indiana myotis *Myotis sodalis* and the Tier II gray myotis *M. grisescens*, among many other more common species. Migratory bats are more difficult to study than migratory birds, both because they migrate nocturnally and because they are more cryptic than birds. As a result, very little is known about migration in bats. However, it appears that bats orient by following ridgelines and other land features during migration (Tuttle 2004).

Since individuals of both of the aforementioned *Myotis* species migrate from other states to hibernate in only a few caves in the Appalachians (Pierson 1998), Virginia's mountain ecoregions may be important not only as a winter destination for bats, but also as a migration route. Therefore, even caves that do not serve as hibernacula are probably important as stopover habitat for many species (Whitaker and Hamilton 1998), especially in light of the fact that bats do not travel very far in one night. For instance, gray bats may hibernate up to about 210km from their maternity caves, but only fly 18-52km per night (Whitaker and Hamilton 1998). These bats must be able to find suitable stopover caves for at least three nights during migration, and perhaps many more. Other bats may travel much further (little brown bats *M. lucifugus* may travel as far as 450km, Linzey 1998), and so may require even more stopover sites.

7.1.2. Land Cover Areas

Approximately 90% of the Ridge and Valley is montane, with almost 7% submontane and the remainder high elevation. This ecoregion contains the largest amount of high elevation areas of any ecoregion in Virginia. Most of the land cover in the Ridge and Valley is forest, followed by agriculture and open habitats (Figure 7.2). Over 25% of the land area is within a Conservation Land and therefore has some degree of conservation protection. This relatively high amount of protection is due to the George Washington and Jefferson National Forests. Because of the presence of National Forest, over 95% of the Conservation Land is covered by forest (Figure 7.2), which is a higher proportion than occurs in the overall Ridge and Valley. Agriculture, open, and developed areas are all protected in lower proportions than they occur ecoregion-wide.

7.1.3. Human Population in the Ridge and Valley

The Ridge and Valley, with 24% of the land area in Virginia, is home to slightly more than 850,000 people, or 12% of Virginia's population (USCB 2003). The average population density is 34.9 people/km^2. The more densely populated areas are within the Valley of Virginia along the eastern part of the ecoregion (Figure 7.3). This area includes the cities of Winchester, Harrisonburg, Waynesboro, Staunton, Roanoke, Blacksburg, Radford, and Bristol, all of which are along Interstate 81. The more mountainous western portion of the Ridge and Valley is much less densely populated (Figure 7.4). Between 2000 and 2009, the population in the ecoregion is expected to grow by about 4.7% (GeoLytics 2005).

Only 4.9% of the Ridge and Valley is within a high impact growth area (Figure 7.4). High growth areas include much of Frederick County in northern Virginia and isolated block-groups along the I-81 corridor in the eastern portion of the ecoregion. Some of the highest growth is expected to occur east and south of the City of Winchester and in section between the cities of Blacksburg, Christiansburg, and Radford.

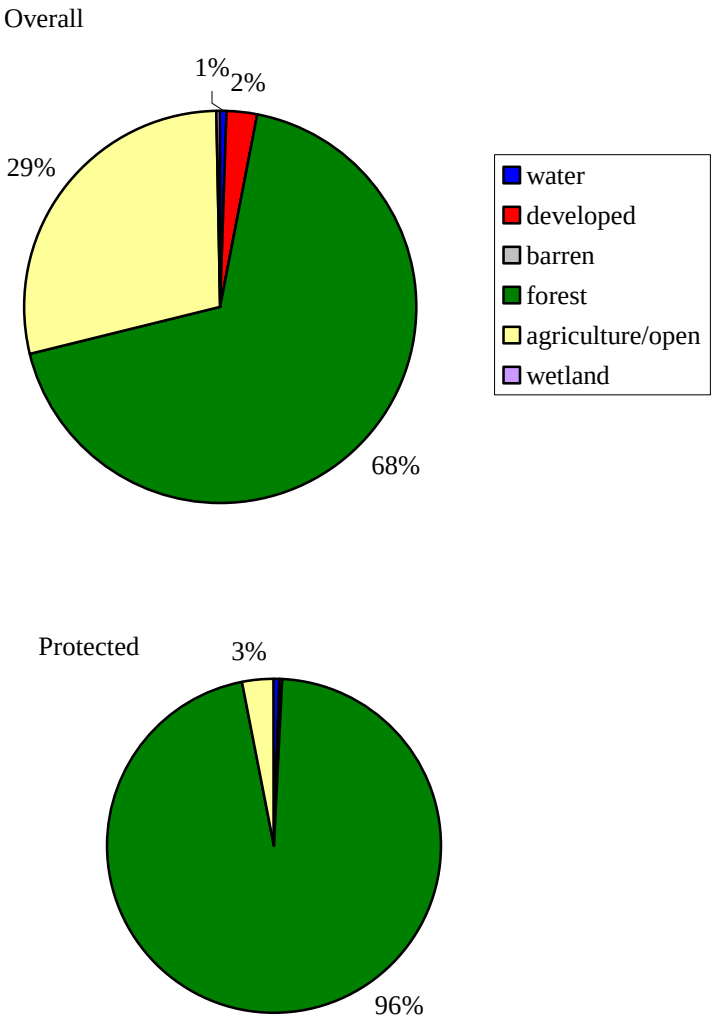

Figure 7.2. Proportional composition of land cover types within the overall Ridge and Valley compared to proportion of land cover types within protected areas in the Ridge and Valley.

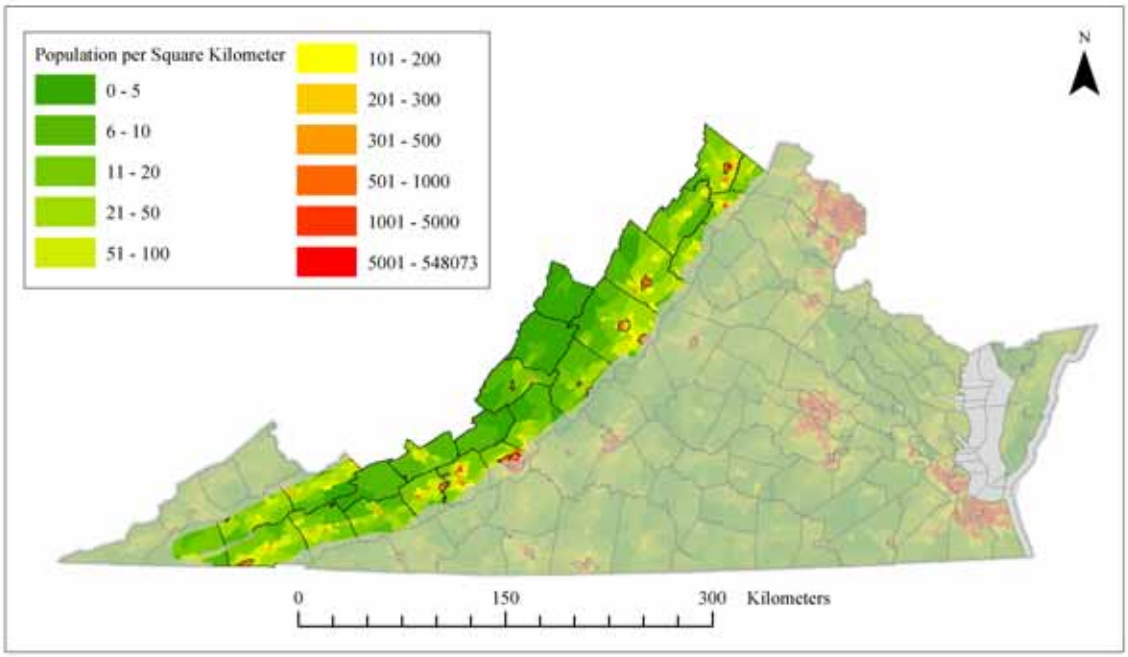

Figure 7.3. Population density from the 2000 census, highlighted for the Ridge and Valley (USCB 2003).

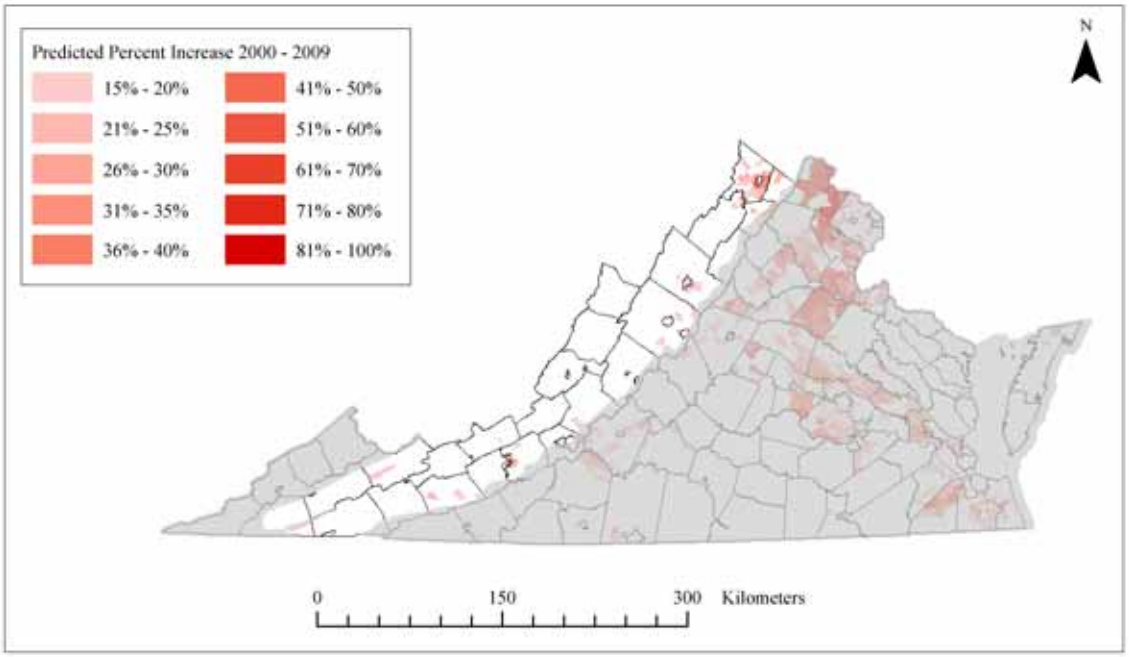

Figure 7.4. High impact growth areas in the Ridge and Valley. This figure contains demographic data from GeoLytics, East Brunswick, New Jersey (GeoLytics 2005).

7.2. The Species of Greatest Conservation Need: Ridge and Valley

Of the 384 species of greatest conservation need that occur in the Ridge and Valley, 57 (15%) are in Tier I, 125 (44%) are in Tier II, 70 (18 %) are in Tier III, and 131 (34 %) are in Tier IV (Table 7.2).

Table 7.2. The species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name
Tier I	
Fishes	
Spotfin chub	*Erimonax monachus*
Sharphead darter	*Etheostoma acuticeps*
Ashy darter	*Etheostoma cinereum*
Duskytail darter	*Etheostoma percnurum*
Yellowfin madtom	*Noturus flavipinnis*
Roanoke logperch	*Percina rex*
Tennessee dace	*Phoxinus tennesseensis*
Amphibians	
None	
Reptiles	
Wood turtle	*Glyptemys insculpta*
Northern pinesnake	*Pituophis melanoleucus*
Birds	
Henslow's sparrow	*Ammodramus henslowii*
Upland sandpiper	*Bartramia longicauda*
Peregrine falcon	*Falco peregrinus*
Loggerhead shrike	*Lanius ludovicianus*
Appalachian yellow-bellied sapsucker	*Sphyrapicus varius appalachiensis*
Appalachian Bewick's wren	*Thryomanes bewickii altus*
Golden-winged warbler	*Vermivora chrysoptera*
Mammals	
Virginia northern flying squirrel	*Glaucomys sabrinus fuscus*
Snowshoe hare	*Lepus americanus*
Indiana myotis	*Myotis sodalis*
Terrestrial Insects	
Appalachian grizzled skipper	*Pyrgus centaureae wyandot*
Regal fritillary	*Speyeria idalia*
Other Terrestrial Invertebrates	
Shaggy coil	*Helicodiscus diadema*
Rubble coil	*Helicodiscus lirellus*
Virginia fringed mountain snail	*Polygyriscus virginianus*
Aquatic Mollusks	
Birdwing pearlymussel	*Lemiox rimosus*
Fanshell	*Cyprogenia stegaria*
Dromedary pearlymussel	*Dromus dromas*
Cumberlandian combshell	*Epioblasma brevidens*
Oyster mussel	*Epioblasma capsaeformis*

Common Name	Scientific Name
Tan riffleshell	*Epioblasma florentina walkeri*
Green-blossom pearlymussel	*Epioblasma torulosa gubernaculum*
Virginia springsnail	*Fontigens morrisoni*
Shiny pigtoe	*Fusconaia cor*
Fine-rayed pigtoe	*Fusconaia cuneolus*
Cracking pearlymussel	*Hemistena lata*
Pink mucket	*Lampsilis abrupta*
Little-winged pearlymussel	*Pegias fabula*
James spinymussel	*Pleurobema collina*
Rough pigtoe	*Pleurobema plenum*
Bottle hornsnail	*Pleurocera gradata*
Rough rabbits foot	*Quadrula cylindrica strigillata*
Cumberland monkeyface	*Quadrula intermedia*
Appalachian monkeyface	*Quadrula sparsa*
Purple bean	*Villosa perpurpurea*
Cumberland bean	*Villosa trabalis*
Crustaceans	
Natural Bridge cave isopod	*Caecidotea bowmani*
Rye Cove isopod	*Lirceus culveri*
Ephemeral cave amphipod	*Stygobromus ephemerus*
Madison Cave amphipod	*Stygobromus stegerorum*
Aquatic Insects	
Virginia stonefly	*Acroneuria kosztarabi*
Big stripetail stonefly	*Isoperla major*
Other Aquatic Invertebrates	
A groundwater planarian	*Procotyla typhlops*
Chandler's planarian	*Sphalloplana chandleri*
Rockbridge County cave planarian	*Sphalloplana virginiana*
A cave lumbriculid worm	*Stylodrilus beattiei*
Tier II	
Fishes	
Roanoke bass	*Ambloplites cavifrons*
Western sand darter	*Ammocrypta clara*
Greenfin darter	*Etheostoma chlorobranchium*
Candy darter	*Etheostoma osburni*
Popeye shiner	*Notropis ariommus*
Roughhead shiner	*Notropis semperasper*
Orangefin madtom	*Noturus gilberti*
Blotchside logperch	*Percina burtoni*
Longhead darter	*Percina macrocephala*
A dace	*Phoxinus sp.1*
Paddlefish	*Polyodon spathula*

Common Name	Scientific Name
Amphibians	
Tiger salamander	*Ambystoma tigrinum*
Green salamander	*Aneides aeneus*
Eastern hellbender	*Cryptobranchus alleganiensis*
Southern zigzag salamander	*Plethodon dorsalis*
Cow Knob salamander	*Plethodon punctatus*
Mountain chorus frog	*Pseudacris brachyphona*
Reptiles	
Mountain earthsnake	*Virginia valeriae*
Birds	
Northern saw-whet owl	*Aegolius acadicus*
American black duck	*Anas rubripes*
Cerulean warbler	*Dendroica cerulea*
Bald eagle	*Haliaeetus leucocephalus*
Swainson's warbler	*Limnothlypis swainsonii*
Yellow-crowned night-heron	*Nyctanassa violacea*
Appalachian winter wren	*Troglodytes troglodytes pullus*
Mammals	
Virginia big-eared bat	*Corynorhinus townsendii virginianus*
Fisher	*Martes pennanti*
Southern rock vole	*Microtus chrotorrhinus*
Gray myotis	*Myotis grisescens*
Southern water shrew	*Sorex palustris*
Terrestrial Insects	
Smyth's Apamea moth	*Apamea smythi*
A cave springtail	*Arrhopalites caedus*
A cave springtail	*Arrhopalites lacuna*
A cave springtail	*Arrhopalites pavo*
A cave springtail	*Arrhopalites sacer*
A cave springtail	*Arrhopalites silvus*
Maureen's shale stream beetle	*Hydraena maureenae*
Tawny crescent	*Phyciodes batesii*
Avernus cave beetle	*Pseudanophthalmus avernus*
New River Valley cave beetle	*Pseudanophthalmus egberti*
A cave beetle	*Pseudanophthalmus gracilis*
Hoffman's cave beetle	*Pseudanophthalmus hoffmani*
Burkes Garden cave beetle	*Pseudanophthalmus hortulanus*
Hubricht's cave beetle	*Pseudanophthalmus hubrichti*
Crossroads Cave beetle	*Pseudanophthalmus intersectus*
Mud-dwelling cave beetle	*Pseudanophthalmus limicola*
Nelson's cave beetle	*Pseudanophthalmus nelsoni*
Thin-neck cave beetle	*Pseudanophthalmus parvicollis*
Petrunkevitch's cave beetle	*Pseudanophthalmus petrunkevithchi*

Common Name	Scientific Name
Natural Bridge cave beetle	*Pseudanophthalmus pontis*
South Branch Valley cave beetle	*Pseudanophthalmus potomaca potomaca*
Overlooked cave beetle	*Pseudanophthalmus praetermissus*
Spotted cave beetle	*Pseudanophthalmus punctatus*
Straley's Cave beetle	*Pseudanophthalmus quadratus*
Saint Paul cave beetle	*Pseudanophthalmus sanctipauli*
A cave beetle	*Pseudanophthalmus seclusus*
Silken cave beetle	*Pseudanophthalmus sericus*
Thomas' cave beetle	*Pseudanophthalmus thomasi*
Vicariant cave beetle	*Pseudanophthalmus vicarius*
Maiden Spring cave beetle	*Pseudanophthalmus virginicus*
A cave springtail	*Pseudosinella bona*
A cave springtail	*Pseudosinella extra*
Gammon's riffle beetle	*Stenelmis gammoni*
A cave springtail	*Typhlogastrura valentini*
Other Terrestrial Invertebrates	
A cave pseudoscorpion	*Apochthonius coecus*
A cave pseudoscorpion	*Apochthonius holsingeri*
Big Cedar Creek millipede	*Brachoria falcifera*
Hoffman's xystodesmid millipede	*Brachoria hoffmani*
Turner's millipede	*Brachoria turneri*
A millipede	*Buotus carolinus*
A cave pseudoscorpion	*Chitrella superba*
Hoffman's cleidogonid millipede	*Cleidogona hoffmani*
A millipede	*Dixioria fowleri*
Montane centipede	*Escaryus cryptorobius*
Whitetop Mountain centipede	*Escaryus orestes*
Rust glyph	*Glyphyalinia picea*
Maryland glyph	*Glyphyalinia raderi*
Talus coil	*Helicodiscus triodus*
A cave pseudoscorpion	*Kleptochthonius anophthalmus*
A cave pseudoscorpion	*Kleptochthonius regulus*
A cave pseudoscorpion	*Mundochthonius holsingeri*
A cave spider	*Nesticus mimus*
Black mantleslug	*Pallifera hemphilli*
Comb supercoil	*Paravitrea dentilla*
Barred supercoil	*Paravitrea seradens*
A millipede	*Pseudotremia alecto*
Ellett Valley Pseudotremia millipede	*Pseudotremia cavernarum*
A millipede	*Pseudotremia sublevis*
Spruce Knob threetooth	*Triodopsis picea*
Aquatic Mollusks	
Brook floater	*Alasmidonta varicosa*
Slippershell	*Alasmidonta viridis*
Spectacle case	*Cumberlandia monodonta*

Common Name	Scientific Name
Coal elimia	*Elimia aterina*
Snuffbox	*Epioblasma triquetra*
Appalachian springsnail	*Fontigens bottimeri*
Tennessee pigtoe	*Fusconaia barnesiana*
Atlantic pigtoe	*Fusconaia masoni*
Tennessee heelsplitter	*Lasmigona holstonia*
Green floater	*Lasmigona subviridis*
Slabside pearlymussel	*Lexingtonia dolabelloides*
Sheepnose	*Plethobasus cyphyus*
Pyramid pigtoe	*Pleurobema rubrum*
Fluted kidneyshell	*Ptychobranchus subtentum*
Purple liliput	*Toxolasma lividus*
Crustaceans	
Madison Cave isopod	*Antrolana lira*
Henrot's cave isopod	*Caecidotea henroti*
Incurved cave isopod	*Caecidotea incurva*
Vandel's cave isopod	*Caecidotea vandeli*
A crayfish	*Cambarus veteranus*
Rockbridge County cave amphipod	*Stygobromus baroodyi*
Burnsville Cove cave amphipod	*Stygobromus conradi*
Craig County cave amphipod	*Stygobromus estesi*
Montgomery County cave amphipod	*Stygobromus fergusoni*
Alleghany County cave amphipod	*Stygobromus hoffmani*
New Castle Murder Hole amphipod	*Stygobromus interitus*
Morrison's cave amphipod	*Stygobromus morrisoni*
Bath County cave amphipod	*Stygobromus mundus*
Luray Caverns amphipod	*Stygobromus pseudospinosus*
Aquatic Insects	
Spatulate snowfly	*Allocapnia simmonsi*
Cherokee clubtail	*Gomphus consanguis*
Green-faced clubtail	*Gomphus viridifrons*
Appalachian stonefly	*Hansonoperla appalachia*
Hoffman's Isonychia mayfly	*Isonychia hoffmani*
A mayfly	*Isonychia tusculanensis*
Appalachian snaketail	*Ophiogomphus incurvatus*
Holston sallfly	*Sweltsa holstonensis*
Other Aquatic Invertebrates	
None	
Tier III	
Fishes	
Bluestone sculpin	*Cottus sp. 1*
Clinch sculpin	*Cottus sp. 4*
Holston sculpin	*Cottus sp. 5*

Common Name	Scientific Name
Steelcolor shiner	*Cyprinella whipplei*
Bluebreast darter	*Etheostoma camurum*
Kanawha darter	*Etheostoma kanawhae*
Tippecanoe darter	*Etheostoma tippecanoe*
Wounded darter	*Etheostoma vulneratum*
Ohio lamprey	*Ichthyomyzon bdellium*
Mountain brook lamprey	*Ichthyomyzon greeleyi*
River redhorse	*Moxostoma carinatum*
Emerald shiner	*Notropis atherinoides*
Channel darter	*Percina copelandi*
Fatlips minnow	*Phenacobius crassilabrum*
Kanawha minnow	*Phenacobius teretulus*
Bigeye jumprock	*Scartomyzon ariommus*
Amphibians	
Mudpuppy	*Necturus maculosus*
Shenandoah Mountain salamander	*Plethodon virginia*
Reptiles	
Spotted turtle	*Clemmys guttata*
Eastern black kingsnake	*Lampropeltis getula nigra*
Smooth greensnake	*Opheodrys vernalis*
Eastern box turtle	*Terrapene carolina*
Birds	
Northern harrier	*Circus cyaneus*
Least bittern	*Ixobrychus exilis*
Black-crowned night-heron	*Nycticorax nycticorax*
Barn owl	*Tyto alba*
Mammals	
Eastern small-footed myotis	*Myotis leibii*
Terrestrial Insects	
Jefferson's short-nosed scorpionfly	*Brachypanorpa jeffersoni*
Pine barrens underwing	*Catocala herodias*
Riverbank tiger beetle	*Cicindela ancocisconensis*
Barrens tiger beetle	*Cicindela patruela*
Mottled duskywing	*Erynnis martialis*
A cave beetle	*Pseudanophthalmus pusio*
A cave springtail	*Pseudosinella granda*
A cave springtail	*Schaefferia hubbardi*
Other Terrestrial Invertebrates	
A cave spider	*Anthrobia mammouthia*
Scott County terrestrial cave isopod	*Ligidium elrodii scottensis*
Racovitza's terrestrial cave isopod	*Miktoniscus racovitzai*

Common Name	Scientific Name
McGraw Gap xystodesmid millipede	*Nannaria ericaea*
Rounded dome	*Ventridens lawae*
Five-tooth vertigo	*Vertigo ventricosa*
Aquatic Mollusks	
Elktoe	*Alasmidonta marginata*
Yellow lance	*Elliptio lanceolata*
Longsolid	*Fusconaia subrotunda*
Spiny riversnail	*Io fluvialis*
Yellow lampmussel	*Lampsilis cariosa*
Black sandshell	*Ligumia recta*
Ohio pigtoe	*Pleurobema cordatum*
Tennessee clubshell	*Pleurobema oviforme*
Brown walker	*Pomatiopsis cincinnatiensis*
Notched rainbow	*Villosa constricta*
Crustaceans	
Greenbrier Valley cave isopod	*Caecidotea holsingeri*
Southwestern Virginia cave isopod	*Caecidotea recurvata*
Tennessee Valley cave isopod	*Caecidotea richardsonae*
James Cave amphipod	*Stygobromus abditus*
Bigger's cave amphipod	*Stygobromus biggersi*
Shenandoah Valley cave amphipod	*Stygobromus gracilipes*
Aquatic Insects	
Spatterdock darner	*Aeshna mutata*
Illinois snowfly	*Allocapnia illinoensis*
Blue Ridge snowfly	*Allocapnia stannardi*
Dusky sallfly	*Alloperla biserrata*
A mayfly	*Baetisca rubescens*
Virginia springfly	*Diploperla morgani*
Mitchell needlefly	*Leuctra mitchellensis*
Widecollar stonefly	*Paragnetina ichusa*
Teays stonefly	*Perlesta teaysia*
Spiny salmonfly	*Pteronarcys comstocki*
Newfound willowfly	*Strophopteryx limata*
Highlands springfly	*Yugus arinus*
Other Aquatic Invertebrates	
None	
Tier IV	
Fishes	
American eel	*Anguilla rostrata*
Freshwater drum	*Aplodinotus grunniens*
Black sculpin	*Cottus baileyi*
Slimy sculpin	*Cottus cognatus*

Common Name	Scientific Name
Streamline chub	*Erimystax dissimilis*
Blotched chub	*Erimystax insignis*
Rainbow darter	*Etheostoma caeruleum*
Bluespar darter	*Etheostoma meadiae (stigmaeum)*
Riverweed darter	*Etheostoma podostemone*
Swannanoa darter	*Etheostoma swannanoa*
Banded darter	*Etheostoma zonale*
Northern studfish	*Fundulus catenatus*
Roanoke hog sucker	*Hypentelium roanokense*
Brook silverside	*Labidesthes sicculus*
American brook lamprey	*Lampetra appendix*
Mountain shiner	*Lythrurus lirus*
Pearl dace	*Margariscus margarita*
Ironcolor shiner	*Notropis chalybaeus*
New River shiner	*Notropis scabriceps*
Sawfin shiner	*Notropis sp. A*
Mirror shiner	*Notropis spectrunculus*
Sand shiner	*Notropis stramineus*
Mountain madtom	*Noturus eleutherus*
Stonecat	*Noturus flavus*
Tangerine darter	*Percina aurantiaca*
Logperch	*Percina caprodes*
Piedmont darter	*Percina crassa*
Gilt darter	*Percina evides*
Appalachia darter	*Percina gymnocephala*
Blackside darter	*Percina maculata*
Sharpnose darter	*Percina oxyrhynchus*
Dusky darter	*Percina sciera*
Stargazing minnow	*Phenacobius uranops*
Bullhead minnow	*Pimephales vigilax*
Sauger	*Stizostedion canadense*
Amphibians	
Jefferson salamander	*Ambystoma jeffersonianum*
Blue Ridge dusky salamander	*Desmognathus orestes*
Yonahlossee salamander	*Plethodon yonahlossee*
Eastern spadefoot	*Scaphiopus holbrookii*
Reptiles	
Spiny softshell	*Apalone spinifera*
Scarletsnake	*Cemophora coccinea*
Timber rattlesnake	*Crotalus horridus*
Northern map turtle	*Graptemys geographica*
Eastern hog-nosed snake	*Heterodon platirhinos*
Queen snake	*Regina septemvittata*
Stripe-necked musk turtle	*Sternotherus minor peltifer*
Common ribbonsnake	*Thamnophis sauritus*

Common Name	Scientific Name
Birds	
Grasshopper sparrow	*Ammodramus savannarum*
Green heron	*Butorides striatus*
Chuck-will's-widow	*Caprimulgus carolinensis*
Whip-poor-will	*Caprimulgus vociferus*
Brown creeper	*Certhia americana*
Chimney swift	*Chaetura pelagica*
Yellow-billed cuckoo	*Coccyzus americanus*
Northern bobwhite	*Colinus virginianus*
Eastern wood-pewee	*Contopus virens*
Prairie warbler	*Dendroica discolor*
Kirtland's warbler (migrant)	*Dendroica kirtlandii*
Yellow warbler	*Dendroica petechia*
Gray catbird	*Dumetella carolinensis*
Willow flycatcher	*Empidonax traillii*
Rusty blackbird (winter)	*Euphagus carolinus*
Worm-eating warbler	*Helmitheros vermivorus*
Wood thrush	*Hylocichla mustelina*
Yellow-breasted chat	*Icteria virens*
Black-and-white warbler	*Mniotilta varia*
Kentucky warbler	*Oporornis formosus*
Northern parula	*Parula americana*
Rose-breasted grosbeak	*Pheuctitus ludovicianus*
Eastern towhee	*Pipilo erythrophthalmus*
Scarlet tanager	*Piranga olivacea*
Prothonotary warbler	*Protonotaria citrea*
Virginia rail	*Rallus limicola*
American woodcock	*Scolopax minor*
Ovenbird	*Seiurus aurocapillus*
Louisiana waterthrush	*Seiurus motacilla*
Brown-headed nuthatch	*Sitta pusilla*
Field sparrow	*Spizella pusilla*
Northern rough-winged swallow	*Stelgidopteryx serripennis*
Eastern meadowlark	*Sturnella magna*
Brown thrasher	*Toxostoma rufum*
Eastern kingbird	*Tyrannus tyrannus*
Yellow-throated vireo	*Vireo flavifrons*
Canada warbler	*Wilsonia canadensis*
Mammals	
Least weasel	*Mustela nivalis*
Allegheny woodrat	*Neotoma magister*
Long-tailed shrew	*Sorex dispar*
Eastern spotted skunk	*Spilogale putorius*
Appalachian cottontail	*Sylvilagus obscurus*
Terrestrial Insects	

Common Name	Scientific Name
A tiger beetle	*Cicindela formosa generosa*
Pink-edged sulphur	*Colias interior*
Milne's Euchlaena moth	*Euchlaena milnei*
Diana fritillary	*Speyeria diana*
A noctuid moth	*Zale curema*
Other Terrestrial Invertebrates	
Black Mountain disc	*Discus nigrimontanus*
Lowland pillsnail	*Euchemotrema leai*
Brilliant glyph	*Glyphyalinia praecox*
Twilight coil	*Helicodiscus multidens*
Temperate coil	*Helicodiscus shimeki*
Widespread column	*Pupilla muscorum*
A millipede	*Rudiloria trimaculata tortua*
Trumpet Vallonia	*Vallonia parvula*
Aquatic Mollusks	
Triangle floater	*Alasmidonta undulata*
Carolina lance mussel	*Elliptio angustata*
Elephant ear	*Elliptio crassidens*
Northern lance mussel	*Elliptio fisheriana*
Dusky Fossaria	*Fossaria dalli*
Pocketbook mussel	*Lampsilis ovata*
Fragile papershell	*Leptodea fragilis*
Seep mudalia	*Leptoxis delatata*
Onyx rocksnail	*Leptoxis praerosa*
Cumberland moccasin	*Medionidus conradicus*
Pagoda hornsnail	*Pleurocera uncialis*
Pimple back	*Quadrula pustulosa pustulosa*
Creeper	*Strophitus undulatus*
Pistolgrip	*Tritogonia verrucosa*
Deertoe	*Truncilla truncata*
Three-ridge valvata	*Valvata tricarinata*
Mountain creekshell mussel	*Villosa vanuxemensis*
Crustaceans	
Price's cave isopod	*Caecidotea pricei*
New River riffle crayfish	*Cambaras chasmodactylus*
A crayfish	*Cambaras longirostris*
Monongahela crayfish	*Cambaras monongalensis*
Scioto crayfish	*Cambaras sciotensis*
Clinch River crayfish	*Cambarus angularis*
A crayfish	*Orconectes erichsonianus*
Sturgeon crayfish	*Orconectes forceps*
Southwestern Virginia cave amphipod	*Stygobromus mackini*
Aquatic Insects	

Common Name	Scientific Name
Tufted sallfly	*Alloperla banksi*
Allegheny mayfly	*Ameletus cryptostimulus*
Sable clubtail	*Gomphus rogersi*
Other Aquatic Invertebrates	
None	

7.3. Terrestrial and Wetland Species in the Ridge and Valley

7.3.1. Tier I Species in the Ridge and Valley

7.3.1.1. Wood turtle, *Glyptemys insculpta*

Life History Summary

The wood turtle is known from the Potomac drainage across northern Virginia, including the Coastal Plain, Piedmont, Blue Ridge, and Ridge and Valley ecoregions (Mitchell 1994). It requires clear streams and an adjacent terrestrial habitat (often fields, sometimes forests), because the turtle spends part of each year in each habitat (Mitchell 1994). The wood turtle is omnivorous, consuming a variety of vegetation and invertebrate prey, and occasionally vertebrates as well (Mitchell 1994). The wood turtle is legally protected, with the status of State threatened. While its correct accepted generic name is *Glyptemys*, this species is still listed as *Clemmys insculpta* in the Virginia Administrative Code (4 VAC 15-20-130). According to VA-GAP (DGIF 2004a), 7% of its statewide predicted potential habitat is protected.

Location

The map of wood turtle habitat (Figure 7.5) includes confirmed locations from Collections (DGIF 2004b) and potential reaches. Reaches were selected based on DGIF's aquatic habitat classification, where attributes were link magnitude, reach elevation, and gradient. Percentage of undeveloped landcover (USGS 1992) was used in reach selection. For more details, see Appendix D.

Description of Habitat Requirements

The wood turtle uses riparian areas and streams in Frederick, Shenandoah, Loudoun, Fairfax and northern Rockingham counties (M. J. Pinder, DGIF, pers. comm.). It is found primarily in and near clear brooks and streams in deciduous woodlands in Virginia, but has been found in woodland bogs and marshy fields at more northern sites. It seems to use variable habitats, as long as some critical aquatic and terrestrial components are present. In all cases, it has been found utilizing wet and/or marshy meadows associated with floodplains. Although highly terrestrial, wood turtles must remain in moist habitats (Mitchell 1994).

We also examined the aquatic habitat types that the wood turtle was most closely associated with in the Potomac drainage of the Ridge and Valley ecoregion (Ridge and Valley-Potomac EDU). The wood turtle was associated near or within a wide variety of stream types (Table 7.3). This association does not mean that they regularly used this type. It simply indicates that at the time of collection they were located near this habitat. Of all occurrences, 52% were near or in very low to moderate gradient small streams.

Relative Condition of Habitat

There are 82 known wood turtle locations in Collections within the Ridge and Valley (113 statewide, DGIF 2004b). Twenty of the 83 locations are within a Conservation Land, primarily National Forest lands (DCR 2003; DGIF 2004b). Approximately 10% of the potential reaches are within a Conservation Land (DCR

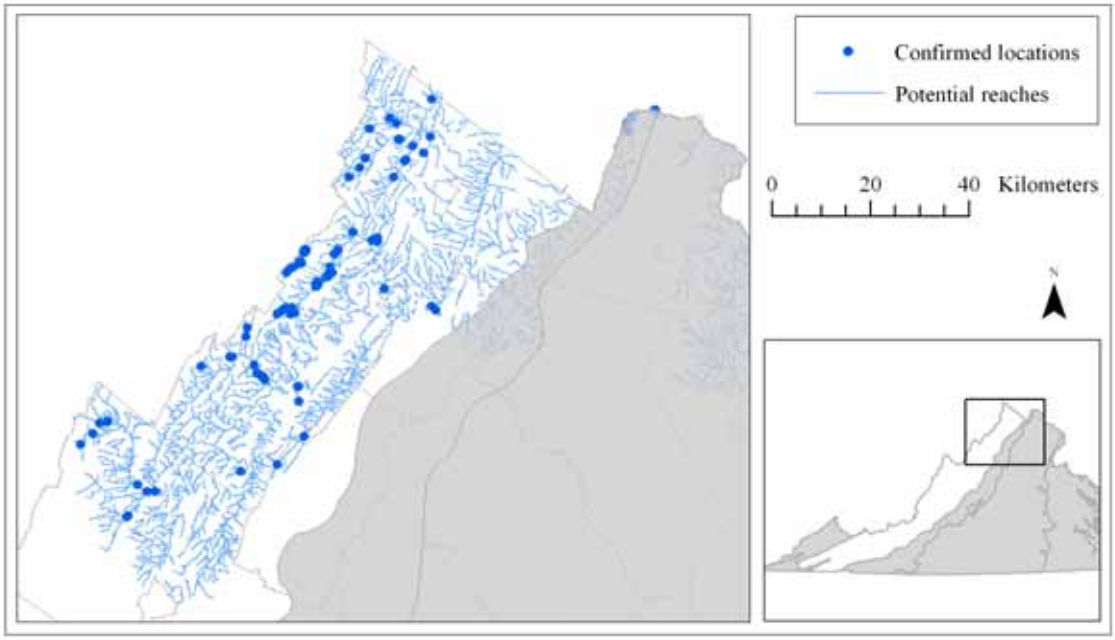

Figure 7.5. Distribution of the wood turtle in the Ridge and Valley.

Table 7.3. DGIF aquatic habitat types used by the wood turtle in the Ridge and Valley.

Aquatic Habitat Type	Number of Reaches
Low gradient small stream connected to another small stream	14
Very low gradient small stream connected to another small stream	7
Moderate gradient small stream connected to another small stream	5
Moderate gradient headwater stream connected to another headwater stream	5
High gradient headwater stream connected to another headwater stream	4
Moderate gradient headwater stream connected to a small stream	2
Very low gradient small stream connected to a large stream	2
Very low gradient large stream connected to another large stream	2
Low gradient headwater stream connected to another headwater stream	1
Very low gradient headwater stream connected to a small stream	1
High gradient headwater stream connected to a small stream	1
Moderate gradient headwater stream connected to a large stream	1
Moderate gradient headwater stream connected to a small river	1
High gradient small stream connected to another small stream	1
Low gradient small stream connected to a large stream	1
Low gradient large stream connected to another large stream	1
Very low gradient small river connected to another small river	1

2003). There are seven DCR-NH Conservation Sites with known wood turtle populations, one protected within a Conservation Land (DCR-NH 2005). Of these Conservation Sites, two have site viability ratings of "Good" and two of "Fair" (DCR-NH 2005). The other occurrences have not been rated.

Approximately half of the confirmed stream habitat for the wood turtle is impaired (DEQ and DCR 2004). The primay causes for impairment were fecal coliform from non-point sources (unknown, agriculture, or wildlife), general standard (benthics) from atmospheric deposition or unknown sources, and temperature violations from natural conditions.

Specific Threats and Trends

The main threats to the wood turtle in Virginia are the illegal pet trade and habitat destruction, particularly as related to riparian zones and effects of siltation from construction (Mitchell 1994), forestry (Herpetofauna TAC 2004), and bank stabilization (NESWDTC 2004) (Table 7.4).

The wood turtle is declining across much of its range (Ernst et al. 1994), though specific trend information is not available and would be difficult to acquire.

Table 7.4. Species-specific stresses on the wood turtle (Herpetofauna TAC 2004). For additional stresses on the wood turtle, please see Appendix H.

Stress	Source of Stress	Scope	Severity	Comments
Intentional take	Economic use of species	3	4	Pet trade
Shoreline alteration	Forestry	2	3	Forestry practices

Conservation Actions and Strategies

Necessary species-specific actions include better enforcement and prosecution of capture laws (wood turtle is protected from all unpermitted take by virtue of its State threatened status) (Herpetofauna TAC 2004). In addition, USFS should be engaged in revising forestry practices in areas inhabited by the wood turtle, and recreational activities should be restricted in these areas (Herpetofauna TAC 2004).

Research and Monitoring Needs

Like many reptiles, the basic life history and distribution of the wood turtle is poorly known. As such, research and monitoring needs include surveys to determine overall wood turtle distribution in Virginia; studies on wood turtle life history; and demographic studies, including population connectivity and gene flow (Herpetofauna TAC 2004; NESWDTC 2004).

7.3.1.2. Northern pinesnake, *Pituophis melanoleucus*

Life History Summary

Little is known about this snake, despite its large size, and both Mitchell (1991) and Tobey (1979) list it as "status undetermined" in Virginia. It occurs in both the Ridge and Valley and the Blue Ridge, where it consumes birds, eggs and small mammals (Mitchell 1994). It seems to prefer dry, open habitats, often on ridgetops or slopes, where it constructs burrows and is very rarely seen (Mitchell 1994). Known predators include common mammalian mesocarnivores, such as raccoon *Procyon lotor* and striped skunk *Mephitis mephitis*, and short-tailed shrews *Blarina brevicauda*. According to VA-GAP (DGIF 2004a), 54% of its limited statewide predicted potential habitat is protected.

Location

The habitat characteristics assumed important for the northern pinesnake cannot be mapped, so the habitat map (Figure 7.6) includes only confirmed locations from Collections (DGIF 2004b).

Description of Habitat Requirements

There is limited knowledge of habitat use in mountain populations. Likely essential habitat includes talus slopes in which they can dig nest sites and burrows (J. C. Mitchell, UR, pers. comm.).

Relative Condition of Habitat

Due to lack of knowledge about habitat requirements, it is difficult to assess the relative condition of habitat. There are four known observations from Collections within the Ridge and Valley, six statewide (DGIF 2004b). Three of these locations are within the George Washington and Jefferson National Forests.

Specific Threats and Trends

Status of this species is completely unknown in Virginia, so specific threats are unknown. Since a viable population has not been discovered in Virginia, no trends are available. Threats have been identified for the Mountain Forest habitat group containing the pinesnake (Herpetofauna 2004, Appendix H).

Conservation Actions and Strategies

Status of this species is completely unknown in Virginia. It may be extremely rare, or simply rarely encountered. Therefore, apart from the research and monitoring needs listed below, no conservation actions are known at this time.

Research and Monitoring Needs

A radio-tracking study should be instituted using the next available live individual, as that may be the only way to get any information on this species (J. C. Mitchell, UR, pers. comm.). Overall, location of a viable population to study is necessary before additional needs can be determined (Mitchell 1994).

7.3.1.3. Henslow's sparrow, *Ammodramus henslowii*

Life History Summary

Henslow's sparrow occurs locally in the Ridge and Valley. In this region, Henslow's sparrow uses dry to wet fields with dense vegetation but no woody plants, such as early-successional old fields (Brindza 1991; Rosenberg 2003; Herkert et al. 2002). During the breeding season, Henslow's sparrow eats mostly crickets,

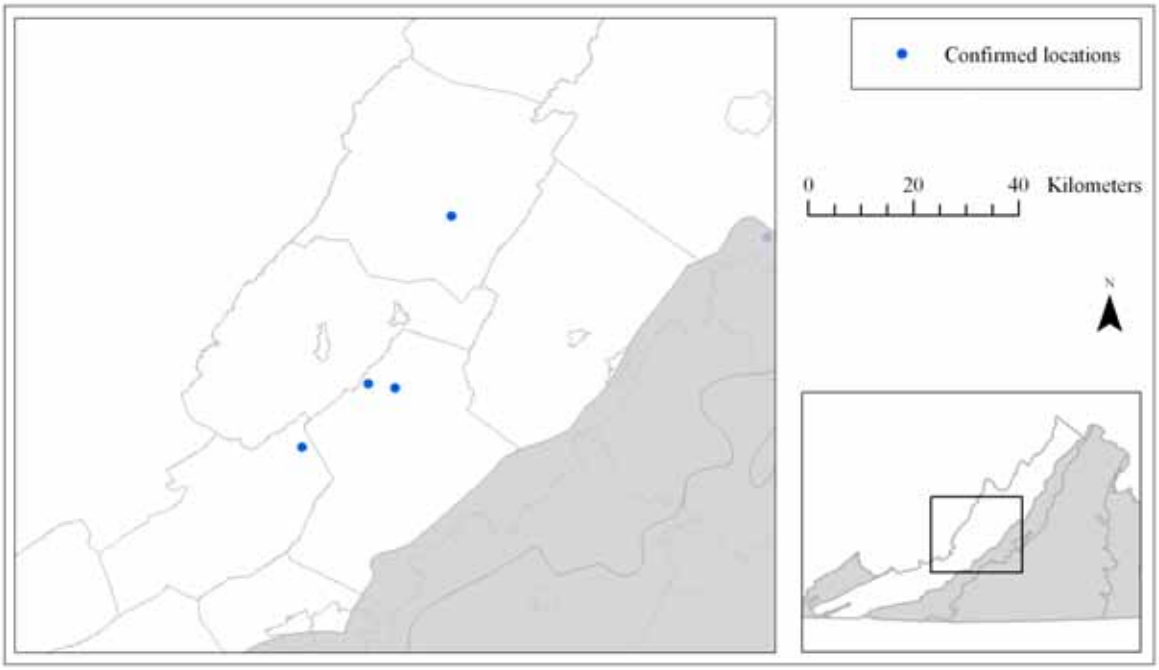

Figure 7.6. Distribution of the northern pinesnake in the Ridge and Valley.

grasshoppers and beetles (Brindza 1991; Herkert et al. 2002). Important threats to this bird in the Ridge and Valley include loss of habitat to exotic plants and habitat conversion to residential or industrial uses (Brindza 1991; Herkert et al. 2002). Henslow's sparrow is legally protected in Virginia, both under MBTA and with the status of State threatened. According to VA-GAP (DGIF 2004a), 12% of its statewide predicted potential habitat is protected.

Location

Because this species' habitat is too specific to be mapped, we have only displayed confirmed locations from Collections (DGIF 2004b, Figure 7.7).

Description of Habitat Requirements

Similar to its occurrences in the Piedmont, essential habitat for populations of Henslow's sparrows in the Ridge and Valley includes large grassland patches (>40ha) with high litter depth, low forb cover and low bare ground exposure. This species prefers grassland with infrequent disturbance, and dense tall grass (up to 80cm tall) (Swanson 1996; J. L. Cooper, DGIF, pers. comm.).

Relative Condition of Habitat

Large patches of grassland habitat are rare in the Ridge and Valley. There are two known observations locations in Collections (ten statewide, DGIF 2004b). Both of these locations occur within Radford Army Ammunition Plant (RAAP), a Conservation Land (DCR 2003). A DCR-NH Conservation Site covers 900ha of Henslow's sparrow habitat on RAAP. This site, encompassing the two Collections locations, has a viability rating of "Fair" (DCR-NH 2005).

Specific Threats and Trends

Henslow's sparrow has suffered a range-wide decline of > 50% over the last 30 years (Rich et al. 2004). Within the PIF Mid-Atlantic Ridge and Valley (physiographic area 12), Rosenberg (2003) reports a similar trend, with a current population of approximately 200 pairs. Within Virginia, both Rosenberg (2004) and

Figure 7.7. Distribution of Henslow's sparrow in the Ridge and Valley.

Bird TAC (2004) report the same trend. Bird TAC (2004) presume a very low statewide population, perhaps as low as < 50 individuals.

While no species-specific stresses have been identified for Henslow's sparrow (Bird TAC 2004), its grassland habitat is under many stresses, as outlined in Appendix H. In fact, Herkert et al. (2002) report that "loss of suitable habitat (is) probably (the) major threat to Henslow's sparrow (p. 15)."

Conservation Actions and Strategies

While no species-specific conservation actions were proposed by Bird TAC (2004), many habitat actions were listed, and appear in Appendix I. All involve the restoration and protection of its grassland habitat. Herkert et al. (2002) and Kearney (2003) point out that CRP and similar programs are likely to benefit an entire suite of grassland birds like Henslow's sparrow. One potential source of habitat in this ecoregion is reclaimed surface coal mines, which have been shown to harbor breeding Henslow's sparrows in the Midwest (Bajema et al. 2001).

Research and Monitoring Needs

No species-specific research or monitoring needs were identified by Bird TAC (2004) for Henslow's sparrow in Virginia. Targeted surveys for this species should be conducted, though they are probably not adequately detected by many standard survey methods, so new protocols may need to be designed (NESWDTC 2004). Herkert et al. (2002) report that, like many secretive grassland birds, little is known about the natural history of Henslow's sparrow, such as reproductive success and effort. In addition, while abundance related to habitat management has been studied, the relationship of reproductive success to various management regimes has not been (Herkert et al. 2002).

7.3.1.4. Upland sandpiper, *Bartramia longicauda*

Life History Summary

The upland sandpiper is a grassland bird, occurring in the northern portions of the Piedmont and Ridge and Valley. It prefers grasslands such as hayfields, with an herbaceous layer of medium height (Bazuin 1991). It also uses short grass areas, such as grazed fields and the mowed expanses around airports (Houston and Bowen 2001). Its main food is invertebrates, with a small number of seeds taken as well (Houston and Bowen 2001). Important threats include habitat conversion to residential or industrial uses and the natural succession of old field/hayfield habitats to forest with the decline of small farms (Bazuin 1991). The upland sandpiper is legally protected, both under MBTA and with the status of State threatened. According to VA-GAP (DGIF 2004a), 3% of its statewide predicted potential habitat is protected.

Location

Because of the ephemeral nature of this species' habitat, a map of its essential habitat is not appropriate. Therefore in the species map (Figure 7.8) only Collections (from the breeding season) are shown (DGIF 2004b).

Description of Habitat Requirements

Key habitat for the upland sandpiper includes medium to large grasslands (>20ha) where grassland vegetation typically is short (15-35cm), sparse, and located in dry soil conditions. Upland sandpipers will occasionally nest in moist soil situations. This species prefers disturbed grassland with either high fire frequency or moderate grazing and almost always avoids tall (>40cm) undisturbed grasslands. The upland sandpiper will use agricultural fields (oats and wheat) as well as managed grasslands (hayfields, airports, pastures) (Swanson 1996; M. D. Wilson, CCB, pers. comm.; J. L. Cooper, DGIF, pers. comm.).

Relative Condition of Habitat

There are six known locations for the upland sandpiper in the Ridge and Valley (DGIF 2004b). None of these locations is within a protected area.

Specific Threats and Trends

While there exist no known, species-specific stresses for the upland sandpiper in Virginia, it shares stresses with other grassland birds (Appendix H).

Bird TAC (2004) estimate that the current population of upland sandpipers in Virginia is fewer than 20 individuals. Trends for the upland sandpiper (range-wide) for the last 30 years of the BBS are unknown (Kearney 2003). M. D. Wilson (CCB, pers. comm.) reports that the upland sandpiper has declined over 50% in Virginia during the same period, while Rosenberg (2004) reports that "population numbers are unavailable at this time" for this species in Virginia.

Conservation Actions and Strategies

While there exist no species-specific conservation actions for the upland sandpiper in Virginia, it shares those of other grassland birds (Appendix I). Houston and Bowen (2001) provide an excellent summary of conservation actions that have been proposed and undertaken in different parts of the upland sandpiper's range. Many of these will be found in Appendix I, and focus on grassland management, including a restoration of historic fire regimes, and preservation and restoration of native grasses (Houston and Bowen 2001).

Research and Monitoring Needs

Houston and Bowen (2001) provide an excellent synopsis for research needs on the upland sandpiper, including mortality causes and rates on its South American wintering grounds. In addition, little is known about basic demography, reproductive success, or survivorship in this species (Houston and Bowen 2001). In Virginia and other eastern states, the species' usage of airports and other grasslands, including bird

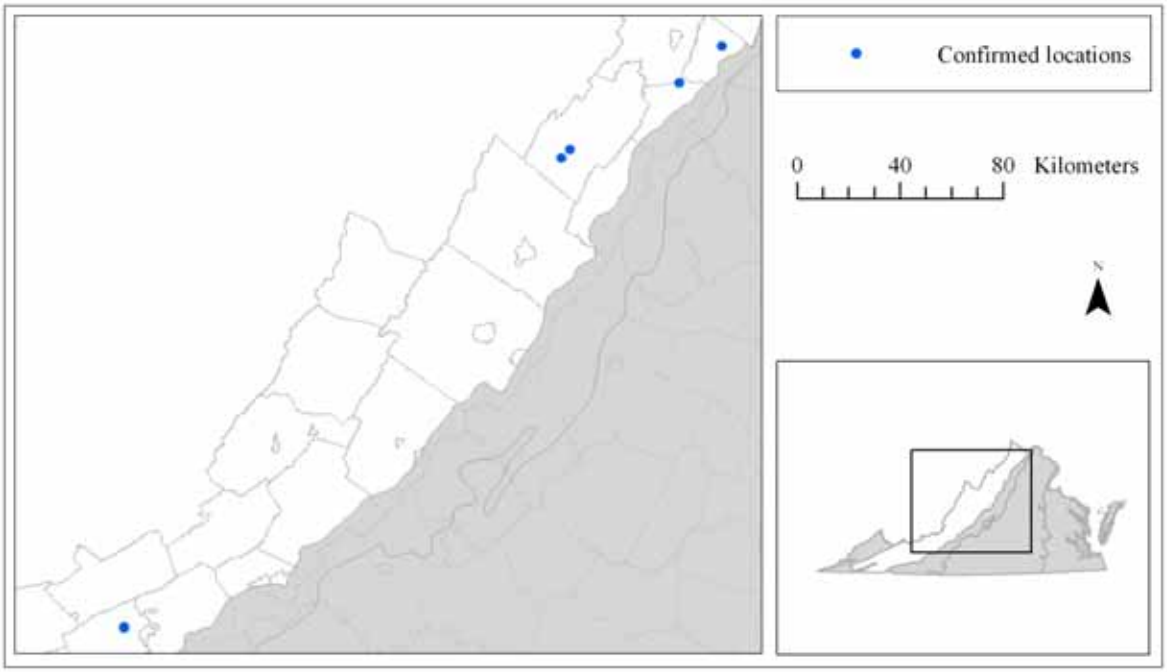

Figure 7.8. Distribution of the upland sandpiper in the Ridge and Valley.

densities and breeding success related to differing management regimes, should be investigated (Houston and Bowen 2001). Surveys should use a standardized protocol and be regionally coordinated (NESWDTC 2004). Overall, this is a poorly-known species, and most aspects of its life history should be investigated.

7.3.1.5. Peregrine falcon, *Falco peregrinus*

Life History Summary

The peregrine falcon occurs most frequently in the Coastal Plain, but it is regularly observed statewide. In the Ridge and Valley, its main nesting habitat is (or will be) cliff faces. They occur year-round in Virginia (Watts 1999). This falcon eats mainly birds, ranging in size from hummingbirds to sandhill cranes (White et al. 2002), but focusing on prey 100-500g (Johnsgard 1990). Young falcons are removed from nests in the Coastal Plain and "hacked," or transplanted, to areas in the mountains, with the hope that these birds will return to their historic mountain range. Peregrine falcon is legally protected, both under MBTA and with the status of State threatened. According to VA-GAP (DGIF 2004a), 20% of its statewide predicted potential habitat is protected.

Location

The map of peregrine falcon habitat (Figure 7.9) includes cliffs mapped during DGIF aerial surveys (Reynolds 2003). No confirmed nesting has occurred in the Ridge and Valley.

Description of Habitat Requirements

Nest sites for this species are typically located on ledge or shelf on cliff faces (J. L. Cooper, DGIF, pers. comm.). Analysis of 15 historic Virginia eyries revealed that all nests were located on sedimentary rock facing southwest or northeast, 402m from flowing water (Gabler 1983).
Relative Condition of Habitat

There are nine potential nest cliffs within the Ridge and Valley ecoregion, four of which are historic nest sites (Reynolds 2003). Six of these potential nest sites are within a Conservation Land, half in the National

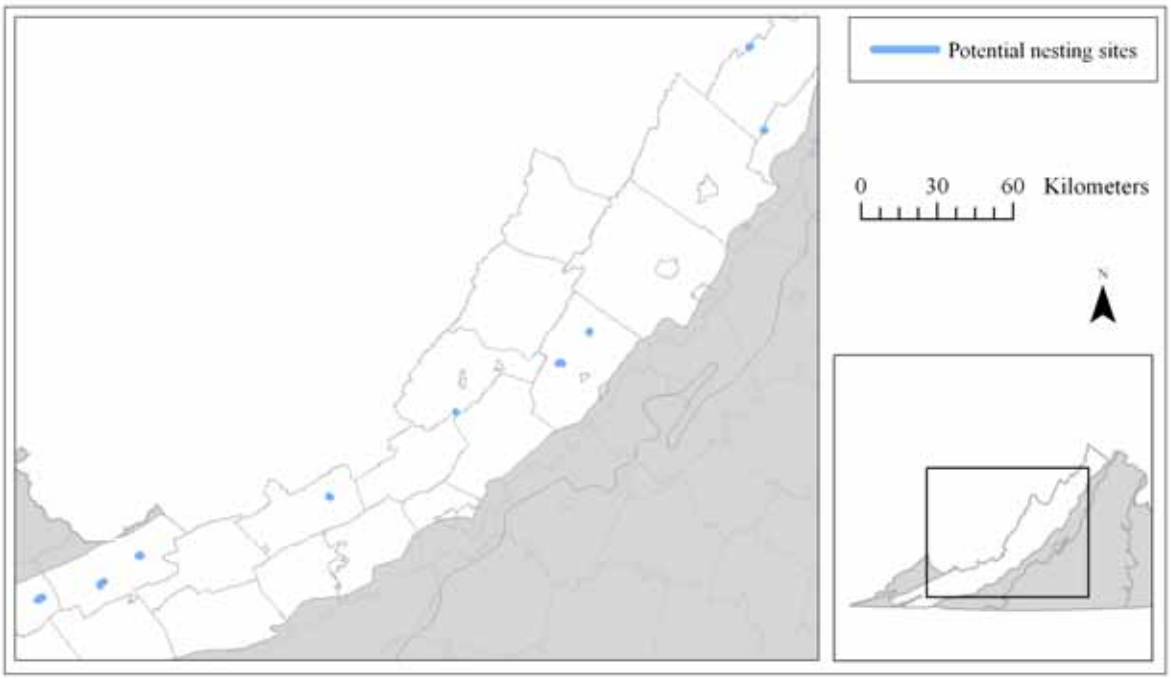

Figure 7.9. Potential peregrine falcon distribution in the Ridge and Valley.

Forest and half on VOF conservation easements (DCR 2003). There appears to be adequate nesting habitat to support breeding birds in Virginia's Ridge and Valley; however, further and more detailed surveys need to be conducted at specified sites (Reynolds 2003).

Specific Threats and Trends

The peregrine falcon is recovering range-wide since the pesticide DDT was banned in the U.S. (Johnsgard 1990; Rich et al. 2004). In Virginia, the breeding population is small but undergoing active management.

Conservation Actions and Strategies

Bird TAC (2004) reported a goal of population maintenance in the Coastal Plain while increasing the population in the mountains (including the Ridge and Valley) of Virginia. Reduction of organochlorine pesticide contamination is important in continuing the peregrine's recovery (White et al. 2002). Protection of nesting areas from disturbance and destruction is important (White et al. 2002). A thorough treatment of needed conservation actions is given in USFWS (1987).

Research and Monitoring Needs

Little is known of nesting populations and success in the mountain population (R. J. Reynolds, DGIF, pers. comm.). An aerial mountain survey of 23 nests found no nesting pairs, but identified key sites that are in need of additional surveying and could be potential hack sites (Reynolds 2003). Specific sublethal effects of toxins on peregrines are poorly known (Bird TAC 2004). Monitoring of the recovery of all populations and the dynamics of these recovering populations should be continued (White et al. 2002).

7.3.1.6. Loggerhead shrike, *Lanius ludovicianus*

Life History Summary

The loggerhead shrike occurs most frequently in Virginia in the Blue Ridge Mountains and Ridge and Valley (Fraser 1991). It occurs year-round in Virginia (Yosef 1996). It prefers open habitats with occasional shrubs, such as large grazed pastures (Fraser 1991). The loggerhead is a predator, taking mostly invertebrates but also some vertebrate prey, such as lizards, birds or rodents (Yosef 1996). It is well known for its habit of impaling its prey on spines of vegetation or barbed wire. Important threats include conversion from pasture to other uses and excessive use of pesticides (Fraser 1991; Yosef 1996). The loggerhead shrike is legally protected, both under MBTA and with the status of State threatened. According to VA-GAP (DGIF 2004a), 14% of its statewide predicted potential habitat is protected.

Location

Loggerhead shrike habitat in this part of the state is ephemeral and cannot be accurately mapped, so the map (Figure 7.10) includes confirmed locations from the breeding season (DGIF 2004b) and Conservation Sites (DCR-NH 2005).

Description of Habitat Requirements

Essential habitat for the loggerhead shrike includes open fields with scattered shrubs, small trees and/or hedges (DeGraff and Rappole 1995). In Virginia, the highest-quality breeding habitat consists of short grass, particularly active pastures with many perches (Luukkonen 1987).

Relative Condition of Habitat

Due to the ephemeral nature of habitat for this shrike, it is difficult to determine the total area and the status of available habitat. There are 98 Collections locations in the Ridge and Valley (DGIF 2004b). Only one of these locations is protected, in this case by a VOF easement (DCR 2003). This lack of protection is due to

the low amount of open habitat protected within Conservation Lands in this ecoregion. There are three DCR-NH Conservation Sites covering approximately 280ha (DCR-NH 2005). None of these sites is within a Conservation Land. One of the elements within the Conservation Sites has a viability rank of "Fair;" the others are not rated (DCR-NH 2005).

Specific Threats and Trends

The loggerhead shrike has declined > 50% over the last 30 years range-wide (Rich et al. 2004). The same trend appears to hold for the PIF Mid-Atlantic Ridge and Valley (Rosenberg 2003), and Rosenberg (2004) and Bird TAC (2004) report a similar trend in Virginia. A decline of 87% in the northeast (which includes Virginia) is reported by NESWDTC (2004). Bird TAC (2004) reports that the population levels of this species are unknown in Virginia, but could be as low as < 100 individuals.

The reasons for the decline of the loggerhead shrike range-wide are unclear (Bird TAC 2004; Yosef 1996). However, threats to its preferred habitat are great, and enumerated in Appendix H. Yosef (1996) reports that the decline of this species corresponded with the increase in organochlorine pesticide use, and these substances are found in the birds in high concentrations. However, the decline also seems to correspond with the decline of pasturelands across its range, though birds do not seem to be habitat-limited in Virginia (that is, habitat exists that is not utilized by shrikes, Bird TAC 2004).

Conservation Actions and Strategies

The primary, species-specific action necessary for loggerhead shrike conservation in Virginia is a concerted, targeted survey effort to determine distribution of the species within the state (Bird TAC 2004) and throughout its breeding range in the northeast U.S. (NESWDTC 2004). This could include following the success of every individual nest (NESWDTC 2004). Other conservation actions are habitat-related. These can be found in Appendix I and generally involve grassland management. Yosef (1996) points out that mid-successional grasslands are often overlooked in habitat restoration in favor of grasslands without the shrubby vegetation that shrikes require for nesting and perching.

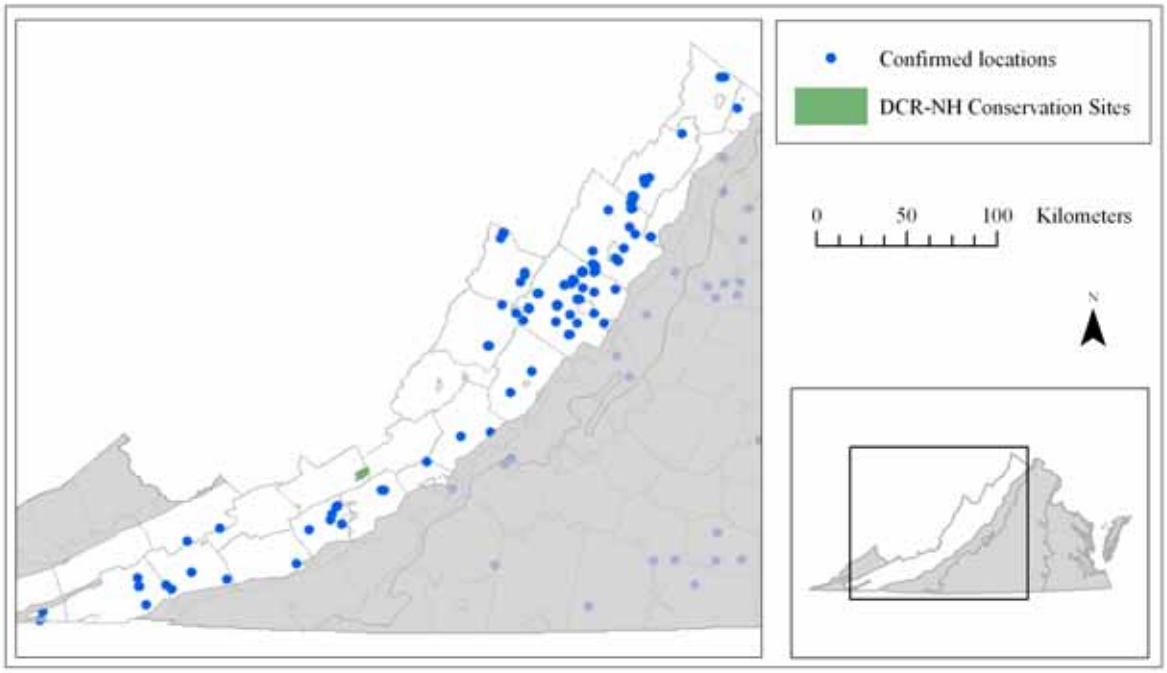

Figure 7.10. Distribution of the loggerhead shrike in the Ridge and Valley.

Research and Monitoring Needs

Little is known about historical distribution of the loggerhead shrike in Virginia, and such information would be useful if compiled (Bird TAC 2004). In addition, due to its spotty distribution across the state, targeted surveys should be considered to determine its true distribution and habitat usage across Virginia (Bird TAC 2004). The causes for the species' decline, both in Virginia and throughout its range, are unclear and need further research (Yosef 1996; Bird TAC 2004). Certainly, the role of pesticides in the decline of this species needs to be better understood.

7.3.1.7. Appalachian yellow-bellied sapsucker, *Sphyrapicus varius appalachiensis*

Life History Summary

The yellow-bellied sapsucker is a common winter bird in Virginia but rare in summer, breeding only in high-elevation, early- to mid-successional deciduous and mixed forests. Its food consists largely of sap, but it also consumes arthropods and fruits (Walters et al. 2002). Potential threats to this species include acid precipitation, overbrowsing by deer, and global climate change. Appalachian yellow-bellied sapsucker is legally protected under MBTA. According to VA-GAP (DGIF 2004a), 12% of its statewide predicted potential habitat is protected.

Location

The map of habitat for this subspecies (Figure 7.11) includes confirmed locations from the breeding season (DGIF 2004b) and potential habitat based on landcover data (USGS 1992) and elevation data (USGS 2003). For more details on potential habitat mapping, see Appendix D.

Description of Habitat Requirements

This species requires very high altitude mixed forest with standing dead or live decaying trees (DeGraaf and Rappole 1995). More specific habitat parameters include forests above 3000ft (914m) in elevation and below 37.5° latitude (M. D. Wilson, CCB, pers. comm.).

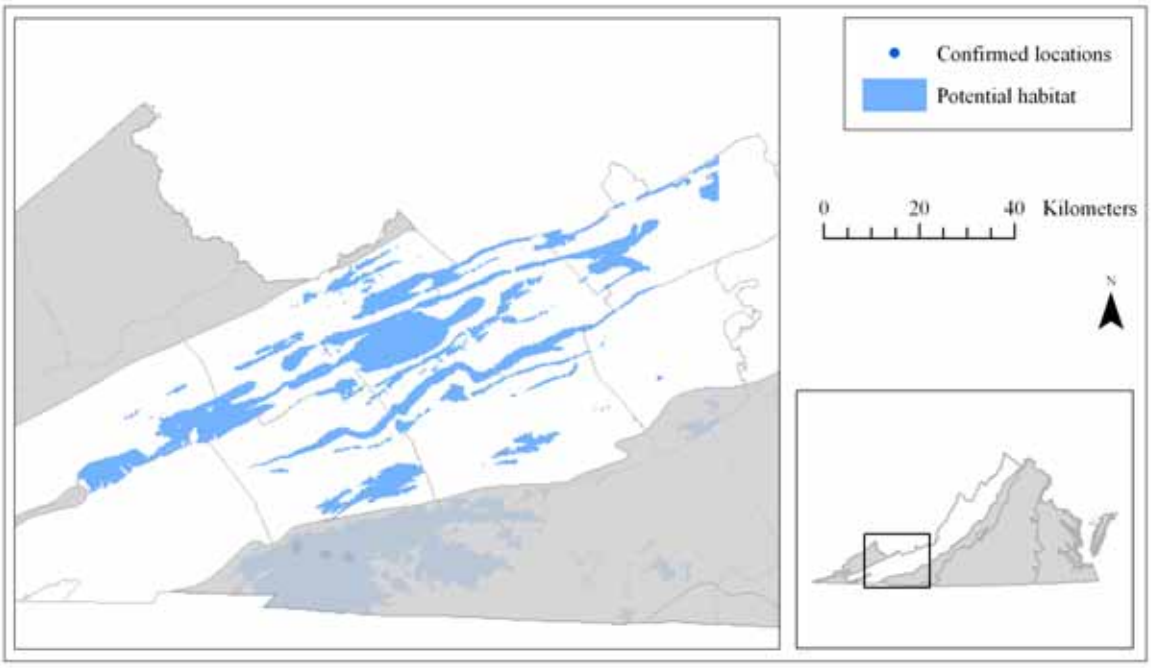

Figure 7.11. Distribution of Appalachian yellow-bellied sapsucker in the Ridge and Valley.

Relative Condition of Habitat

There are no known Collections locations (eight statewide) or Conservation Sites for this subspecies in the Ridge and Valley (DGIF 2004b; DCR-NH 2005). There are slightly less than 90,000ha of potential habitat, almost 40,000 of which are protected by a Conservation Land (DCR 2003). Most of the protected habitat occurs in National Forest land, but also includes Clinch Mountain, Hidden Valley, and Big Survey WMAs.

Specific Threats and Trends

Trends and population size are unknown for this subspecies, but there are possibly fewer than 100 individuals in the state (Bird TAC 2004). While there exist no known, species-specific stresses for the Appalachian yellow-bellied sapsucker in Virginia, it shares stresses with other birds of high-elevation deciduous forests (Appendix H). This species seems to be somewhat susceptible to collisions with stationary objects (such as buildings or communications towers) during migration (Walters et al. 2002).

Conservation Actions and Strategies

While there exist no species-specific conservation actions for the Appalachian yellow-bellied sapsucker in Virginia, it shares those of the rest of other high-elevation deciduous forest birds (Appendix I).

Research and Monitoring Needs

Dispersal of young and migratory routes are not well-known (Walters et al. 2002). The role of sapsuckers in forest ecology should be studied (Walters et al. 2002). Bird TAC (2004) reports that more inventory is needed for this species.

7.3.1.8. Appalachian Bewick's wren, *Thryomanes bewickii altus*

Life History Summary

The Appalachian Bewick's wren has become a very rare bird in the mountains of Virginia; in fact, it may be extirpated (Rosenberg 2003). It was fairly common in the era between deforestation and reforestation, peaking around the 1930s. Its habitat in Virginia is brushy, high-altitude areas, where it was common around farmsteads, utilizing fencerows, brushpiles, and snags, while nesting in and among outbuildings (Adkisson 1991). It builds its nest in a cavity or on a ledge. Like all wrens, its primary foods are arthropods (Kennedy and White 1997). Important threats are unclear, though reversion of landcover to forest has undoubtedly played a part in this species' decline (Adkisson 1991). In addition, range expansion by house wren *Troglodytes aedon* may have contributed to the decline (Kennedy and White 1997), though Bewick's wren has been observed nesting near both house and Carolina wrens *Thryothorus ludovicianus* without apparent interspecific aggression (Adkisson 1991). Competition with exotic house sparrow *Passer domesticus* and European starling *Sturnus vulgaris* may also have contributed to the decline of Bewick's wren in the east (Adkisson 1991; Kennedy and White 1997). Appalachian Bewick's wren is legally protected under MBTA and with the status of State endangered. According to VA-GAP (DGIF 2004a), 2% of its statewide predicted potential habitat is protected.

Location

Because the habitat requirements for this species are ephemeral and cannot be mapped accurately, the map (Figure 7.12) includes confirmed locations from the breeding season (DGIF 2004b) and a Conservation Site (DCR-NH 2005).

Description of Habitat Requirements

This species only occurs at high elevation, in farmyards or overgrown fields with tree cavities or abandoned buildings (NatureServe 2004).

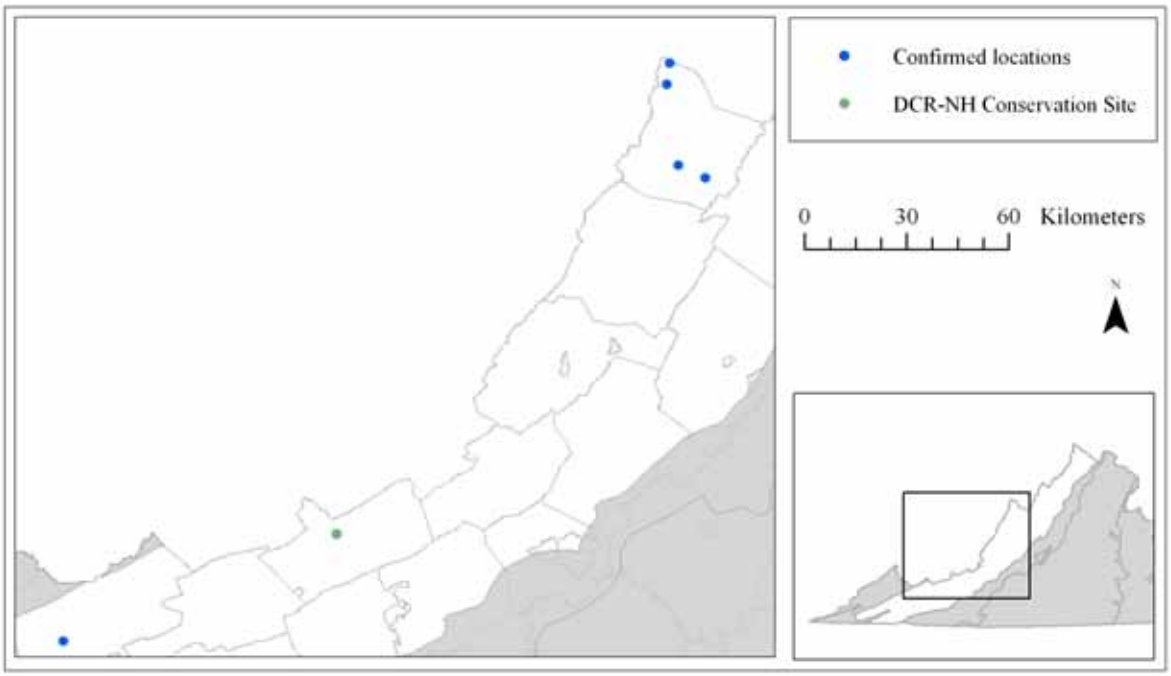

Figure 7.12. Distribution of the Appalachian Bewick's wren in the Ridge and Valley.

Relative Condition of Habitat

There are six known Collections locations and two known Conservation Sites (one overlaps with Collections) representing the Appalachian Bewick's wren in the Ridge and Valley ecoregion (DGIF 2004b; DCR-NH 2005). Of these seven locations, only one is partially protected by a Conservation Land.

Specific Threats and Trends

As mentioned earlier, causes for the decline of Bewick's wren are unclear. It has exhibited a strong negative trend in the region (Rosenberg 2003). While there exist no known, species-specific stresses for this species, it shares stresses with other early Successional birds (Bird TAC 2004; Appendix H). However, due to it only occurring at high elevations, some of these threats may not be as severe to this species as those that occur at lower elevations. It seems likely that natural succession of habitat and competition with house wrens have negative impacts on Bewick's wren (Adkisson 1991; Kennedy and White 1997).

Conservation Actions and Strategies

Effective conservation actions for this species are not clear, though those associated with early successional birds seem likely to be helpful (Bird TAC 2004; Appendix I). Bird TAC (2004) indicates that Bewick's wren in Virginia numbers fewer than 20 individuals, and that the population needs to be increased while being more closely inventoried. Rosenberg (2003) gives a population goal of 100 pairs throughout the PIF Mid-Atlantic Ridge and Valley, which includes portions of Virginia and neighboring states. Nest boxes in areas without house wrens may be helpful; removal of nest boxes in areas with house wrens may also be helpful to reduce that competitor's numbers in the area.

Research and Monitoring Needs

Knowledge of this species would benefit from an effort to gather historical data regarding distribution and abundance in Virginia (Bird TAC 2004). In addition, targeted surveys for this species should be performed to determine whether this species is still extant in Virginia, and if so, where (Bird TAC 2004). The extent and nature of interspecific competition with house wrens needs to be fully investigated to determine its

effect on the decline of Bewick's wren (Kennedy and White 1997). Overall, a better understanding of the nature and causes of its rapid decline in the Appalachians is needed (Rosenberg 2003).

7.3.1.9. Golden-winged warbler, *Vermivora chrysoptera*

Life History Summary

The golden-winged warbler occurs in the mountains of Virginia, where its preferred habitat is shrubby areas with scattered trees, generally near a forest edge (Confer 1992; Confer and Larkin 1998; Confer et al. 2003). It eats mostly moths and caterpillars, along with other insects and spiders (Confer 1992). Important threats to the golden-winged warbler include natural succession and hybridization with and competitive exclusion by blue-winged warblers *Vermivora pinus* (Confer 1992). Interaction and hybridization with the blue-winged warbler has been studied extensively. The golden-winged warbler tends to disappear from an area within about 50yr of initial invasion of *V. pinus* (Gill et al. 2001), although there is some evidence that blue-winged does not competitively exclude golden-winged (Confer and Larkin 1998). The dynamics of this interaction is not entirely clear, though the genetic pattern of hybridization that accompanies this phenomenon is beginning to be understood (Gill 2004; Shapiro et al. 2004). The golden-winged warbler is protected under MBTA and has been designated a State special concern species. According to VA-GAP (DGIF 2004a), 19% of its statewide predicted potential habitat is protected.

Location

Because this species is very particular about its needs, requiring early successional habitat, the map (Figure 7.13) only includes confirmed locations from the breeding season (DGIF 2004b).

Description of Habitat Requirements

This species may breed in a variety of early-successional or disturbed habitats, including shrubby fields, abandoned farmland, shrubby swamps, successional forest, utility right-of-ways, clearings within forests, brushy clearcuts or shelterwood cuts, in deciduous woods. The common features of these habitats are

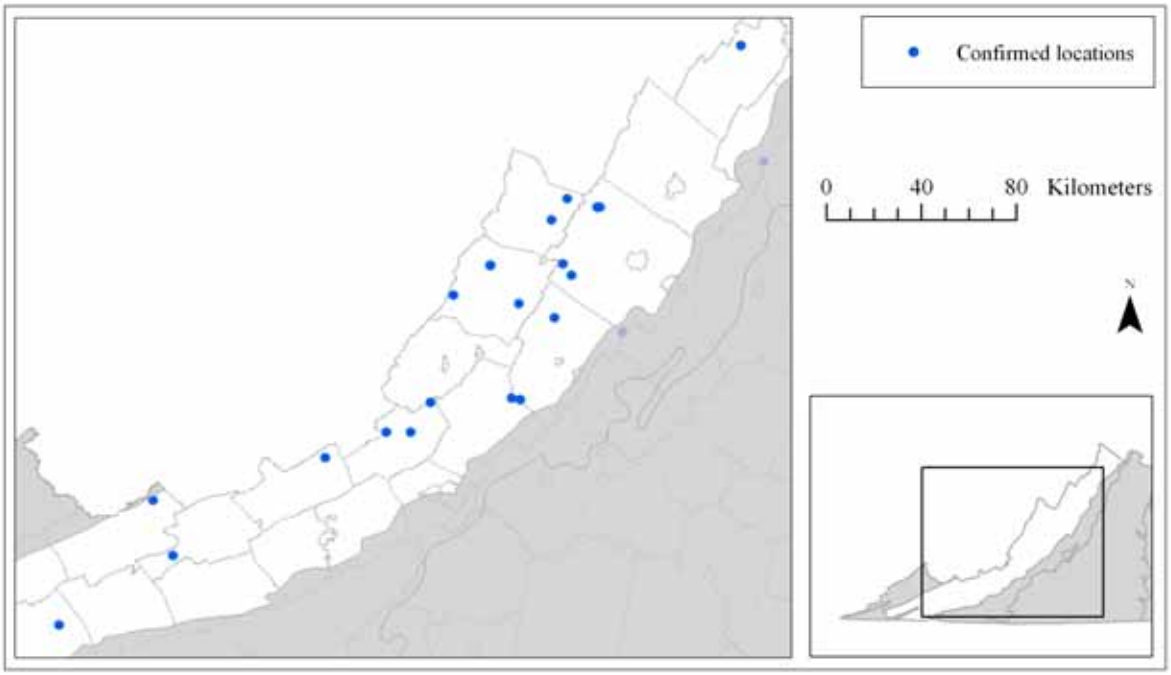

Figure 7.13. Distribution of the golden-winged warbler in the Ridge and Valley.

patches of dense herbaceous growth, shrubby cover, scattered young trees and, often, a forested perimeter. It is very specific in its habitat requirements, and once a disturbed area becomes too old, this species disappears (Curson et al. 1994).

Relative Condition of Habitat

There are 21 locations of golden-winged warblers within Collections in the Ridge and Valley (25 statewide, DGIF 2004b). Eleven of these are protected within a Conservation Land, including National Forest, WMAs, and a VOF easement (DCR 2003).

Specific Threats and Trends

The only species-specific stress reported by Bird TAC (2004) is hybridization with the blue-winged warbler. This species also appears to displace the golden-winged warbler, although the dynamics of this process is not clear (e.g., is it direct competition, or is it more closely related to habitat structure?). In addition, the golden-winged warbler shares stresses with other early successional birds (Bird TAC 2004; Appendix H). However, due to it only occurring at high elevations, some of these threats may not be as severe to this species as those that occur at lower elevations. It seems likely that loss of habitat due to natural succession and human development, as well as competition with blue-winged warblers, have contributed significantly to the decline of this species. In addition, nest parasitism by the brown-headed cowbird *Molothrus ater* affects this species in many parts of its range, though its impact in Virginia is not clear and seems likely to be minor (Confer et al. 2003).

Conservation Actions and Strategies

Active management is essential to maintain quality early successional habitat on the landscape in the Southern Appalachians (Bulluck et al. 2005). In this region, regenerating clearcuts are occupied by golden-winged warblers from approximately 4-13 years post-harvest (Klaus and Buehler 2001). In West Virginia, golden-winged warblers remained in cut-over areas for only 3-8 years following a harvest, and colonized burned areas 2-6 years after a burn (Canterbury 2005). Prescribed fire is an effective management tool for maintaining early successional habitat suitable for the species. The burning cycle should be planned so as to ensure that suitable habitat is available between burns. Because this approach manages directly for this species (and possibly a few others, such as the Appalachian Bewick's wren) at the expense of birds of mature forests, management planning should take place within the context of the larger surrounding landscape. The use of prescribed burning may mimic natural historical disturbance regimes, such as lightning-caused fires. Grazing at low cattle densities also appears to be an effective management tool in the Southern Appalachian region (Bulluck et al. 2005). In addition, the golden-winged warbler shares conservation actions with other members of the "Bird: Early Successional" habitat group (Bird TAC 2004; Appendix I). Rosenberg (2003) proposes a goal of > 6,000 pairs of golden-winged warblers in the entire PIF Mid-Atlantic Ridge and Valley (physiographic area 12) by maintaining known breeding sites and creating new sites with similar conditions where possible.

Research and Monitoring Needs

Bird TAC (2004) recommends targeted surveys for this species, plus accumulation of historical distribution and abundance information. As mentioned throughout, further study on the interactions of golden-winged with blue-winged warblers, including dominance and patterns of hybridization at first contact, are warranted specifically for Virginia birds, since these interactions seem to differ greatly depending on location (Shapiro et al. 2004).

7.3.1.10. Virginia northern flying squirrel, *Glaucomys sabrinus fuscus*

Life History Summary

The Virginia northern flying squirrel is one of two subspecies of this northern relict species in Virginia, and one of two species of flying squirrel (the other being the southern flying squirrel *Glaucomys volans*, which

is common statewide, Linzey 1998). The Virginia northern flying squirrel requires high-altitude, old growth forest with a significant spruce-fir component (Linzey 1998; Menzel 2003). Nest trees in West Virginia were most commonly Norway spruce *Picea abies*, American beech *Fagus grandifolia*, yellow birch *Betula alleghaniensis*, and black birch *B. lenta*. This subspecies occurs only in Highland County in Virginia (Linzey 1998). Food habits of this species are not well understood, but appear to revolve around lichens and fungi, supplemented with nuts, seeds, and arthropod and vertebrate flesh (Whitaker and Hamilton 1998). It is entirely nocturnal, being active just after dusk, then again in the hours before dawn (Wells-Gosling and Heaney 1984). This species is often displaced from nest cavities in areas with a large hardwood component by the smaller but more aggressive southern flying squirrel (Wells-Gosling and Heaney 1984). Important threats to this species include competition from southern flying squirrel and habitat loss. This subspecies is protected with the status of Federal and State endangered. VA-GAP was performed using both subspecies of *G. sabrinus*, so no "percentage of habitat protected" is available.

Location

The habitat map for this species (Figure 7.14) includes confirmed locations (DGIF 2004b) and potential habitat mapped using spruce-fir areas based on data from the Southern Appalachian Assessment (SAMAB 1996) and Continuous Inventory of Stand Condition (USFS 2002) within Highland county. For more details on mapping of potential habitat, see Appendix D.

Description of Habitat Requirements

This species requires high-altitude old growth forest with a significant component of spruce-fir (Wells-Gosling and Heaney 1984; Whitaker and Hamilton 1998; Menzel 2003).

Relative Condition of Habitat

There are 60 Collections locations for the Virginia northern flying squirrel, in six sites in northwest Highland County (DGIF 2004b). Two Conservation Sites are within the same areas, each containing an occurrence of this species (DCR-NH 2005). These occurrences have been given "Good" and "Fair" viability ratings (DCR-NH 2005). There are approximately 300ha of high elevation spruce-fir habitat is this

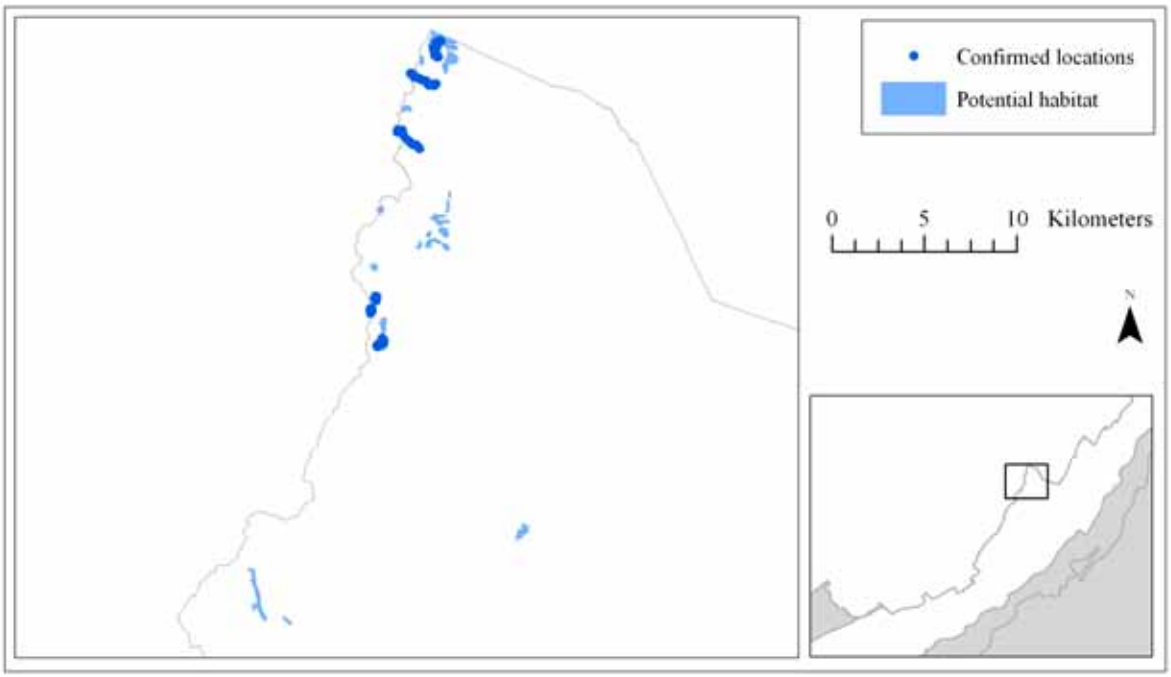

Figure 7.14. Distribution of the Virginia northern flying squirrel in the Ridge and Valley.

area. Approximately 60% of the potential habitat and Collections locations are protected within National Forest land.

This habitat is threatened by two major issues: balsam woolly adelgid *Adelges piceae*, and because it occurs in areas often targeted for development of wind power generation facilities. In addition, global climate change and acid precipitation are possibly problematic for high-elevation spruce-fir in Virginia.

Specific Threats and Trends

Mammal TAC (2004) identified largely habitat stresses for this species (Table 7.5). In addition, USFWS (1990a) discuss other stresses, including: heavy metals, which concentrate at higher elevations and could be bioaccumulated by squirrels through lichens and fungi; acid precipitation, which damages mature conifers and kills mycorrhizal fungi, an important food source; discontinuous distribution due to natural causes and historical deforestation; and possibly parasites contracted from southern flying squirrels.

Table 7.5. Species-specific stresses on the Virginia northern flying squirrel (Mammal TAC 2004).

Stress	Source of Stress	Scope	Severity	Comments
Habitat degradation	Climate alteration	2	2	
Habitat degradation	Exotic/invasive species	3	3	Spruce and balsam adelgids
Competition	Native species	2	2	
Habitat destruction	Industrial – power generation	U	U	Wind turbines
Habitat destruction	Forestry	2	4	

Conservation Actions and Strategies

Conservation actions for the Virginia northern flying squirrel identified by Mammal TAC (2004) include maintenance or increase of population levels, and a return of spruce forest area to historic levels. The recovery plan for this species (USFWS 1990a) is 15 years old. It focuses on research questions (discussed in the following section), developing and implementing management guidelines, habitat acquisition and protection, and "vigorous enforcement" of legal protections (USFWS 1990a). Menzel (2003) provides a thorough summary of the management implications of her work with this subspecies in West Virginia that is likely applicable to habitat restoration and management efforts in Virginia.

Research and Monitoring Needs

Research needs discussed by Mammal TAC (2004) include studies of the population genetics of this subspecies, as well as effects of parasites on it (Mammal TAC 2004). Research needs mentioned by the out of date recovery plan (USFWS 1990) include: determination of current range and survey of that range to identify all populations; in-depth life history and ecological studies to identify critical factors in population regulation; squirrel densities related to habitat quality; and toxic accumulation in its food supply. For a complete list of research needs, see USFWS (1990a).

7.3.1.11. Snowshoe hare, *Lepus americanus*

Life History Summary

This northern relict hare occurs only in Highland County in Virginia, where it seems to be tied to areas with significant spruce cover. It has declined precipitously in Virginia since most of the spruce forest was logged around the turn of the last century (Linzey 1998). It requires very thick, brushy understory to provide escape cover and a winter food supply (Carreker 1985), and occurs in young spruce stands that provide that kind of cover (Whitaker and Hamilton 1998). Areas of second growth forest with this type of thick understory have declined as reforested areas in western Virginia have matured. Winter food supplies seem to be more critical than summer foods (Carreker 1985), and largely consist of deciduous and spruce twigs and buds (Whitaker and Hamilton 1998). The most important threat to this species in Virginia is natural

succession: as the overstory increases, the understory decreases. M. L. Fies (DGIF, pers. comm.) believes that the snowshoe hare has been extirpated from Virginia, but that if any remain, they are confined to a very small area near Locust Springs Campgound, near the West Virginia line. This species is protected as State endangered in Virginia. According to VA-GAP (DGIF 2004a), 38% of its statewide predicted potential habitat is protected.

Location

The map of habitat for the snowshoe hare (Figure 7.15) includes confirmed locations (DGIF 2004b) and potential habitat made up of spruce-fir areas (USFS 2002) near Locust Springs Campground. For more details on mapping of potential habitat, see Appendix D.

Description of Habitat Requirements

This species requires forested habitat with a dense understory of second-growth forest or evergreen shrubs (M. L. Fies, DGIF, pers. comm.). It requires habitat with snow cover that persists through most of the winter (Whitaker and Hamilton 1998).

Relative Condition of Habitat

There are six Collections locations for the snowshoe hare within northwest Highland County (DGIF 2004b). Potential habitat consists of approximately 110ha of spruce-fir forest. A DCR-NH Conservation Site encompasses all of the Collections locations and potential habitat (DCR-NH 2005). The occurrence for snowshoe hare within this Conservation Site has a "Poor" viability rating. All locations, potential habitat, and the Conservation Site are within the George Washington and Jefferson National Forests.

This habitat is exceedingly rare in Virginia, and it is declining rapidly (M. L. Fies, DGIF, pers. comm.). The only known populations were near Locust Spring Campground, but the species may now be extirpated. Previously occupied forested habitats have matured and the understory is generally too thin to provide adequate escape cover (M. L. Fies, DGIF, pers. comm.).

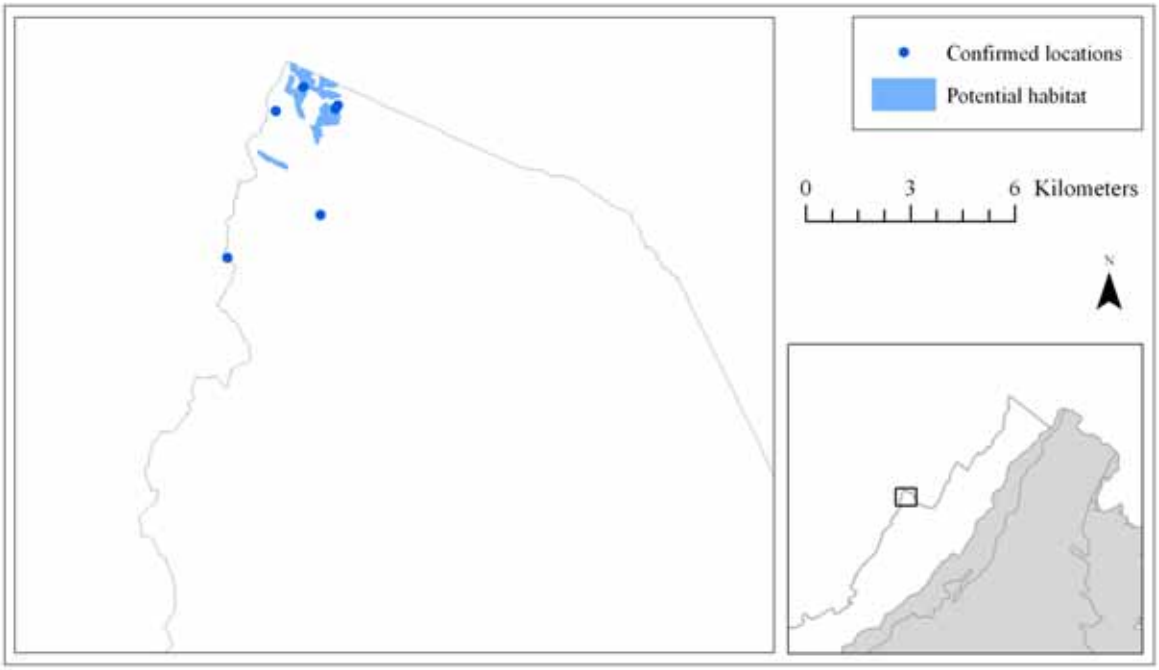

Figure 7.15. Distribution of the snowshoe hare in the Ridge and Valley.

Specific Threats and Trends

Mammal TAC (2004) identified two species-specific stresses on the snowshoe hare in Virginia (Table 7.6).

Table 7.6. Species-specific stresses on Virginia northern flying squirrel (Mammal TAC 2004).

Stress	Source of Stress	Scope	Severity	Comments
Natural succession	Reduction in forestry	4	4	
Other habitat stress	Climate/atmospheric alteration	2	2	Lack of snow cover

Conservation Actions and Strategies

Timber harvest, preferably heavy thinning, is desperately needed to open the overstory and promote understory growth in these areas (Mammal TAC 2004; M. L. Fies, DGIF, pers. comm.). Since the species is extirpated or critically imperiled in Virginia, the conservation goal given by Mammal TAC (2004) is simply to increase the current population.

Research and Monitoring Needs

Surveys to locate any possible remaining populations should be carried out, and if any are located, they should be closely monitored (Mammal TAC 2004).

7.3.1.12. Indiana myotis, *Myotis sodalis*

Life History Summary

The Indiana myotis is a small brown bat that occurs throughout much of the eastern U.S. It spends summer in small maternity colonies in a complex of snags exposed to sunlight (Whitaker and Hamilton 1998). This species is migratory, and the majority of individuals winter in only 15 caves, nine of which are in the eastern U.S. (with the remainder in Missouri, Whitaker and Hamilton 1998). The concentrated nature of its winter range is part of the reason for its Federal listing, as such a concentration renders a larger proportion of the population susceptible to negative effects at each winter site (USFWS 1983d; Pierson 1998). Its main foods are small moths, beetles, and dipterans (Whitaker and Hamilton 1998). Major threats to this species include: human disturbance of hibernacula and destruction of the riparian forest necessary for maternity colonies and foraging. The Indiana myotis is protected with the status of Federal and State endangered. According to VA-GAP (DGIF 2004a), 26% of its statewide predicted potential habitat is protected.

Location
The map of habitat for the Indiana myotis (Figure 7.16) includes confirmed locations from Collections (DGIF 2004b) and cave Conservation Sites (DCR-NH 2004).

Description of Habitat Requirements

This species requires caves with cool stable temperatures (Whitaker and Hamilton, 1998). More specifically, R. J. Reynolds (DGIF, pers. comm.) states that essential habitat includes caves with high humidity and stable temperatures (3-10°C), and that Indiana myotis is often associated with old saltpeter mines.

Relative Condition of Habitat

There are 25 known Indiana myotis locations in Collections (39 statewide, DGIF 2004b). All but one of these locations are within 14 Conservation Sites (DCR-NH 2005). Eight of the Collections locations are protected within a Conservation Land, and parts of 13 others are within or adjacent to a Conservation Land (DCR 2003).

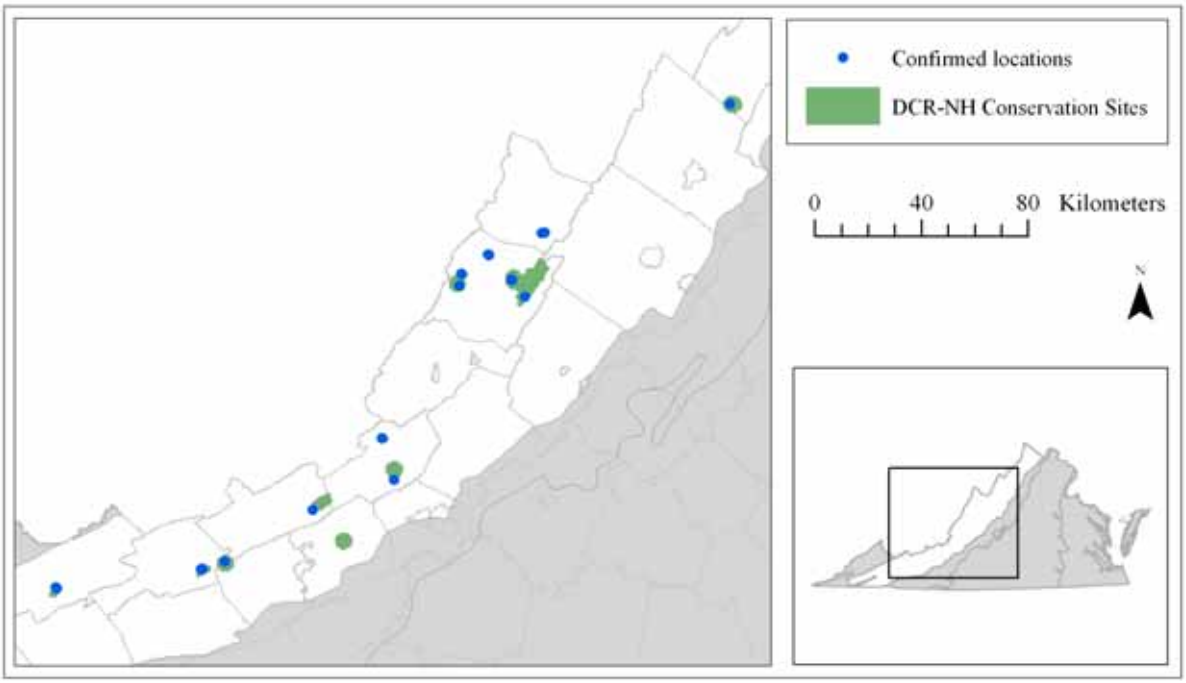

Figure 7.16. Distribution of the Indiana myotis in the Ridge and Valley.

Specific Threats and Trends

Mammal TAC (2004) identified two stresses on the Indiana myotis in Virginia (Table 7.7). Additional stresses were identified by USFWS (1983d), and include: collapse of hibernacula; destruction of riparian areas; and (potentially) pesticide poisoning. In addition, Thomson (1982) listed alteration of hibernaculum microclimate as a cause for decline.

Table 7.7. Species-specific stresses on the Indiana myotis (Mammal TAC 2004).

Stress	Source of Stress	Scope	Severity	Comments
Unintentional kills	Power generation	U	U	Effects of wind turbines unknown
Human disturbance	Recreational use of habitat	3	3	Disturbance of hibernacula

Conservation Actions and Strategies

No conservation actions were identified by Mammal TAC (2004). USFWS (1983d) identify several in the recovery plan. These include: prevent disturbance to hibernacula; protect, maintain, and restore foraging and nursery areas; and carry out a public information campaign. For detailed conservation actions, see USFWS (1983d).

Research and Monitoring Needs

No research or monitoring needs were identified by Mammal TAC (2004). USFWS (1983d) identify several in the recovery plan. These include: monitoring of summer and hibernacula population trends; monitoring levels of toxins and researching their effects; and research on summer habitat requirements. For a full list and further details, see USFWS (1983d).

7.3.1.13. Appalachian grizzled skipper, *Pyrgus centaureae wyandot*

Life History Summary

This skipper inhabits open woodlands across its range. In Virginia, it isfound on shale barrens near woods in the Ridge and Valley; it also does well in powerline cuts on shale slopes (Schweitzer 1991). This species requires dwarf cinquefoil *Potentilla canadensis*, which serves as the larval food plant (Chazal et al. 2004). Adults feed on nectar, primarily on low-growing, yellow-flowered plants (Chazal et al. 2004). Schweitzer (1991a) indicates that this species is likely a good disperser, and individuals may be able to find appropriate new habitat. However, this species is exceedingly rare in Virginia, with only approximately 80 individuals observed since 1992 (Chazal et al. 2004). Threats include forest succession and spraying for gypsy moth control (Schweitzer 1991a; Chazal et al. 2004). The taxonomy of this subspecies is also in question; it is also known as the species *Pyrgus wyandot*. The Appalachian grizzled skipper is protected with the status of State threatened and has been designated a species of concern by the Virginia Field Office of USFWS.

Location

Because of its sensitivity to collection, the map of habitat for the Appalachian grizzled skipper (Figure 7.17) includes areas delineated by DCR-NH (2005), which are large areas encompassing conservation sites.

Description of Habitat Requirements

This species inhabits shale barrens, recent clearcuts and powerlines on south- to west-facing slopes with bare rock or soil, usually within 30m of woods (Schweitzer 1991a; S. M. Roble, DCR-NH, pers. comm.). However, S. M. Roble (DCR-NH, pers.comm) mentions that many shale barrens in Virginia have been checked where this species was not found (also see Chazal et al. 2004).

Relative Condition of Habitat

There are five occurrences of the Appalachian grizzled skipper within two broad areas in the Ridge and Valley (DCR-NH 2005). All of these areas are at least partially protected within the George Washington

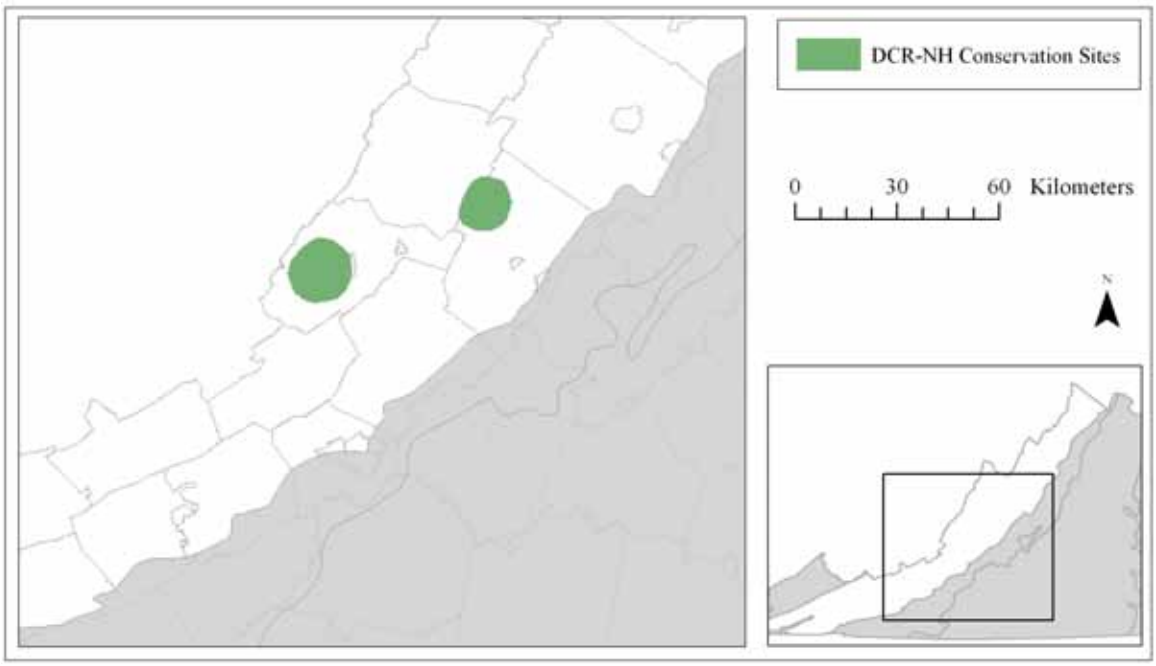

Figure 7.17. Distribution of the Appalachian grizzled skipper in the Ridge and Valley.

and Jefferson National Forests, or as a Nature Conservancy preserve. Of the five occurrences, three have viability ratings of "Poor" and two have ratings of "Good-to-fair."

Specific Threats and Trends

No specific threats were reported by Invertebrate TAC. Schweitzer (1991a) and Chazal et al. (2004) both listed habitat succession and gypsy moth control measures as stresses on this species.

Conservation Actions and Strategies

No specific conservation actions were reported by Invertebrate TAC. Schweitzer (1991a) suggests that all shale barrens and powerline corridors in the Ridge and Valley be exempted from gypsy moth spraying. It is not clear whether maintenance of open areas (that is, active slowing of succession) would benefit this species (Chazal et al. 2004).

Research and Monitoring Needs

No specific research or monitoring needs were reported by Invertebrate TAC. The precise taxonomy of this species needs to be resolved (Chazal et al. 2004). Intensive surveys need to be continued to locate any additional populations (Chazal et al. 2004). The relationship of population distribution and density to disturbance regimes needs to be investigated (Chazal et al. 2004), as instigating such regimes may be a method that will increase population levels.

7.3.1.14. Regal fritillary, *Speyeria idalia*

Life History Summary

This is a grassland species, preferring open areas with tall grass and wet patches; the habitat must contain adequate nectar sources throughout the flight season (Schweitzer 1991b), from late June to mid-September (Allen 1997). Important nectar sources are milkweeds *Asclepias* spp., red clover *Trifolium* spp., and thistle *Cirsium* spp. (Allen 1997). Presence of violet *Viola* spp. is required as the larval host plant (Scott 1986). The regal fritillary was not rare in Virginia as late as the early 1970s, but is currently declining (Schweitzer 1991b). This species has been recorded in at least 35 counties in Virginia, but is now reduced to one known population and a few unconfirmed sightings at other locations in the past decade (S. M. Roble, DCR-NH, pers. comm.). It has been designated a species of concern by the Virginia Field Office of USFWS.

Location

The map of habitat for the regal fritillary (Figure 7.18) includes confirmed locations (DGIF 2004b) and Conservation Sites (DCR-NH 2005).

Description of Habitat Requirements

This species requires violets as larval food and uses large tracts of grasslands (Opler and Krizek 1984).

Relative Condition of Habitat

There are four known locations of the regal fritillary in Collections (DGIF 2004b). Of the two Conservation Sites, one encompasses three of the Collections locations (DCR-NH 2005). The Conservation Sites have viability ratings of "Fair" and "Poor." All Collections locations and the large Conservation Site are within the Radford Army Ammunition Plant, but the second Conservation Site is unprotected (DCR 2003).

Specific Threats and Trends

No specific stresses were reported by Invertebrate TAC. Schweitzer (1991b) reports that regal fritillary is "in an ongoing state of decline (p. 243)." This author also reports that causes for this decline are not well

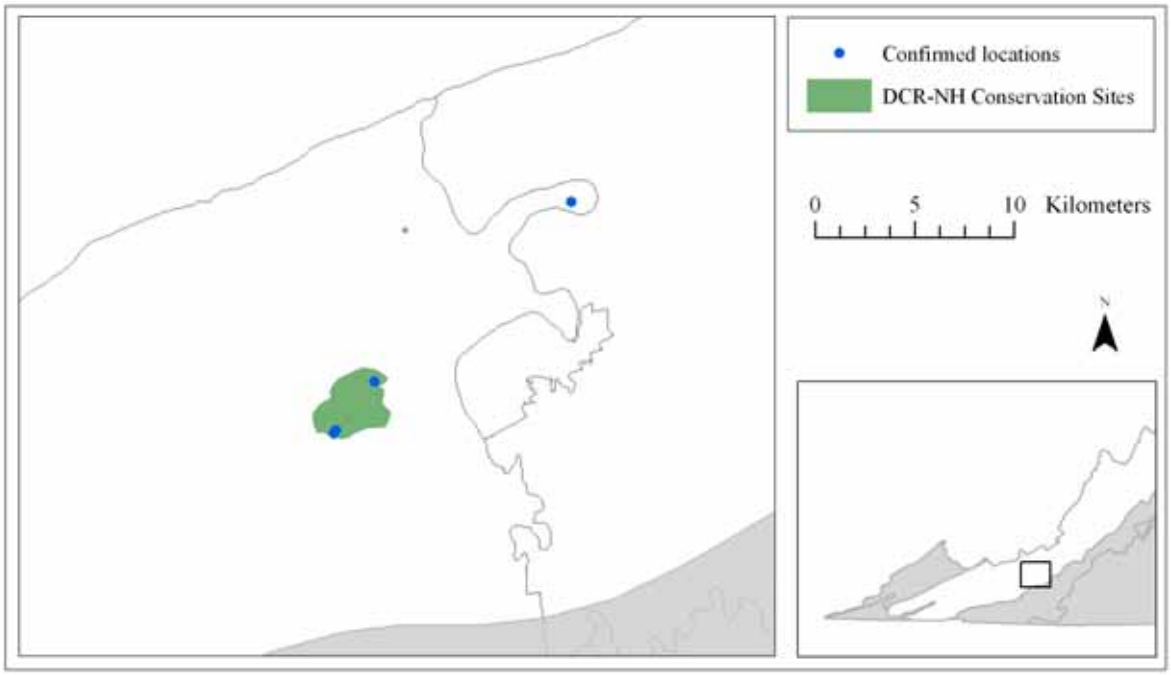

Figure 7.18. Distribution of the regal fritillary in the Ridge and Valley.

understood, but may be related either to insecticide spraying for gypsy moth control, or to increasing distances between suitable habitats that are too far for dispersing fritillaries to travel.

Conservation Actions and Strategies

No specific conservation actions were reported by Invertebrate TAC. Schweitzer (1991b) recommends the following: cessation of gypsy moth spraying in areas that contain or recently contained the regal fritillary; protection of remaining grassland within its range; and a cessation of collection.

Research and Monitoring Needs

Systematic surveys for extant populations are important, as is close monitoring of known populations. If possible, research on the exact cause of decline would be useful (Schweitzer 1991b).

7.3.1.15. Shaggy coil, *Helicodiscus diadema*

Life History Summary

This snail is endemic to a small portion of the Ridge and Valley. It only occupies leaf litter at the base of limestone/shale outcrops (Batie 1991b). Nothing is known of its natural history or ecology. It is protected with the status of State endangered and has been designated as a species of concern by the Virginia Field Office of USFWS.

Location

The shaggy coil map (Figure 7.19) includes only confirmed locations from Collections (DGIF 2004b).

Description of Habitat Requirements

Habitat for this species includes leaf litter at the base of limestone outcrops with locust scrub (Batie 1991b).

Figure 7.19. Distribution of the shaggy coil in the Ridge and Valley.

Relative Condition of Habitat

There are four known locations of the shaggy coil in Collections (DGIF 2004b). These were observed in the late 1960s. None of these locations is within a Conservation Land (DCR 2003).

Specific Threats and Trends

No specific stresses were reported by Invertebrate TAC. Disturbance of the rock, surrounding trees that provide leaf litter, or the leaf litter itself all have the potential to cause the shaggy coil's extinction (Batie 1991b).

Conservation Actions and Strategies

No specific conservation actions were reported by Invertebrate TAC.

Research and Monitoring Needs

No specific research or monitoring needs were reported by Invertebrate TAC. Batie (1991b) recommends surveys near the known populations to attempt to locate additional populations. In addition, very little is known about the basic life history of this species.

7.3.1.16. Rubble coil, *Helicodiscus lirellus*

Life History Summary

This snail is endemic to a small portion of the Ridge and Valley. It occupies limestone rubble at the base of two hills in Rockbridge County (Batie 1991a). Nothing is known of its natural history or ecology. It is protected with the status of State endangered and has been designated a species of concern by the Virginia Field Office of USFWS.

Location

The map of habitat for the rubble coil (Figure 7.20) includes confirmed locations from Collections (DGIF 2004b) and two Conservation Sites (DCR-NH 2005).

Description of Habitat Requirements

Information on this species is limited to a habitat description from the location of the only known populations, which is in limestone rubble at the bases of two hills in Rockbridge County (Batie 1991a).

Relative Condition of Habitat

There is one Collections location and two Conservation Sites (one containing the Collection location) in Rockbridge County (DGIF 2004b; DCR-NH 2005). Neither of these areas is protected by a Conservation Land (DCR 2003).

Specific Threats and Trends

No specific stresses were reported by Invertebrate TAC. Batie (1991a) reports that any disturbance of the slopes where this snail has been found could cause its extinction, as this species appears to be endemic to this location.

Conservation Actions and Strategies

No specific conservation actions were reported by Invertebrate TAC. Protection of the hills where the species has been recorded is obviously critical.

Research and Monitoring Needs

No specific research or monitoring needs were reported by Invertebrate TAC. Batie (1991a) suggests that additional surveys near the known locations could confirm additional locations/populations nearby. In addition, very little is known about the basic life history of this species.

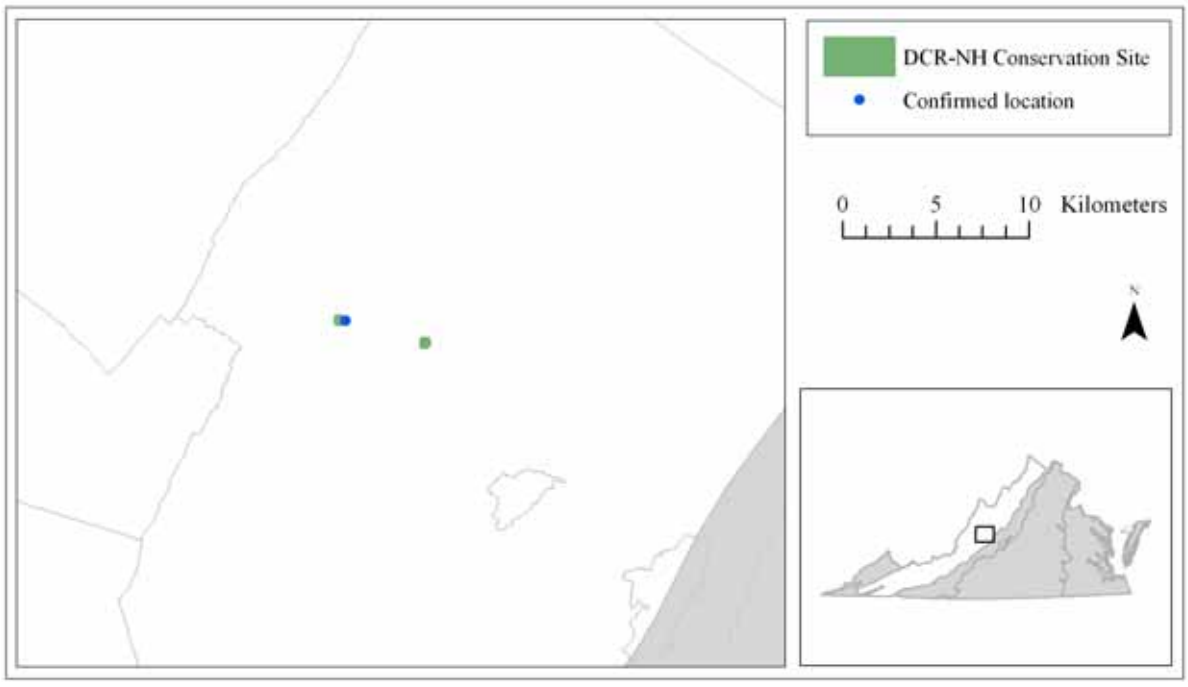

Figure 7.20. Distribution of the rubble coil in the Ridge and Valley.

7.3.1.17. Virginia fringed mountain snail, *Polygriscus virginianus*

Life History Summary

This very small snail (approximately 4mm) is endemic to a small portion of the Ridge and Valley (USFWS 1983g). Shells have been found along a 9.9km stretch of bluff along the New River in Pulaski County, although live snails have only been found in 70m of this area (Batie 1991c). This area is permanently damp, free of humus, and overgrown with honeysuckle *Lonicera* spp. and other vines (USFWS 1983g). This species is subterranean, unpigmented, and likely blind; nothing further is known of its natural history or ecology (USFWS 1983g). It is protected with the status of Federal and State endangered.

Location

The map of habitat for the Virginia fringed mountain snail (Figure 7.21) includes one Conservation Site (DCR-NH 2005).

Description of Habitat Requirements

This snail occurs beneath the surface of the soil from 10-60cm. These areas are shaded with clay soils mixed with limestone fragments (Batie 1991c). This species is found in damp, calcium-rich rocky soil associated with weathered Elbrook formation dolomitic limestone (USFWS 1983g). Soils are clayey and free of humus, and the habitat surface generally lacks a leaf litter layer (USFWS 1983g).

Relative Condition of Habitat

There is one Conservation Site for the Virginia fringed mountain snail (DCR-NH 2005). See *Life History Summary* above for a description of this single site. The occurrence has a viability rating of "Fair."

Specific Threats and Trends

No specific stresses were reported by Invertebrate TAC. USFWS (1983g) list several potential threats to this species, including: herbicide spraying along roadsides near the sites; widening of River Road at the

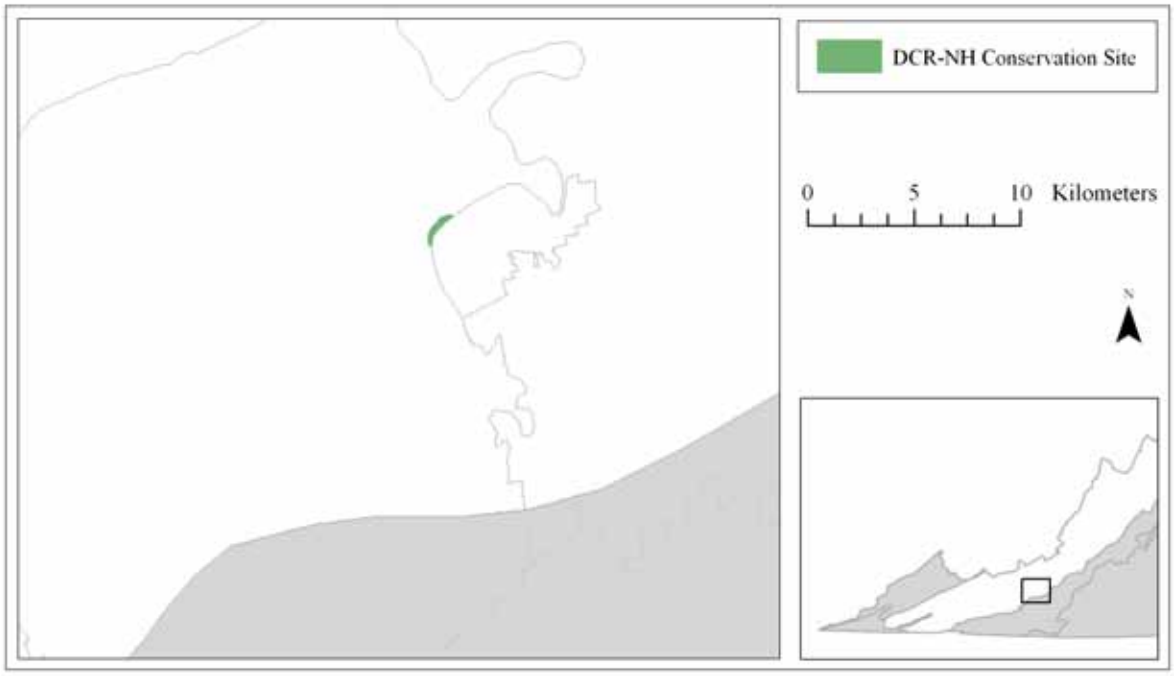

Figure 7.21. Distribution of the Virginia fringed mountain snail in the Ridge and Valley.

western collection point; reactivation of a local quarry, which is within the range of this species; and collecting, including surveying for the species. The excavation necessary for these surveys damages the habitat, which may not regenerate for very long periods of time (Solem, in USFWS 1983g). As of 1983, there were no known plans for quarry reactivation or for road widening in the area (USFWS 1983g).

Conservation Actions and Strategies

No specific conservation actions were reported by Invertebrate TAC. USFWS (1983g) list several, which include: protection of known habitat areas through easements, cooperative agreements and acquisitions; survey likely areas in the vicinity of the known locations for shells during summer and fall; and establishment of monitoring and long-term management programs. Please see the recovery plan for this species for full details (USFWS 1983g).

Research and Monitoring Needs

No specific research or monitoring needs were reported by Invertebrate TAC. Clearly, surveys in areas surrounding the two known locations should be carried out in an attempt to locate additional areas that harbor this species. However, it is important that these surveys consist of methods that do not disturb the rocky habitat unless as a last resort; surveys should therefore focus on locating recently-dead shells following rains (Solem, in USFWS 1983g). Follow-up surveys for live individuals in areas where shells are found can be conducted in spring, when they may be closer to the surface (Solem, in USFWS 1983g).

7.3.2. Forest Species of Greatest Conservation Need in the Ridge and Valley

7.3.2.1. Species of Greatest Conservation Need by Forest Type

Of the 71 tiered species that occur in Ridge and Valley forest, 29 are generalists that occur in all forest types (Table 7.8). Of the remaining 39 species, 29 occur in deciduous forest (Table 7.9), 10 occur in coniferous forest (Table 7.10), and 24 occur in mixed forest (Table 7.11).

Table 7.8. Forest generalist species of greatest conservation need in the Ridge and Valley. "Open woods," throughout Tables 7.8-7.11, unless otherwise indicated, indicates mature, closed canopy, open understory forest, and not open canopy, shrubby understory forests, such as shelterwood cuts.

Common Name	Scientific Name	Tier	Special Habitat Needs
Peregrine falcon	*Falco peregrinus*	I	Cliffs for nesting, often near water
Bald eagle	*Haliaeetus leucocephalus*	II	Large trees near a river or lake
Fisher	*Martes pennanti pennanti*	II	Forest with extensive clutter and litter
Southern rock vole	*Microtus chrotorrhinus*	II	Moist cool talus over 915m elevation
Eastern black kingsnake	*Lampropeltis getula nigra*	III	Ground litter and logs
Eastern small-footed myotis	*Myotis leibii*	III	Caves and crevices in forested areas
Eastern box turtle	*Terrapene carolina*	III	Forest generalist
Green heron	*Butorides striatus*	IV	Near streams or wetlands
Chuck-will's-widow	*Caprimulgus carolinensis*	IV	Open woods
Northern bobwhite	*Colinus virginianus*	IV	Open woods
Eastern wood-pewee	*Contopus virens*	IV	Open second-growth to mature woods
Prairie warbler	*Dendroica discolor*	IV	Open woods
Blue Ridge dusky salamander	*Desmognathus orestes*	IV	Wet rockfaces, seeps, forest floor
Worm-eating warbler	*Helmitheros vermivorus*	IV	Thick understory near water
Eastern hog-nosed snake	*Heterodon platirhinos*	IV	Forest ecotones with sandy soils

Common Name	Scientific Name	Tier	Special Habitat Needs
Yellow-breasted chat	*Icteria virens*	IV	Open shrubby woods
Black-and-white warbler	*Mniotilta varia*	IV	Forest generalist
Least weasel	*Mustela nivalis*	IV	Habitat generalist
Allegheny woodrat	*Neotoma magister*	IV	Wooded bottomlands, banks, cliffs
Kentucky warbler	*Oporornis formosus*	IV	Thick understory, closed canopy near water
Northern parula	*Parula americana*	IV	Damp or wet woods near water
Eastern towhee	*Pipilo erythrophthalmus*	IV	Shrubby openings and edges
Eastern spadefoot	*Scaphiopus holbrookii*	IV	Forest with sandy or otherwise loose soils
Ovenbird	*Seiurus aurocapillus*	IV	Open mature woods
Long-tailed shrew	*Sorex dispar*	IV	Talus slopes and moist rocky areas at high altitudes
Eastern spotted skunk	*Spilogale putorius*	IV	Weedy clearcuts, avoids heavy woods
Appalachian cottontail	*Sylvilagus obscurus*	IV	Thickets within mixed forest
Brown thrasher	*Toxostoma rufum*	IV	Shrubby clearcuts
Canada warbler	*Wilsonia canadensis*	IV	Thick understory near water

Table 7.9. Deciduous forest species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Wood turtle	*Glyptemys insculpta*	I	Clear streams
Indiana myotis	*Myotis sodalis*	I	Snags in sunlight (breeding)
Virginia fringed mountain snail	*Polygyriscus virginianus*	I	Rocky bluffs along the New River
Appalachian yellow-bellied sapsucker	*Sphyrapicus varius appalachiensis*	I	High-elevation forest with large deciduous portion
Golden-winged warbler	*Vermivora chrysoptera*	I	Regenerating clearcuts with scattered saplings
American black duck	*Anas rubripes*	II	Near emergent or wooded wetlands
Green salamander	*Aneides aeneus*	II	Damp crevasses in cove hardwoods
Cerulean warbler	*Dendroica cerulea*	II	Mature forest with complex canopy structure
Swainson's warbler	*Limnothlypis swainsonii*	II	Non-flooding bottomland hardwoods
Southern zigzag salamander	*Plethodon dorsalis*	II	Moist woods with abundant surface debris
Cow Knob salamander	*Plethodon punctatus*	II	High-elevation woods with abundant surface debris
Mountain chorus frog	*Pseudacris brachyphona*	II	Wooded hillsides near wet areas
Mountain earthsnake	*Virginia valeriae*	II	Heavy ground cover
Shenandoah Mountain salamander	*Plethodon virginia*	III	Under forest litter on slopes or in ravines
Jefferson salamander	*Ambystoma jeffersonianum*	IV	Shallow ponds within woodlands
Whip-poor-will	*Caprimulgus vociferus*	IV	Open woods near large fields
Chimney swift	*Chaetura pelagica*	IV	Large snags or houses with chimneys
Yellow-billed cuckoo	*Coccyzus americanus*	IV	Tall forest with partially open canopy
Timber rattlesnake	*Crotalus horridus*	IV	South-facing ledges and talus slopes
Gray catbird	*Dumetella carolinensis*	IV	Dense thickets in forest openings or edges
Willow flycatcher	*Empidonax traillii*	IV	Willow thickets near water
Wood thrush	*Hylocichla mustelina*	IV	Mature upland forest with undergrowth
Rose-breasted grosbeak	*Pheuctitus ludovicianus*	IV	Second-growth mesic forest

Common Name	Scientific Name	Tier	Special Habitat Needs
Scarlet tanager	*Piranga olivacea*	IV	Mature forest, min size 10-12ha
Yonahlossee salamander	*Plethodon yonahlossee*	IV	Mountain slopes with deep leaf litter
Prothonotary warbler	*Protonotaria citrea*	IV	Near water
American woodcock	*Scolopax minor*	IV	Moist or wet woods near wetlands
Louisiana waterthrush	*Seiurus motacilla*	IV	Near water
Yellow-throated vireo	*Vireo flavifrons*	IV	Tall forest with partially open canopy

Table 7.10. Coniferous forest species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Virginia northern flying squirrel	*Glaucomys sabrinus fuscus*	I	High-elevation spruce-fir
Snowshoe hare	*Lepus americanus*	I	Extensive thickets and spruce pockets
Northern pinesnake	*Pituophis melanoleucus*	I	Dry upland forest on ridges
Northern saw-whet owl	*Aegolius acadicus*	II	High-elevation spruce-fir
Tiger salamander	*Ambystoma tigrinum*	II	Fishless ponds in wooded areas
Green salamander	*Aneides aeneus*	II	Damp crevasses in upland pines
Winter wren	*Troglodytes troglodytes*	II	Cool moist forest with thickets
Scarletsnake	*Cemophora coccinea*	IV	Sandy forests; largely subterranean
Brown creeper	*Certhia americana*	IV	Mature montane spruce-fir (breeding)
Yellow-throated vireo	*Vireo flavifrons*	IV	Tall forest with partially open canopy

Table 7.11. Mixed forest species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Virginia northern flying squirrel	*Glaucomys sabrinus fuscus*	I	High-elevation spruce-fir component
Snowshoe hare	*Lepus americanus*	I	Extensive thickets and spruce pockets
Indiana myotis	*Myotis sodalis*	I	Snags in sunlight (breeding)
Appalachian yellow-bellied sapsucker	*Sphyrapicus varius appalachiensis*	I	High-elevation forest with large deciduous portion
Golden-winged warbler	*Vermivora chrysoptera*	I	Regenerating clearcuts with scattered saplings
Northern saw-whet owl	*Aegolius acadicus*	II	High-elevation spruce-fir component
Tiger salamander	*Ambystoma tigrinum*	II	Fishless ponds in wooded areas
Cow Knob salamander	*Plethodon punctatus*	II	High elevation forest with litter cover
Mountain chorus frog	*Pseudacris brachyphona*	II	Wooded hills with wet areas or pools
Southern water shrew	*Sorex palustris*	II	Wooded banks of cold, fast streams
Winter wren	*Troglodytes troglodytes*	II	Cool moist forest with thickets
Mountain earthsnake	*Virginia valeriae pulchra*	II	Heavy ground cover
Jefferson salamander	*Ambystoma jeffersonianum*	IV	Shallow ponds within woodlands
Whip-poor-will	*Caprimulgus vociferous*	IV	Open woods near fields
Chimney swift	*Chaetura pelagica*	IV	Large snags or houses with chimneys
Yellow-billed cuckoo	*Coccyzus americanus*	IV	Open woods with dense understory
Timber rattlesnake	*Crotalus horridus*	IV	South-facing ledges and talus slopes
Gray catbird	*Dumetella carolinensis*	IV	Dense thickets in forest openings or edges
Wood thrush	*Hylocichla mustelina*	IV	Mature upland forest with undergrowth
Rose-breasted grosbeak	*Pheuctitus ludovicianus*	IV	Second-growth mesic forest
Scarlet tanager	*Piranga olivacea*	IV	Mature forest, min size 10-12ha

Common Name	Scientific Name	Tier	Special Habitat Needs
Prothonotary warbler	*Protonotaria citrea*	IV	Near water
American woodcock	*Scolopax minor*	IV	Moist or wet woods near wetlands
Louisiana waterthrush	*Seiurus motacilla*	IV	Near water

7.3.2.2. Status of Forested Habitats

The 2001 FIA reported 0.26 million acres (0.10 million ha) of coniferous forest, 2.92 million acres (1.18 million ha) of deciduous forest, 0.43 million acres (0.17 million ha) of mixed forest, and 2.38 million acres (1.54 million ha) of non-forested land in the Ridge and Valley (USFS 2001).

7.3.2.3. Trends in Forested Habitats

According to USDA (2000), non-federal forestland in the Ridge and Valley increased by > 40,000 acres (> 16,000ha) during the period between 1982 and 1997. Forest trends by type are not available at the ecoregional level. Please see Section 4.2.3.1 for statewide status and trends in forested habitats.

7.3.3. Open Vegetated Habitat Species of Greatest Conservation Need in the Ridge and Valley

7.3.3.1. Species of Greatest Conservation Need by Open Vegetated Habitat Type

Of the 43 tiered species that occur in open vegetated habitats in the Ridge and Valley, 19 are generalists that occur in all open vegetated habitat types (Table 7.12). Of the remaining 23 species, 15 occur in herbaceous open habitats (Table 7.13) and eight occur in scrub-shrub (Table 7.14).

Table 7.12. Open vegetated habitat generalist species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Henslow's sparrow	*Ammodramus henslowii*	I	Native warm season grasses
Loggerhead shrike	*Lanius ludovicianus*	I	Scattered perches over short vegetation
Appalachian Bewick's wren	*Thryomanes bewickii*	I	High-elevation brushy areas, old fields
Golden-winged warbler	*Vermivora chrysoptera*	I	Old fields with scattered saplings
Northern harrier	*Circus cyaneus*	III	Damp to wet fields with few trees/shrubs
Eastern box turtle	*Terrapene carolina*	III	Dense groundcover, some shrubs
Whip-poor-will	*Caprimulgus vociferus*	IV	Forages over open fields
Northern bobwhite	*Colinus virginianus*	IV	Grassy fields with shrubby cover, also agricultural fields (active and fallow)
Eastern wood-pewee	*Contopus virens*	IV	Forest openings of all kinds for foraging
Prairie warbler	*Dendroica discolor*	IV	Open habitat with some trees or shrubs
Eastern hog-nosed snake	*Heterodon platirhinos*	IV	Ecotonal areas with sandy soils
Yellow-breasted chat	*Icteria virens*	IV	Dense tall vegetation
Least weasel	*Mustela nivalis*	IV	Habitat generalist
Eastern towhee	*Pipilo erythrophthalmus*	IV	Dense tall vegetation
American woodcock	*Scolopax minor*	IV	Fields for foraging and in winter
Eastern spotted skunk	*Spilogale putorius*	IV	Weedy old fields, avoids heavy woods
Field sparrow	*Spizella pusilla*	IV	Weedy fields with scattered shrubs
Brown thrasher	*Toxostoma rufum*	IV	Dense tall vegetation
Eastern kingbird	*Tyrannus tyrannus*	IV	Scattered perches (shrubs, trees, fences)

Table 7.13. Herbaceous habitat species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Bachman's sparrow	*Aimophila aestivalis*	I	Old fields
Upland sandpiper	*Bartramia longicauda*	I	Short to medium height grass
Wood turtle	*Glyptemys insculpta*	I	Clear streams
Indiana myotis	*Myotis sodalis*	I	Uses solitary sunlit snags in summer
Regal fritillary	*Speyeria idalia*	I	Grassy areas containing *Viola* spp.
Virginia big-eared bat	*Corynorhinus townsendii virginianus*	II	Frequently forages over open fields
Mountain chorus frog	*Pseudacris brachyphona*	II	Breeds in wet fields adjacent to woodlands
Eastern black kingsnake	*Lampropeltis getula nigra*	III	Old buildings in fields
Smooth greensnake	*Opheodrys vernalis*	III	High-elevation grassy areas
Barn owl	*Tyto alba pratincola*	III	Dense grass near human structures
Grasshopper sparrow	*Ammodramus savannarum*	IV	Grassy fields with few to no shrubs
Chuck-will's-widow	*Caprimulgus carolinensis*	IV	Near pine forest (forages over fields)
Rusty blackbird (winter)	*Euphagus carolinus*	IV	Croplands in winter
Queen snake	*Regina septemvittata*	IV	Open riparian areas
Northern rough-winged swallow	*Stelgidopteryx serripennis*	IV	Stream banks in open areas
Eastern meadowlark	*Sturnella magna*	IV	Grassy fields (pastures, etc.)

Table 7.14. Scrub-shrub species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Shaggy coil	*Helicodiscus diadema*	I	Leaf litter near limestone-shale outcrops
Rubble coil	*Helicodiscus lirellus*	I	Limestone rubble in two locations
Northern pinesnake	*Pituophis melanoleucus*	I	Open hilly areas with sandy soils
Yellow-billed cuckoo	*Coccyzus americanus*	IV	Dense shrubby thickets
Kirtland's warbler	*Dendroica kirtlandii*	IV	Pine scrub (migration only)
Gray catbird	*Dumetella carolinensis*	IV	Ecotonal thickets and shrubby clearings
Willow flycatcher	*Empidonax traillii*	IV	Willow thickets near water
Wood thrush	*Hylocichla mustelina*	IV	Shrubby clearings within deciduous forest
Black-and-white warbler	*Mniotilta varia*	IV	Sapling stage of forest clearings

7.3.3.2. Status of Open Habitats

The 1997 NRI reports 139,000 acres (56,000ha) of cultivated cropland and 1.62 million acres (0.66 million ha) of noncultivated cropland, CRP, and pasture in the Ridge and Valley (USDA 2000). These totals do not include a total of 1.55 million acres (0.63 million ha) of federal land in the ecoregion (USDA 2000).

7.3.3.3. Trends in Open Habitats

According to USDA (2000), during the period from 1982 through 1997, cultivated cropland decreased by > 100,000 acres (> 40,000ha) and pastureland, CRP, and non-cultivated cropland decreased by > 40,000 acres (> 16,000ha). These totals do not include a total of 1.55 million acres (0.63 million ha) of federal land in the ecoregion. Please see Section 4.2.3.2 for statewide status and trends in open habitats for Virginia.

7.3.4. Barren Habitat Species of Greatest Conservation Need in the Ridge and Valley

7.3.4.1. Species of Greatest Conservation Need by Barren Habitat Type

Of the 20 tiered species that occur in barren or developed habitats in the Ridge and Valley, 13 occur primarily in developed residential areas (Table 7.15), eight occur in other barren areas (Table 7.16), and two occur on balds (Table 7.17).

Table 7.15. Developed habitat generalist species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Upland sandpiper	*Bartramia longicauda*	I	Airports, sod farms
Appalachian Bewick's wren	*Thryomanes bewickii*	I	Old farms, residential areas
Eastern black kingsnake	*Lampropeltis getula*	III	Residential neighborhoods
Eastern box turtle	*Terrapene carolina*	III	Residential neighborhoods
Chuck-will's-widow	*Caprimulgus carolinensis*	IV	Residential neighborhoods
Chimney swift	*Chaetura pelagica*	IV	Residential neighborhoods
Yellow-billed cuckoo	*Coccyzus americanus*	IV	Residential neighborhoods
Eastern wood-pewee	*Contopus virens*	IV	Residential neighborhoods
Gray catbird	*Dumetella carolinensis*	IV	Residential neighborhoods
Least weasel	*Mustela nivalis*	IV	Old farms, residential areas
Eastern spotted skunk	*Spilogale putorius*	IV	Residential neighborhoods
Northern rough-winged swallow	*Stelgidopteryx serripennis*	IV	Bridges
Brown thrasher	*Toxostoma rufum*	IV	Residential neighborhoods

Table 7.16. Other barren habitat species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Northern pinesnake	*Pituophis melanoleucus*	I	Rocky areas within pine forests
Appalachian Bewick's wren	*Thryomanes bewickii*	I	Rock outcroppings
Mountain earthsnake	*Virginia valeriae pulchra*	II	Rocky slopes within mixed forest areas
Eastern small-footed myotis	*Myotis leibii*	III	Sometimes roosts under rocks on the ground, in quarries
Timber rattlesnake	*Crotalus horridus*	IV	Ledges, rock slides
Allegheny woodrat	*Neotoma magister*	IV	Rock slides, talus
Eastern spotted skunk	*Spilogale putorius putorius*	IV	Rock slides
Northern rough-winged swallow	*Stelgidopteryx serripennis*	IV	Sand pits

Table 7.17. Balds species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Appalachian grizzled skipper	*Pyrgus centaureae wyandot*	I	Shale barrens with dwarf cinquefoil
Smooth greensnake	*Opheodrys vernalis*	III	High elevation balds and grassy areas

Beach Species of Greatest Conservation Need in the Ridge and Valley

Appropriate beaches do not occur in the Ridge and Valley.

7.3.4.2. Status of Barren and Developed Habitats

The 1997 NRI reports 320,000 acres (129,000ha) of urban and built-up land and 103,000 acres (41,000ha) of rural transportation infrastructure in the Ridge and Valley (USDA 2000). This does not include a total of 1.55 million acres (0.63 million ha) of federal lands in the ecoregion (USDA 2000).

7.3.4.3. Trends in Barren and Developed Habitats

Trends for most barren areas are not available. However, the NRI (USDA 2000) does track developed areas. Developed areas in the Ridge and Valley increased by > 100,000 acres (> 40,000 ha) between 1982-1997. See Section 4.2.3.3 for statewide status and trends of barren and developed areas in Virginia.

7.3.5. Wetland Species of Greatest Conservation Need in the Ridge and Valley

7.3.5.1. Species of Greatest Conservation Need by Wetland Type

Of the 41 tiered species that occur in Ridge and Valley wetlands, nine are generalists that may occur in either wetland type (Table 7.18). Of the remaining 31 species, four occur in emergent wetlands (Table 7.19), and 27 occur in wooded wetlands (Table 7.20).

Table 7.18. Wetland generalist species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Wood turtle	*Glyptemys insculpta*	I	Adjacent to clear streams
American black duck	*Anas rubripes*	II	Any wetland
Bald eagle	*Haliaeetus leucocephalus*	II	Large trees for nesting
Spotted turtle	*Clemmys guttata*	III	Shallow wetlands
Black-crowned night-heron	*Nycticorax nycticorax*	III	Nest in any vegetated wetland
Green heron	*Butorides striatus*	IV	Nests in wooded wetlands, forages in any but avoids open water
Willow flycatcher	*Empidonax traillii*	IV	Willow thickets near water
Eastern spadefoot	*Scaphiopus holbrookii*	IV	Vernal/temporary pools with sandy soil
Common ribbonsnake	*Thamnophis sauritus*	IV	Permanent/semi-permanent water

Table 7.19. Emergent wetland species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Northern harrier	*Circus cyaneus*	III	Fresh marshes
Least bittern	*Ixobrychus exilis*	III	Dense emergent vegetation (*Typha/Carex/Scirpa*)
Yellow warbler	*Dendroica petechia*	IV	Willow thickets near water
Virginia rail	*Rallus limicola*	IV	Shallow water, dense emergent cover

Table 7.20. Wooded wetland species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Indiana myotis	*Myotis sodalis*	I	Colonies in snags in sunlight; forages in wet or dry forest
Tiger salamander	*Ambystoma tigrinum*	II	Fishless ponds in wooded areas
Swainson's warbler	*Limnothlypis swainsonii*	II	Dense river swamp
Fisher	*Martes pennanti*	II	Forest with extensive clutter and litter
Mountain chorus frog	*Pseudacris brachyphona*	II	Seepage areas in wooded hills

Common Name	Scientific Name	Tier	Special Habitat Needs
Winter wren	*Troglodytes troglodytes*	II	Cool moist forest with thickets
Yellow-crowned night-heron	*Nyctanassa violacea*	III	Wooded wetland with open understory
Eastern box turtle	*Terrapene carolina*	III	Forest generalist
Jefferson salamander	*Ambystoma jeffersonianum*	IV	Shallow ponds in deciduous/mixed forest
Brown creeper	*Certhia americana*	IV	Mature montane spruce-fir (breeding)
Yellow-billed cuckoo	*Coccyzus americanus*	IV	Dense thickets in deciduous bottomland
Eastern wood-pewee	*Contopus virens*	IV	Seasonally-flooded bottomland forest
Gray catbird	*Dumetella carolinensis*	IV	Dense shrubs near water
Rusty blackbird (winter)	*Euphagus carolinus*	IV	Trees near marshes or wooded swamps
Worm-eating warbler	*Helmitheros vermivorus*	IV	Thick understory near water
Wood thrush	*Hylocichla mustelina*	IV	Mature forest
Black-and-white warbler	*Mniotilta varia*	IV	Hardwood swamps and bottomlands
Kentucky warbler	*Oporornis formosus*	IV	Dark, wooded swamps
Northern parula	*Parula americana*	IV	Wooded swamps with tree moss present
Rose-breasted grosbeak	*Pheuctitus ludovicianus*	IV	Deciduous wooded swamps
Scarlet tanager	*Piranga olivacea*	IV	Mature bottomland forest
Prothonotary warbler	*Protonotaria citrea*	IV	Open wooded swamps with snags
Queen snake	*Regina septemvittata*	IV	Water with overhanging branches
American woodcock	*Scolopax minor*	IV	Moist or wet woods near wetlands
Louisiana waterthrush	*Seiurus motacilla*	IV	Wooded streams or wooded swamps
Diana fritillary	*Speyeria diana*	IV	Streamside forests with *Viola* spp.
Yellow-throated vireo	*Vireo flavifrons*	IV	Wooded swamps

7.3.5.2. Status and Trends of Wetlands

Wetlands are rare in the Ridge and Valley. According to the 1992 NLCD (USGS 1992), the Ridge and Valley contains 1817ha of wooded and shrubby wetlands and 1655ha of emergent wetlands.

Trends of wetlands are not currently available at an ecoregional level for Virginia. Please see Section 4.2.3.4 for statewide status and trends of wetlands in Virginia.

7.4. Aquatic Species in the Ridge and Valley

7.4.1. Ridge and Valley-Clinch EDU

The Ridge and Valley-Clinch River EDU (Figure 7.22) is part of the Tennessee-Cumberland freshwater ecoregion, which is considered "globally outstanding" in terms of biological distinctiveness (Abell et al. 2000). Abell et al. (2000) also considered this freshwater ecoregion to have the conservation status of "Endangered." The Tennessee drainage contains the most diverse fish assemblage in North America (Jenkins and Burkhead 1994). There is a high level of endemism in this freshwater ecoregion, with 29% of the fish, 16% of the mussels, and 62% of the crayfish considered to be endemic (Abell et al. 2000).

The Clinch River flows 251km in Virginia before entering Tennessee (Jenkins and Burkhead 1994). Shortly after entering Tennessee, it joins with the Powell and is impounded into the Norris Reservoir. The Clinch largely drains the Ridge and Valley, with some tributaries flowing off the Cumberland Mountain

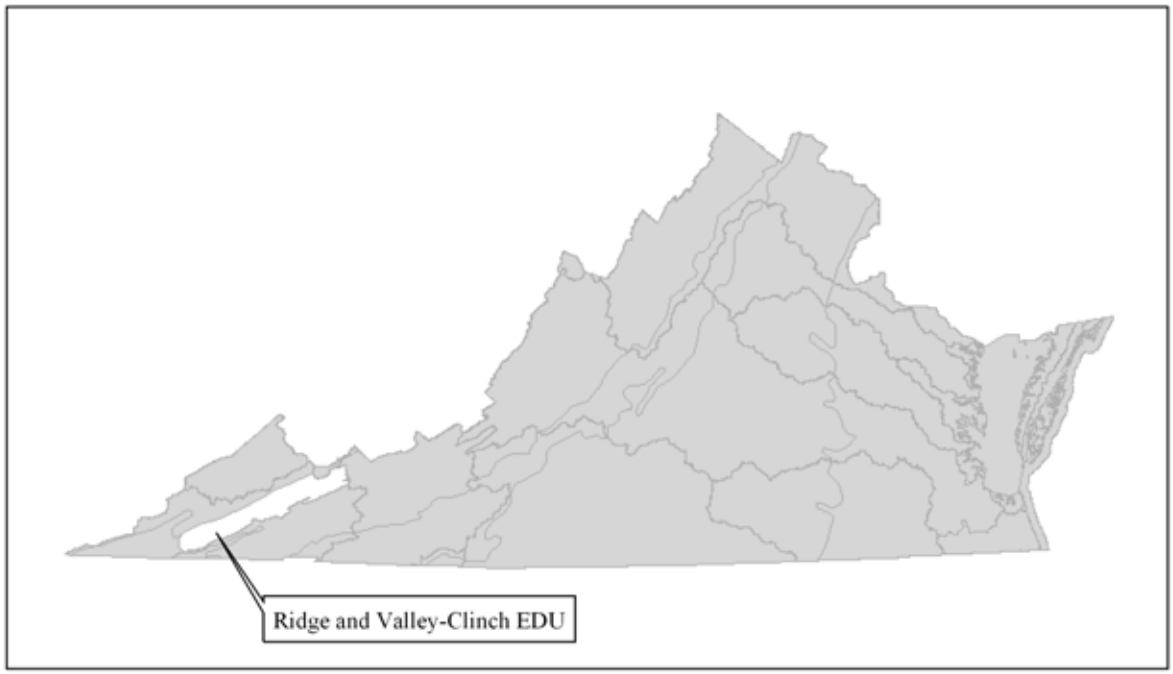

Figure 7.22. Location of the Ridge and Valley-Clinch EDU.

ecoregions, and approximately the last half of the mainstem flowing through the Southern Cumberland Mountain ecoregion.

7.4.1.1. Tier I Species in the Ridge and Valley-Clinch EDU

7.4.1.1.1. Ashy darter, *Etheostoma cinereum*

Life History Summary

Much of what is known about the ashy darter was determined by one study (Shepard and Burr 1984). Food items include aquatic insect larvae and oligochaete worms. It is believed that the papillose lips of this species are modifications for food detection. The maximum life span is slightly more than four years. Ashy darter probably spawns in late February to mid-April (Shepard and Burr 1984; Jenkins and Burkhead 1994). This species has been designated a species of concern by the Virginia Field Office of USFWS.

Location

The ashy darter is widespread but localized in the Tennessee and Cumberland drainages (Shepard and Burr 1984). Burkhead and Jenkins (1991) considered it to be extirpated from the state. It was collected near the Tennessee border in 1992 (DGIF 2004b), so it is uncertain whether it occurs in this EDU. The map of locations for this species (Figure 7.23) includes DCR-NH Stream Conservation Units (DCR-NH 2005).

Description of Essential Habitat

The ashy darter is found in streams and rivers of moderate gradient that are typically clear (Jenkins and Burkhead 1994). It has been found in both cool and warm water.

This species is extremely rare in Virginia and determining essential habitat would be difficult. In its only Virginia location, it occurs in runs with slow to moderate current, less than one meter deep (P. L. Angermeier, VCFWRU, pers. comm.). Etnier and Starnes (1993) stated that this species was found in small to medium upland rivers of 0.5 to 2m in depth, with boulders and a sluggish current. Jenkins and Burkhead

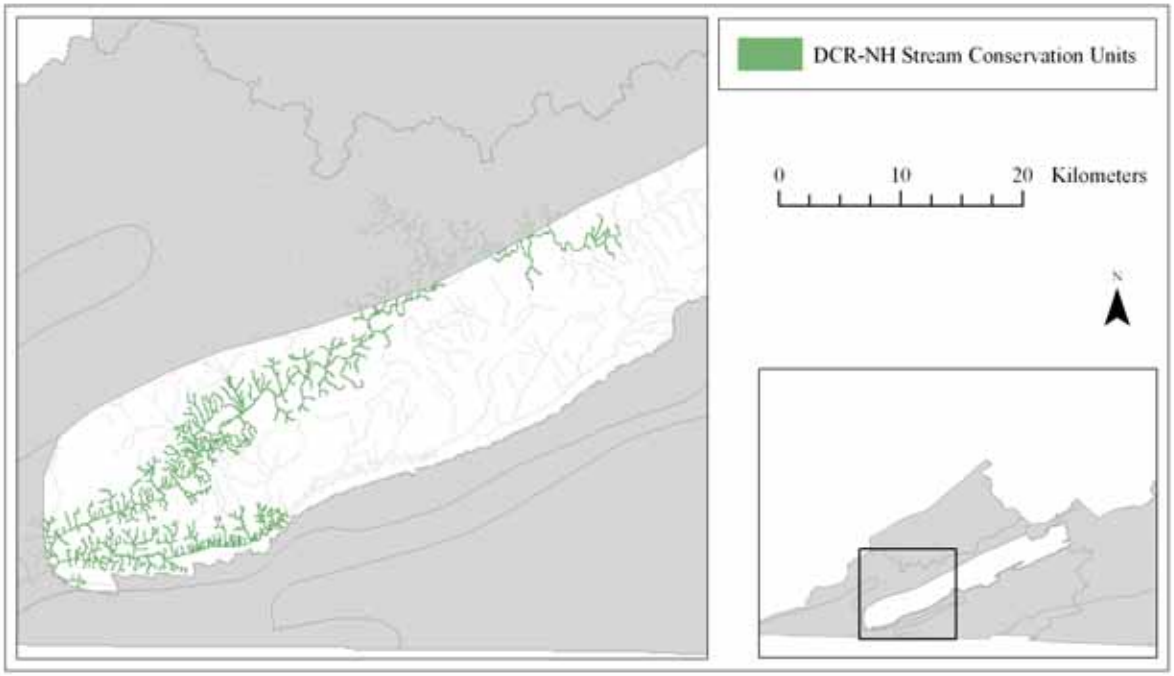

Figure 7.23. Location of the Stream Conservation Unit containing the ashy darter in the Ridge and Valley-Clinch EDU (DCR-NH 2005).

(1994) added that it was found in streams and rivers of moderate gradient that are typically clear. The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in one habitat type (Table 7.21).

Table 7.21. DGIF aquatic habitat types used by the ashy darter in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	1

Relative Condition of Habitat

The entire Virginia range of the ashy darter is found in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

Historic declines in this species are believed to have been caused by impoundment and siltation (Etnier and Starnes 1993). These threats continue to affect the habitat of ashy darter.

Fish TAC (2004) did not identify any specific threats for the ashy darter. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

Improvements in water quality and land use practices could positively affect the habitat required by the ashy darter. Fish TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

Fish TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to the ashy darter.

7.4.1.1.2. Duskytail darter, *Etheostoma percnurum*

Life History Summary

The duskytail darter feeds largely on benthic invertebrates. Layman (1991) found its longevity to be two years. It appears that most spawning takes place in April and May (Jenkins and Burkhead 1994). The duskytail darter lays a single tier of clustered eggs while inverted under cobble slabs in depths of at least 55cm. This species is very vulnerable to extirpation from short-term and/or localized habitat alterations (e.g. chemical spills) due to its limited range, habitat specificity, and relatively short life span (USFWS 1993). This species is legally protected with the status of Federal and State threatened.

Location

The duskytail darter is endemic to the upper Tennessee and middle Cumberland drainages. According to Jenkins and Burkhead (1994) only six relict populations exist: one in Virginia (Copper Creek) and five in Tennessee. The map depicting locations for this species (Figure 7.24) includes confirmed reaches from Collections (DGIF 2004b) and potential habitat based on link magnitude, reach elevation and gradient attributes within DGIF's aquatic habitat classification. See Appendix D for more details.

Description of Essential Habitat

The duskytail darter is found in larger, warm streams of moderate gradient that are typically clear (Jenkins and Burkhead 1994). Stream width ranges from 10 to 80m. It occurs in gently flowing pools with depths of 0.3 to 1.2m that are near riffles and have large rocks (Etnier and Starnes 1993). The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in three habitat types (Table 7.22). Most of the occurrences were in very low gradient small streams.

Table 7.22. DGIF aquatic habitat types used by the duskytail darter in the Clinch-Powell watershed.

Aquatic Habitat Type	**Number of Reaches**
Very low gradient small stream connected to another small stream	6
Very low gradient large stream connected to another large stream	2
Very low gradient small river connected to another small river	1

Relative Condition of Habitat

Approximately half of the known habitat for the duskytail darter is impaired by fecal coliform or *E. coli* from unknown sources (DEQ and DCR 2004).

Specific Threats and Trends

Burkhead and Jenkins (1991) list siltation, agricultural runoff, and impoundment as threats to the duskytail darter. USFWS (1993) agreed that siltation from coal mining and adverse land use practices have contributed to the loss of this species. They also list other water pollutants and impoundments as threats to this species. Competition with the fantail darter *Etheostoma flabellare* may also be a threat (Burkhead and Jenkins 1991).

Fish TAC (2004) did not identify any specific threats for the duskytail darter. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

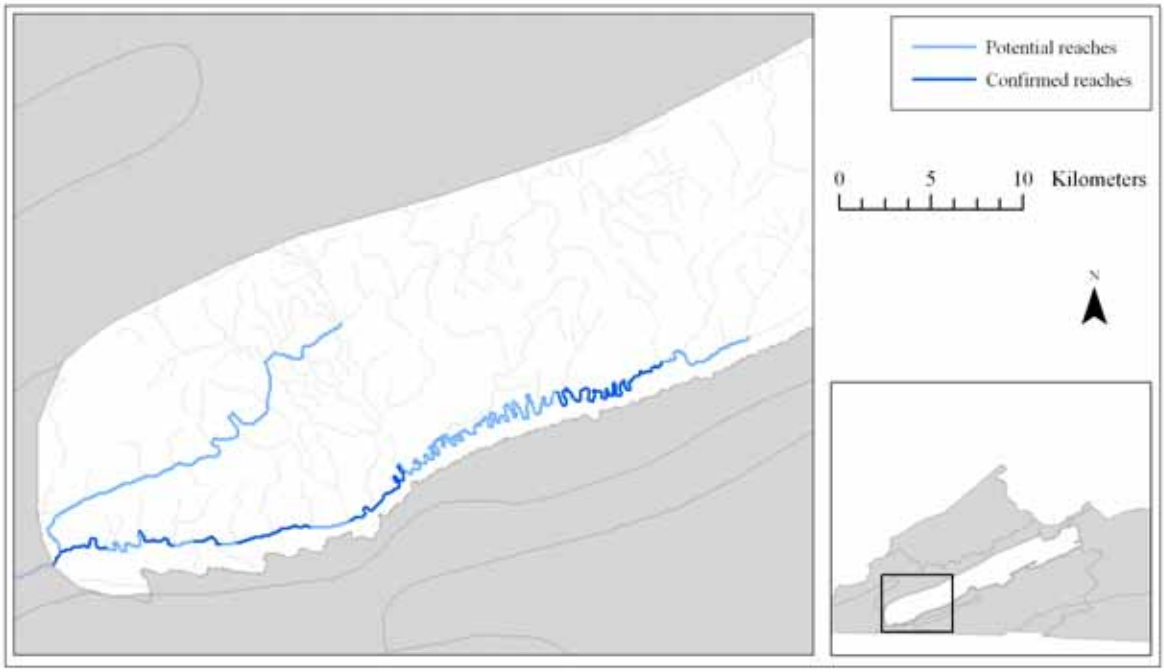

Figure 7.24. Location of confirmed and potential duskytail darter habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Conservation Actions and Strategies

Burkhead and Jenkins (1991) recommended identifying and then correcting the sources of riparian erosion in the watershed. The USFWS recovery plan listed several actions and research and monitoring needs for the recovery of this species (USFWS 1993). The conservation actions included utilizing existing legislation and regulations to protect the species, developing and utilizing an education program, alleviating identified threats, and establishing five viable populations within its range through reintroduction and protection.

Fish TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

USFWS (1993) identified four general categories of research and monitoring needed for the duskytail darter. These include searching for new populations, monitoring existing populations, determining its requirements at various life history stages, and determining threats to the species. More details can be found in this recovery plan (USFWS 1993).

Fish TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to the duskytail darter.

7.4.1.1.3. Yellowfin madtom, *Noturus flavipinnis*

Life History Summary

This species is endemic to the Ridge and Valley region of the Tennessee drainage. Two life history studies have been completed for the yellowfin madtom (Jenkins 1975; Shute 1984). This madtom was found to eat mostly aquatic insect larvae during both day and night. Its life expectancy is about five years. Spawning occurs from about mid-May to Mid-July. This species is legally protected, with the status of Federal and State threatened.

Location

The habitat map for the yellowfin madtom (Figure 7.25) includes confirmed reaches from Collections (DGIF 2004b), potential reaches, and critical habitat (USFWS 2004). Potential reaches were selected in DGIF's aquatic habitat classification using magnitude of confirmed link, downstream link, reach elevation, and gradient variables. See Appendix D for more details.

Description of Essential Habitat

The yellowfin madtom is found in small streams to medium or large rivers (Jenkins and Burkhead 1994). They are found in warm water and the warm-cool water transition. This madtom prefers quiet water, usually pools and backwaters beside runs and riffles. Preferred cover is large, flat rocks, under which nests are spawned and defended (Dinkins and Shute 1996). The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in four habitat types (Table 7.23). The majority of the records were in very low gradient small streams.

Table 7.23. DGIF aquatic habitat types used by the yellowfin madtom in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small stream connected to another small stream	11
Very low gradient large stream connected to another large stream	3
Very low gradient small stream connected to a large stream	1
Low gradient headwater connected to a large stream	1

Relative Condition of Habitat

Most of the known habitat for this species in this EDU is impaired or is downstream of an impaired reach (DEQ and DCR 2004). The impairments are largely fecal coliform, but there are some instances of general standard (benthics) impairment. The sources of impairment are urban, unknown, or resource extraction.

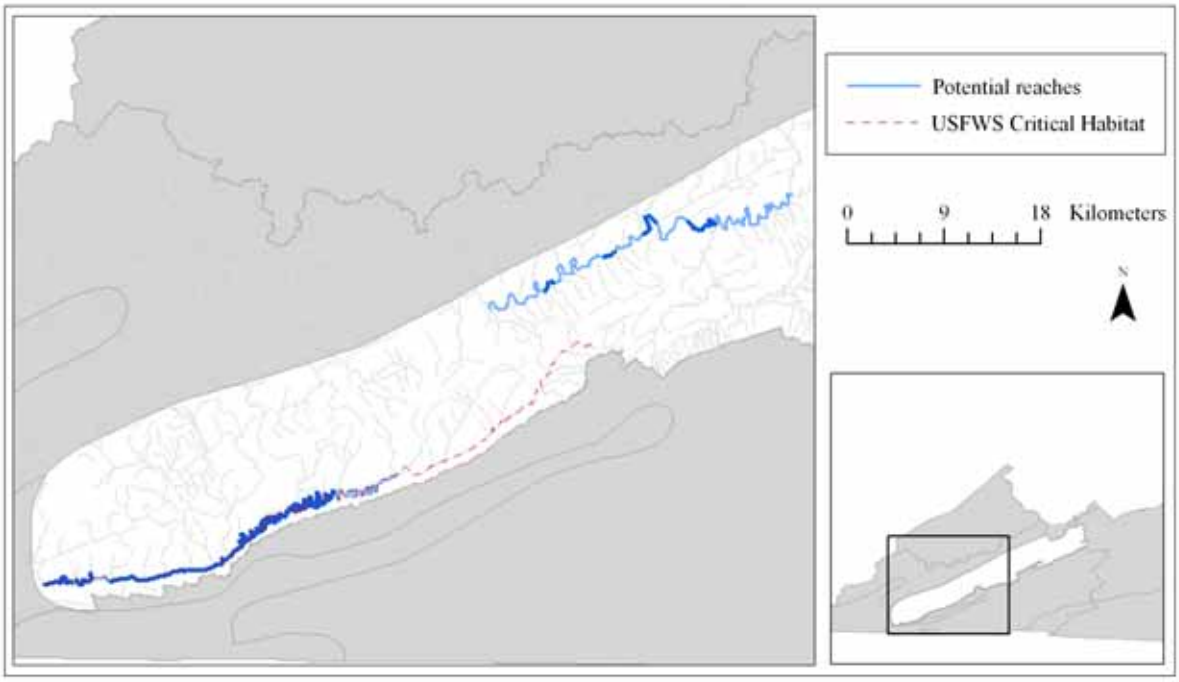

Figure 7.25. Confirmed and potential habitat and USFWS critical habitat for the yellowfin madtom in the Ridge and Valley-Clinch EDU (DGIF 2004b; USFWS 2004).

Specific Threats and Trends

This species seems to be most affected by habitat degradation from siltation, agricultural runoff, and impoundment (Burkhead and Jenkins 1991). Siltation and water quality degradation from mining activities are also threats to this species (USFWS 1983h).

Fish TAC (2004) did not identify any specific threats for the yellowfin madtom. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

The USFWS (1983h) recovery plan for the yellowfin madtom listed several actions necessary for the recovery of the species. These included research and monitoring needs, which are listed in the next section. Their highest priority action is to utilize existing legislation and regulations to protect the species and its habitat. One conservation action from the recovery plan was to preserve populations and currently occupied habitat. Also, once feasibility is determined, this species should be introduced into its historic range. Lastly, sites should be located and techniques developed and implemented for habitat improvement.

Fish TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

The yellowfin madtom recovery plan lists several research or monitoring projects necessary for the recovery of the species (USFWS 1983h). One of the projects is to determine the feasibility of reestablishing the species in its native range. The next is to conduct life history studies as needed. The document also discussed the need to identify areas for habitat improvement. Monitoring tasks included monitoring population levels and habitat conditions, as well as the success of the recovery plan.

Fish TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to the yellowfin madtom.

7.4.1.1.4. Birdwing pearlymussel, *Lemiox rimosus*

Life History Summary

The birdwing pearlymussel is rare throughout its range and considered extremely rare in Virginia (Neves 1991b). It is relatively small, to 50mm in length, with a subtriangular to subovate shape (Parmalee and Bogan 1998). Its shell is very thick and very slightly inflated. Evidence suggests that it is bradytictic, or a long-term brooder, becoming gravid in the fall and holding the glochidia through the winter (Ortmann 1916). The glochidia are released in June or July. Research by TVA (1986) suggests that the banded darter *Etheostoma zonale* and the greenside darter *E. blennioides* are possible fish hosts. This species is legally protected with the status of Federal and State endangered. While its correct accepted scientific name is *Lemiox rimosus*, this species is still listed as *Conradilla caelata* in the Code of Federal Regulations (50 CFR 17.11).

Location

The map of habitat for this species (Figure 7.26) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Potential reaches were determined using reach size and connectivity attributes within DGIF's aquatic habitat classication. See Appendix D for more details.

Description of Essential Habitat

The birdwing pearlymussel is a riffle-dwelling species, preferring moderate to fast flowing water of shallow to moderate depth (USFWS 1983b). It is found in small to medium rivers with sand and gravel

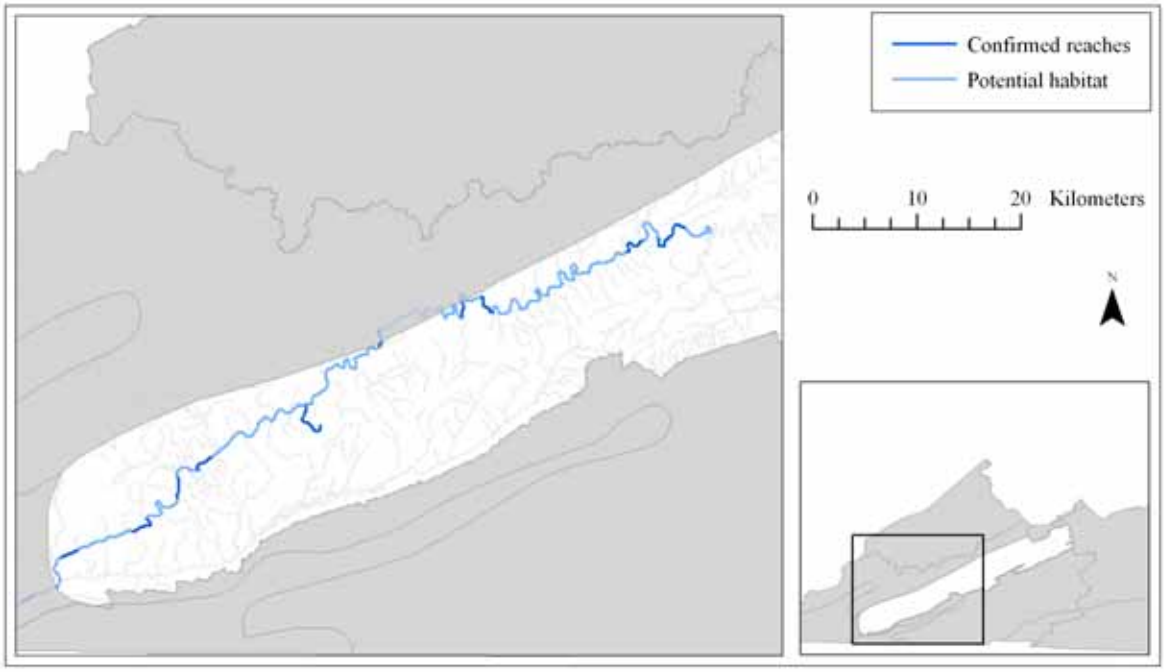

Figure 7.26. Location of confirmed and potential birdwing pearlymussel habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

substrate (Parmalee and Bogan 1998). The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in three habitat types (Table 7.24). All of the records were in large streams and small rivers.

Table 7.24. DGIF aquatic habitat types used by the birdwing pearlymussel in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	11
Very low gradient large stream connected to another large stream	5
Very low gradient large stream connected to another small river	1

Relative Condition of Habitat

The recovery plan for the birdwing pearlymussel describes some issues related to past and current conditions of its habitat (USFWS 1983b). All habitat for this species in this EDU is found in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

The recovery plan identifies impoundment as the greatest contributor to the loss of this species (USFWS 1983b). Impoundment affects this species through habitat alteration (i.e. reduction of flow and altered temperatures). Siltation is also listed as a strong contributing factor in the decline of this species. The sources of siltation included coal mining activities, farming, logging, and road construction. The third factor listed is water pollution from agricultural, municipal, and industrial discharges. Extremely small population sizes also threaten the viability of this species in the Clinch and Powell Rivers (Neves 1991b).

Mussel TAC (2004) did not identify any specific threats for the birdwing pearlymussel. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

The USFWS (1983b) recovery plan identified several high priority tasks to support the recovery of the birdwing pearlymussel. These tasks represent both conservation actions and research and monitoring needs. The top conservation action on the list is to continue to utilize existing legislation and regulations to protect species and habitat. Other actions include reintroducing the species into native rivers where feasible and implementing habitat improvement techniques where appropriate.

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

The USFWS (1983b) recovery plan identified several research or monitoring needs for the recovery of the birdwing pearlymussel. The top two are identification of current and foreseeable threats and conducting life history studies. Other needs include determining the feasibility of reintroducing this species to its native waters, determining the need and appropriate techniques for habitat improvement, developing and implementing a program to monitor populations and habitats, and monitoring the success of the recovery program overall (USFWS 1983b).

Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to the birdwing pearlymussel.

7.4.1.1.5. Fanshell, *Cyprogenia stegaria*

Life History Summary

The fanshell is rare throughout its range and is extremely rare in Virginia. It has an inflated, somewhat rounded shell with a maximum length of 55mm (Lipford 1991). The life history of this species is not well known. It is believed to be a long-term brooder. Its fish host is unknown (Parmalee and Bogan 1998). Most of the existing populations of the fanshell are geographically isolated and small, reducing the genetic viability of the species (USFWS 1991). This, coupled with the dramatic decline of the species across its range, could lead to its extinction in coming years (Lipford 1991). This species is legally protected with the status of Federal and State endangered.

Location

The map of fanshell habitat (Figure 7.27) includes confirmed reaches from Collections (DGIF 2004) and potential habitat using link magnitude from DGIF's aquatic habitat classification. See Appendix D for more details.

Description of Essential Habitat

The fanshell is found in medium to large rivers and is associated with coarse sand and gravel substrates (Ortmann 1919; Ahlstedt 1984; Dennis 1985). It occurs in both shoals and riffles with strong current. The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species is found in two habitat types, very low gradient small rivers and large streams (Table 7.25).

Table 7.25. DGIF aquatic habitat types used by the fanshell in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	12
Very low gradient large stream connected to another large stream	3

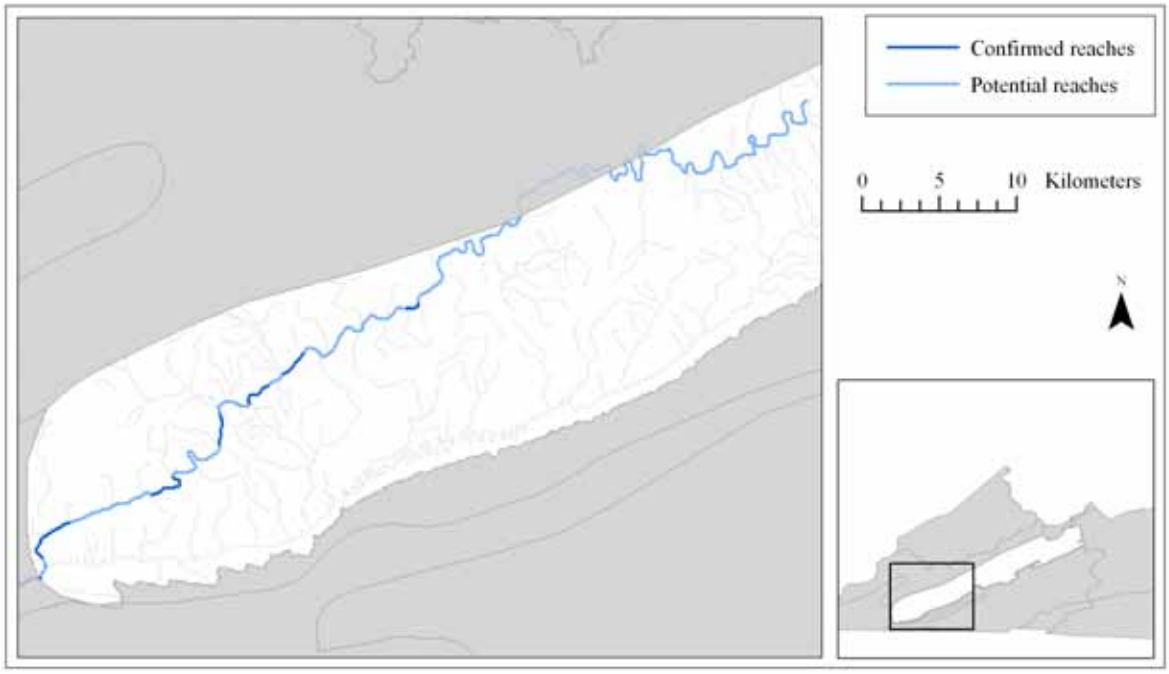

Figure 7.27. Confirmed and potential fanshell habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Relative Condition of Habitat

The recovery plan for the fanshell describes some issues related to past and current conditions of its habitat (USFWS 1991). All known habitat for this species is found in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

Historic declines of the fanshell have been caused by the impacts of impoundments, pollution, and habitat alteration (USFWS 1991). These stresses may have affected the fanshell both directly and indirectly through the loss of its fish host. Lipford (1991) identified the degradation of water quality from a variety of sources as the greatest current threat to the species. The USFWS recovery plan also indicated that small population size is a serious threat to the viability of the species (USFWS 1991).

Mussel TAC (2004) did not identify any specific threats to the fanshell. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

Lipford (1991) has made several recommendations for the recovery of the fanshell. Specific conservation actions include protecting and restoring the habitat of the species (including that of its fish hosts), improving water quality in the Clinch River, and implementing and enforcing BMPs for forestry and agriculture. The USFWS recovery plan also lists conservation actions as well as research and monitoring needs for the fanshell (USFWS 1991). The highest priority actions include utilizing existing legislation and regulations to protect species and its habitat and developing techniques and appropriate sites for reintroduction.

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

As so little is known of the fanshell, there are some critical research projects needed to protect this species. One is to conduct needed species management and recovery research, including determining habitat requirements, life history and biology, and threats analysis (Lipford 1991; USFWS 1991). The second is to search for additional populations and appropriate habitat. Lipford (1991) goes on to recommend expanding water quality monitoring stations in the Clinch River.

Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific for fanshell.

7.4.1.1.6. Dromedary pearlymussel, *Dromus dromas*

Life History Summary

The dromedary pearlymussel is rare throughout its range and exceptionally rare in Virginia (Neves 1991g). It has two forms or types, including an inflated large river type and a more compressed headwater form (USFWS 1983c). It can reach lengths of 90 to 100mm, with a subtriangular or subelliptical shape (Parmalee and Bogan 1998). This mussel is a long-term brooder (bradytictic). Fish hosts are unknown, though Neves (1991g) suggests from a personal communication with B. Yeager (TVA) that the gilt darter *Percina evides* is a possibility. The dromedary pearlymussel is believed to have been one of the more common species in the Tennessee River historically, based on samples found at aboriginal sites (Parmalee and Bogan 1998). This species is legally protected with the status of Federal and State endangered.

Location

The map of habitat for this species (Figure 7.28) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches selected using reach size, connectivity and gradient attributes in the DGIF aquatic habitat classification. See Appendix D for more details.

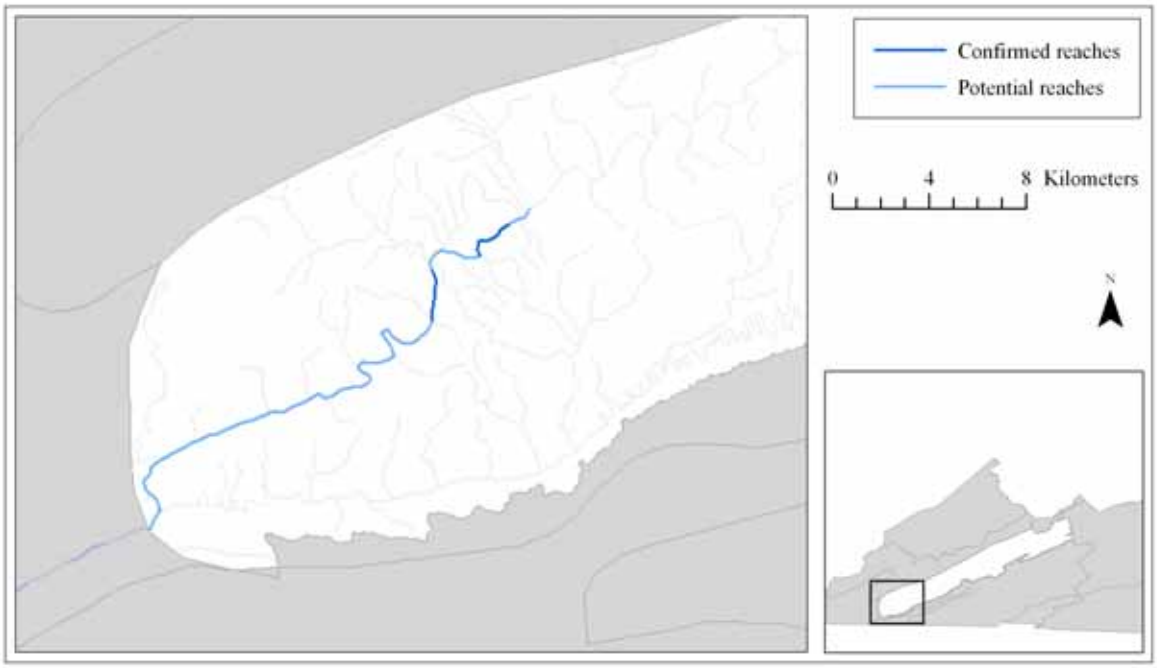

Figure 7.28. Location of confirmed and potential dromedary pearlymussel habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Description of Essential Habitat

As with many other Cumberlandian mussels, the dromedary pearlymussel is a riffle-dwelling species. It typically inhabits shoals with moderate current but has been taken in deeper, slow moving waters in Tennessee (USFWS 1983c). It seems to prefer silt-free substrates of mixed sizes including sand and cobble (Neves 1991g). The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in two habitat types representing small rivers and large streams (Table 7.26).

Table 7.26. DGIF aquatic habitat types used by the dromedary pearlymussel in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	5
Very low gradient large stream connected to another large stream	5

Relative Condition of Habitat

The recovery plan for the dromedary pearlymussel describes some issues related to past and current conditions of its habitat (USFWS 1983c). All habitat for this species in this EDU is found in or downstream of waters impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

The recovery plan for the dromedary pearlymussel lists the impoundment of Tennessee drainage mainstem and tributaries as the factor that has contributed most to this species' decline (USFWS 1983c). Siltation is a continuing threat and ranks second in the list of threats or factors in the species' decline. Pollutants from various sources, including industrial, municipal, and agricultural, are also considered a threat to this species. Natural resource extraction including coal, oil and gas are believed to have an impact on this species. Neves (1991g) indicated that populations of this species in the Clinch and Powell Rivers have fallen below viable numbers.

Mussel TAC (2004) did not identify any specific threats for the dromedary pearlymussel. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

The recovery plan for the dromedary pearlymussel indicates that the top priority conservation action is to continue to utilize existing legislation and regulations to protect species and habitat (USFWS 1983c). Neves (1991g) recommends improving water quality in the Powell River including updating water treatment plants, reducing coal mining waste dumping, and enforcing requirements of discharge permits. He also indicated that improving water quality in the Clinch River from "fair to good" to "good to excellent" would be beneficial for many mussel species.

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

The USFWS (1983c) recovery plan recommends two high priority research or monitoring projects for the dromedary pearlymussel. These include determining present and future threats and conducting life history studies as needed.

Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to the dromedary pearlymussel.

7.4.1.1.7. Cumberlandian combshell, *Epioblasma brevidens*

Life History Summary

The Cumberlandian combshell is extremely rare throughout its range. It is a medium-sized mussel, reaching an average length of 50mm (Parmalee and Bogan 1998). It is quadrangular or rhomboid in shape and very solid. It exhibits a bradytictic reproductive cycle (Ahlstedt 1991c). Some fish hosts have been identified, including greenside darter *Etheostoma blennioides*, spotted darter *E. maculatum*, redline darter *E. rufilineatum*, Tennessee snubnose darter *E. simoterum*, logperch *Percina caprodes*, banded sculpin *Cottus carolinae*, and wounded darter *E. vulneratum* (Yeager 1987; Neves 1991f; Yeager and Saylor 1995). This species is legally protected with the status of Federal and State endangered.

Location

The map of habitat for this species (Figure 7.29) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches selected using link magnitude and the link magnitude of downstream reaches from the DGIF aquatic habitat classification. See Appendix D for more details.

Description of Essential Habitat

Neves (1991f) describes the habitat of the Cumberlandian combshell as medium-sized streams with gravel shoals and riffles. This species appears to be absent from smaller tributaries. The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in two habitat types (Table 7.27). All occurrences were in small rivers and large streams.

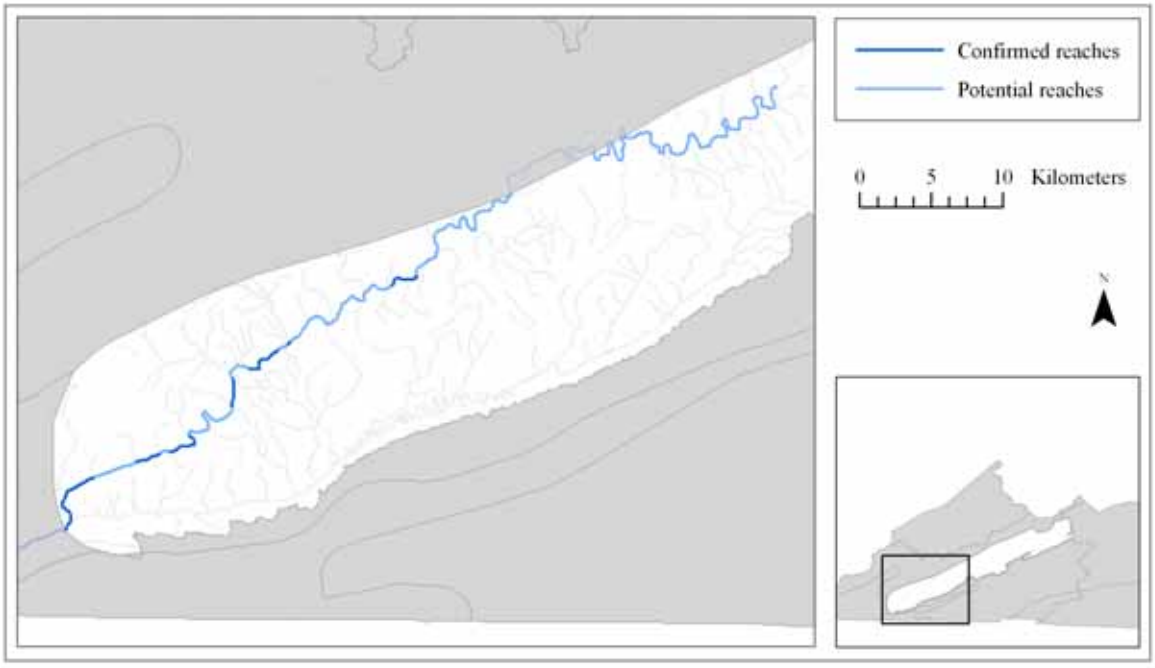

Figure 7.29. Confirmed and potential Cumberlandian combshell habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Table 7.27. DGIF aquatic habitat types used by the Cumberlandian combshell in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	18
Very low gradient large stream connected to another large stream	7

Relative Condition of Habitat

All known habitat for this species is found in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

The reasons for the decline of this species are not well documented or understood (Neves 1991f). However, poor water quality and habitat alteration from siltation and pollution are believed to be its biggest problems. Members of this genus appear to be very sensitive to alteration in environmental quality and are the first to drop out of a faunal assemblage when environmental disturbance occurs (Dennis 1987).

Mussel TAC (2004) did not identify any specific threats for the Cumberlandian combshell. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

Neves (1991f) recommended that measures must be taken to protect habitat from further degradation. The draft recovery plan that includes this species listed four high priority conservation actions, including continuing to use existing legislation and regulations to protect the species and its habitats, soliciting help to protect the species and associated habitat through the development of cooperative partnerships with a range of entities, developing cooperative projects with private landowners to improve and restore riparian habitats using USFWS and USDA programs, and developing a public outreach and education program with an aquatic ecosystem and community-based watershed focus (USFWS 2003).

While Mussel TAC (2004) did not list any species-specific conservation actions for this species, they identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

The draft recovery plan that includes this species indicated four high priority research and monitoring needs for the Cumberlandian combshell (USFWS 2003). These include investigating the need for management activities including habitat improvement, conducting detailed anatomical and genetic analyses throughout the range of the species, surveying for additional populations and appropriate habitat, and conducting a feasibility analysis of augmenting existing populations and reintroducing the species to suitable habitats.

Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to the Cumberlandian combshell.

7.4.1.1.8. Oyster mussel, *Epioblasma capsaeformis*

Life History Summary

The oyster mussel is extremely rare throughout its range. Populations in the Clinch and Powell rivers are rapidly declining, probably due to degradation of water quality (Dennis 1991b). This is a relatively small to medium-sized mussel (50-70mm) of elliptical or irregularly obovate shape (Dennis 1991b; Parmalee and Bogan 1998). This species is bradytictic. Fish hosts include the spotted darter *Etheostoma maculatum*, redline darter *E. rufilineatum*, wounded darter *E. vulneratum*, dusky darter *Percina sciera*, and banded

sculpin *Cottus carolinae* (Yeager 1987; Yeager and Saylor 1995). This species is legally protected with the status of Federal and State endangered.

Location

The map of habitat for the oyster mussel (Figure 7.30) includes confirmed reaches from Collections (DGIF 2004b) and potential habitat using variables (link magnitude, reach elevation and gradient) from DGIF's aquatic habitat classification. See Appendix D for more details.

Description of Essential Habitat

As with other members of this genus, the oyster mussel inhabits riffle or shoal habitats of small to medium-sized streams with silt-free gravel substrate (Dennis 1991b). The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in four habitat types (Table 7.28). The majority of the records were in small rivers and large streams.

Table 7.28. DGIF aquatic habitat types used by the oyster mussel in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	20
Very low gradient large stream connected to another large stream	8
Low gradient large stream connected to another large stream	1
Very low gradient small stream connected to a large stream	1

Relative Condition of Habitat

All of the known habitat for this species is found in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

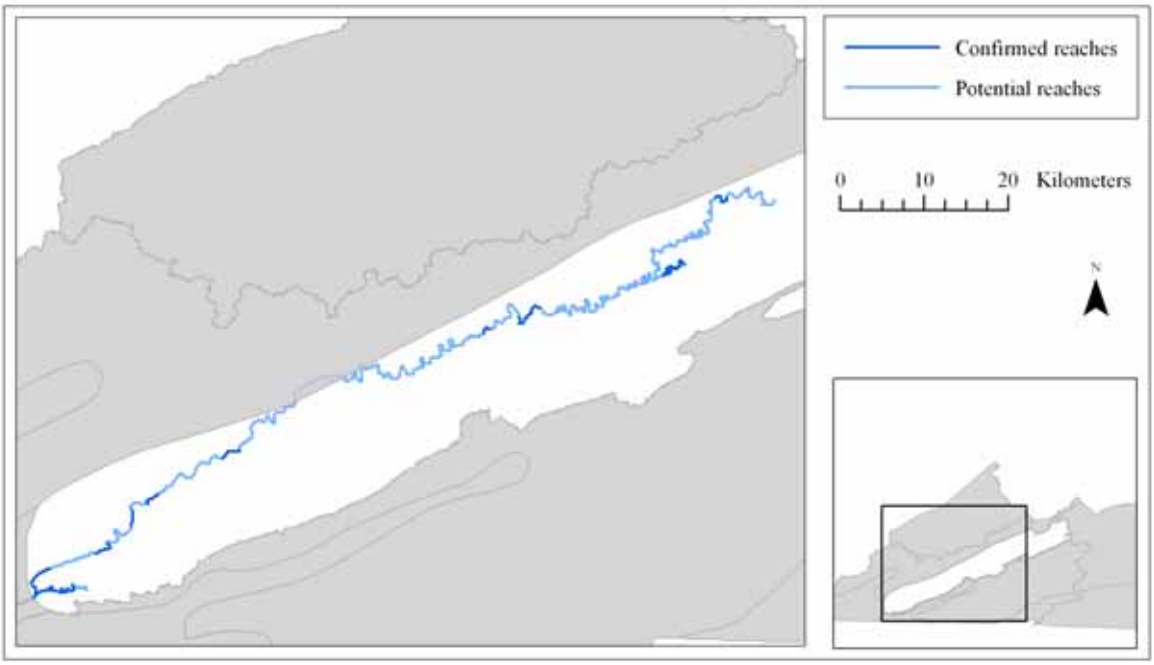

Figure 7.30. Location of confirmed and potential oyster mussel habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Specific Threats and Trends

This genus is more sensitive to water quality and habitat alterations than other genera of mussels (Dennis 1987). Therefore, the relatively recent decline of this species is likely due to changes in water quality, though not enough is known about the specific habitat requirements of this species to identify threats with any certainty (Dennis 1991b). Likely causes for the decline of the oyster mussel are siltation, industrial and municipal effluent pollution, mine wastes, and agricultural and urban runoff.

Mussel TAC (2004) did not identify any specific threats for the oyster mussel. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

Dennis (1991b) postulated that, due to the low numbers of this species, it might be too late to save it from extinction. However, actions that were recommended (and that would likely benefit many aquatic species) include protecting and improving habitat for this species and its fish hosts.

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

Little is known of the habitat needs of the oyster mussel and subsequently the threats to this species (Dennis 1991b). Therefore, assessment of basic habitat requirements and causes of decline are needed.

Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to the oyster mussel.

7.4.1.1.9. Tan riffleshell, *Epioblasma florentina walkeri*

Life History Summary

The tan riffleshell is extremely rare throughout its range. Its decline in Virginia is believed to be due to habitat degradation (Dennis 1991c). It is a relatively small mussel, rarely exceeding 60mm in length (Parmalee and Bogan 1998). It is obovate or irregularly elliptical. There is little life history information for this subspecies. Based on the life history of related *Epioblasma* species, it is probably bradytictic. Watson and Neves (1996) found that the greenside darter *Etheostoma blennioides*, fantail darter *E. flabellare*, redline darter *E. rufilineatum*, and sculpin *Cottus* sp. were fish hosts for this subspecies. This species is legally protected with the status of Federal and State endangered.

Location

The map of locations for this species (Figure 7.31) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Potential reaches were selected using link magnitude, the link magnitude of downstream reaches and gradient within DGIF's aquatic habitat classification. See Appendix D for more details.

Description of Essential Habitat

This subspecies occurs in headwater, small, and medium-sized streams of the Tennessee drainage in substrates of coarse sand, gravel and some silt (Parmalee and Bogan 1998). They prefer areas with current and water depths of < 3ft (1m). The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in four habitat types (Table 7.29).

Figure 7.31. Confirmed and potential tan riffleshell habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Table 7.29. DGIF aquatic habitat types used by the tan riffleshell in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient large stream connected to another large stream	2
Low gradient small stream connected to a large stream	1
Low gradient large stream connected to another large stream	1
Very low gradient small stream connected to another small stream	1

Relative Condition of Habitat

The recovery plan for this species provides information about past and recent habitat quality. The entire range of known habitat is impaired or is downstream of an impaired reach (DEQ and DCR 2004). The impairments are primarily fecal coliform, with some instances of *E. coli* and general standard (benthics) impairment. The sources of these impairments are primarily urban with some resource extraction.

Specific Threats and Trends

The greatest threats to the tan riffleshell in Virginia are channelization of the Middle Fork of the Holston River and industrial development in Marion and Chilhowie (Dennis 1991c). Additional current threats include: siltation from erosion, agriculture, construction, and channelization; effluent pollution from industries and municipalities; and agricultural and urban runoff (USFWS 1984e; Dennis 1991c).

Mussel TAC (2004) did not identify any specific threats for the tan riffleshell. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

The recovery plan for the tan riffleshell lists three high priority conservation actions for recovery (USFWS 1984e). These include preserving the population and its habitat in the Middle Fork Holston River, coordinating with governmental agencies to determine the potential effects of ongoing and proposed

projects on this subspecies and its habitat, and recommending corrective measures to entities responsible for threats to the population. Dennis (1991c) stresses the importance of habitat protection as well.

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I). They did not identify anything specific to the tan riffleshell.

Research and Monitoring Needs

Dennis (1991c) cautioned that biological research may adversely affect the tan riffleshell. However, the recovery plan indicates the need for some studies (USFWS 1984). In particular, it recommends determining the species current distribution and range, describing habitat requirements for all life stages, documenting the effects of threats, and conducting life history research.

Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to the tan riffleshell.

7.4.1.1.10. Green blossom pearlymussel, *Epioblasma torulosa gubernaculum*

Life History Summary

The green blossom pearlymussel is extremely rare throughout its range (Dennis 1991a), and may be extinct. It is a medium-sized mussel (up to 65mm) with an irregularly ovate, elliptical or obovate shape (Parmalee and Bogan 1998). The life history of this mussel is not well known; however, it is probably bradytictic, (Dennis 1991a). This species is legally protected with the status of Federal and State endangered.

Location

The map of habitat for this species (Figure 7.32) includes confirmed reaches from Collections (DGIF 2004b) and potential habitat selecting using attributes (reach size and connectivity) from DGIF's aquatic habitat classification. See Appendix D for more details.

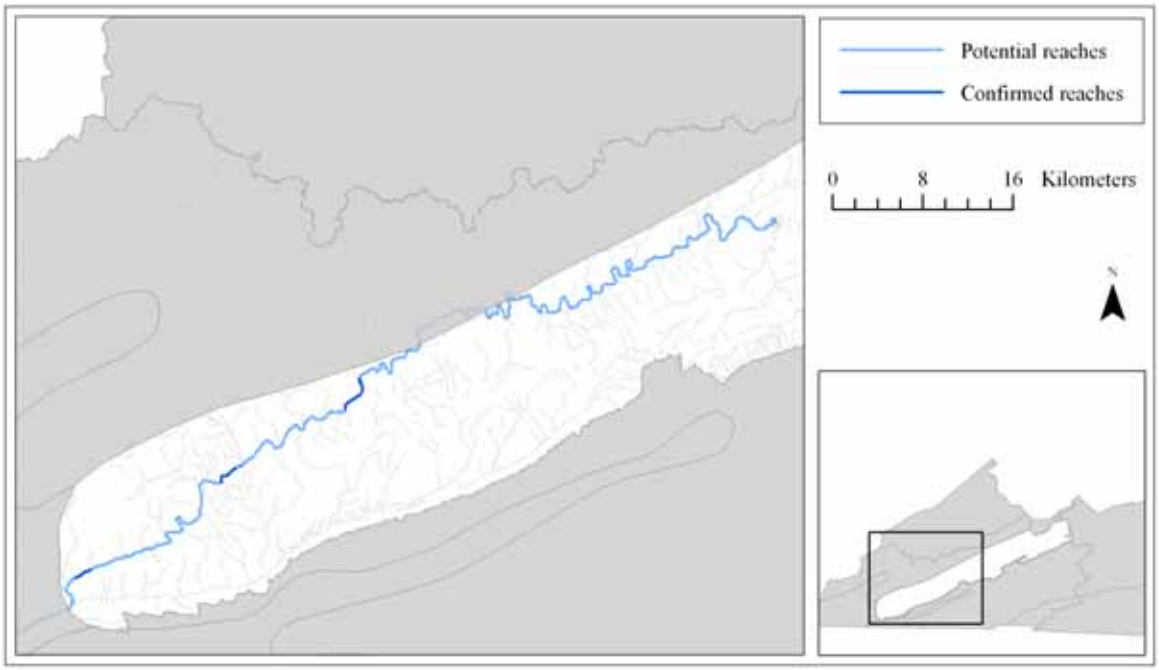

Figure 7.32. Confirmed and potential green blossom pearlymussel habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Description of Essential Habitat

The green blossom pearlymussel is a lotic species found in fast flowing water with riffles and shoals (Dennis 1991a). It appears to prefer a silt-free gravel substrate. The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in one habitat type (Table 7.30).

Table 7.30. DGIF aquatic habitat types used by the green blossom pearlymussel in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	6

Relative Condition of Habitat

The recovery plan for the green blossom pearlymussel describes some issues related to the past and current conditions of its habitat (USFWS 1984c). All habitat for this species in this EDU is impaired or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

If not extinct, this species is most threatened by habitat and water quality degradation (Dennis 1991a). Its historic decline is most likely due to the impoundment of the Tennessee and Cumberland drainages; siltation from mining activities, dredging, agriculture, logging, and road construction; and general water pollution from industrial, agricultural, and urban sources (USFWS 1984c).

Mussel TAC (2004) did not identify any specific threats for the green blossom pearlymussel. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

Dennis (1991a) indicated that the only strategy to possibly protect such a rare species is habitat protection and recovery. Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I), but nothing specific to the green blossom pearlymussel.

Research and Monitoring Needs

Several research or monitoring projects were recommended in the recovery plan for the green blossom pearlymussel, including determining the feasibility of reintroducing the species within its historic range; conducting life history studies; determining the necessity and techniques for habitat improvement; and developing and implementing a program to monitor populations and habitat conditions (USFWS 1984c).

Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to the green blossom pearlymussel.

7.4.1.1.11. Shiny pigtoe, *Fusconaia cor*

Life History Summary

The shiny pigtoe is very rare in Virginia and rare throughout its range (Neves 1991l). Its decline is likely due to habitat degradation. Adult size ranges from 60-80mm, and the shell is typically subtriangular (Neves 199l; Parmalee and Bogan 1998). This mussel is tachytictic (Kitchel 1985). Kitchel (1985) listed these fish

hosts: telescope shiner *Notropis telescopus*, warpaint shiner *Luxilus coccogenis*, and common shiner *L. cornutus*. This species is legally protected with the status of Federal and State endangered.

Location

The map of shiny pigtoe habitat (Figure 7.33) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Potential habitat was selected using attributes (link magnitude, link magnitude of downstream reaches, and gradient) in DGIF's aquatic habitat classification. See Appendix D for details.

Description of Essential Habitat

The shiny pigtoe occurs in fords, shoals, and other shallow areas of riverine habitats with moderate to swift current (Bogan and Parmalee 1983). It can be found in stable substrates with anything from sand to cobbles. The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in three habitat types (Table 7.31).

Relative Condition of Habitat

The recovery plan for the shiny pigtoe describes issues related to past and current conditions of its habitat (USFWS 1983e). All known habitat for this species is found in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Table 7.31. DGIF aquatic habitat types used by the shiny pigtoe in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	31
Very low gradient large stream connected to another large stream	9
Very low gradient small stream connected to another small stream	2

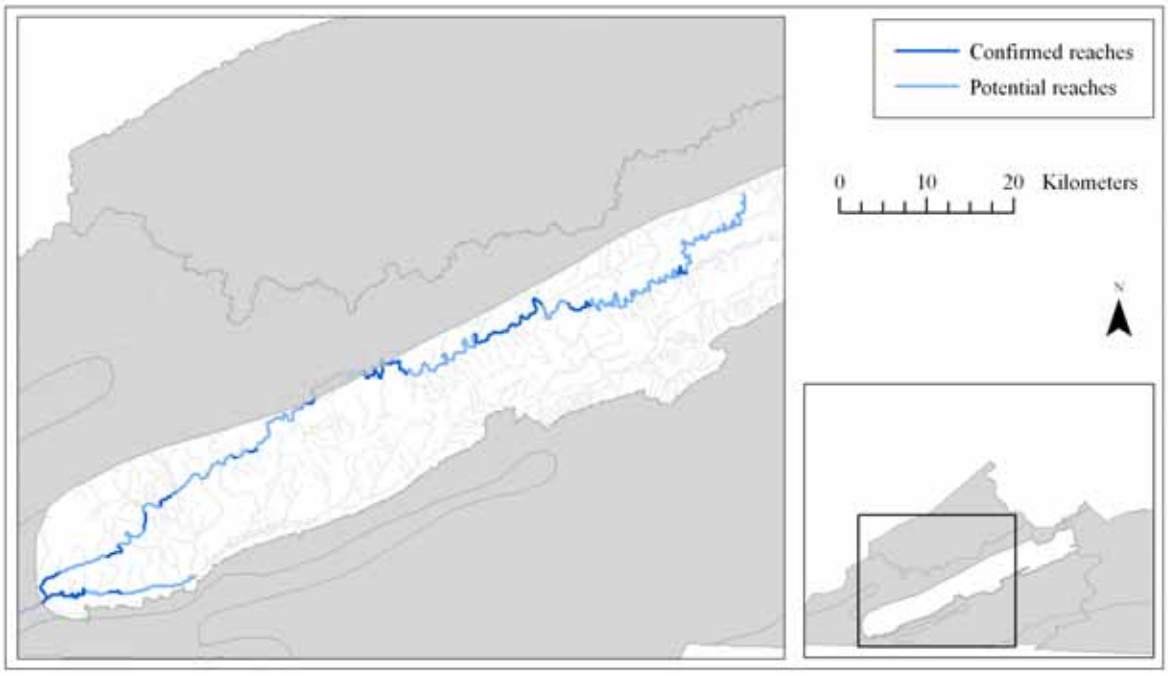

Figure 7.33. Confirmed and potential shiny pigtoe habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Specific Threats and Trends

The recovery plan for the shiny pigtoe identifies impoundments, siltation and general water pollution as contributing factors in the decline of this species (USFWS 1983e). Current threats include the water quality and sedimentation effects of mining activities, general water quality degradation (especially fecal coliform levels), and catastrophic toxic spills (Neves 1991l).

Mussel TAC (2004) did not identify any specific threats for the shiny pigtoe. However, it identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

Neves (1991l) recommends strict enforcement of existing water quality regulations to improve water and habitat quality. The recovery plan for the shiny pigtoe recommends two high priority conservation actions (USFWS 1983e): protection of existing populations and habitats, and mitigation or elimination of current threats.

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I), but nothing specific to the shiny pigtoe.

Research and Monitoring Needs

The recovery plan (USFWS 1983e) recommends that life history studies be completed. Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). It did not identify anything specific to the shiny pigtoe.

7.4.1.1.12. Fine-rayed pigtoe, *Fusconaia cuneolus*

Life History Summary

The fine-rayed pigtoe is very rare in Virginia and throughout its range (Neves 1991h). It is subtriangular in shape and may reach 80mm (Parmalee and Bogan 1998). The fine-rayed pigtoe is tachytictic. Laboratory research has indicated that the river chub *Nocomis micropogon*, white shiner *Luxilus albeolus*, telescope shiner *Notropis telescopus*, Tennessee shiner *N. leuciodus*, central stoneroller *Campostoma anomalum*, fathead minnow *Pimephales promelas*, and mottled sculpin *Cottus bairdi* could serve as hosts for glochidia of this species (Bruenderman 1989). This species is believed to live up to 35 years. This species is legally protected with the status of Federal and State endangered.

Location

The map of fine-rayed pigtoe habitat (Figure 7.34) includes confirmed reaches Collections (DGIF 2004b) and potential reaches. Potential habitat was selected using attributes (link magnitude and link magnitude of downstream reaches, as well as gradient) within DGIF's aquatic habitat classification. See Appendix D for more details.

Description of Essential Habitat

Neves (1991h) indicated that the fine-rayed pigtoe is a lotic, riffle-dwelling species that is typically found in shallow ford and shoal areas with moderate gradient. The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in three habitat types representing small rivers and large streams (Table 7.32).

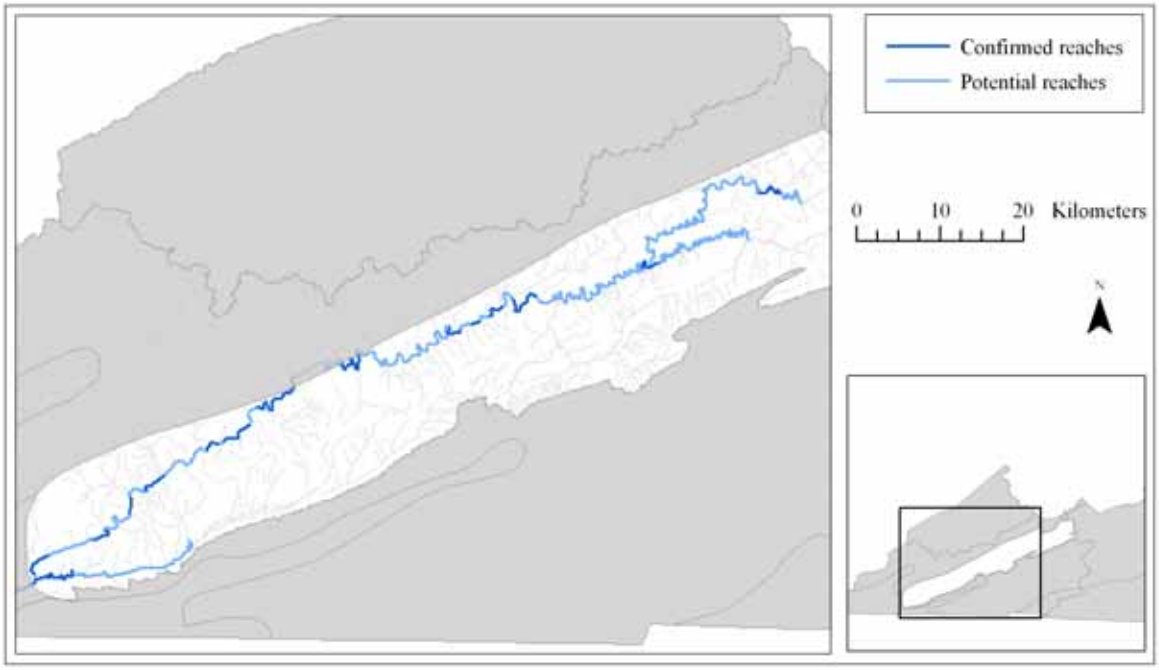

Figure 7.34. Location of confirmed and potential fine-rayed pigtoe habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Table 7.32. DGIF aquatic habitat types used by the fine-rayed pigtoe in the Clinch-Powell watershed EDU.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	30
Very low gradient large stream connected to another large stream	8
Low gradient large stream connected to another large stream	1

Relative Condition of Habitat

The recovery plan for the fine-rayed pigtoe describes some issues related to past and current conditions of its habitat (USFWS 1984b). All habitat for this species in this EDU is found in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

Industrial development and agriculture has likely caused the historic declines in the fine-rayed pigtoe (USFWS 1984b). This development was the source of impoundments, mining wastes, herbicides, pesticides, siltation, and channelization. Existing populations are threatened by oil and gas drilling, impacts of coal mining, fecal coliform pollution, and siltation (Neves 1991h).

Mussel TAC (2004) did not identify any specific threats to the fine-rayed pigtoe. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

Neves (1991h) suggests that recolonizing the section of the Clinch River between Carbo and St. Paul would help to ensure the viability of the population in Virginia. In general, improvements in water quality would help populations in both the Clinch and Powell Rivers. Specifically, the following actions would increase

the viability of this species: upgrades to sewage treatment plants, expedition of reclamation of mined lands, elimination of the dumping of coal wastes into the river, and strict enforcement of permitted discharges.

The recovery plan for the fine-rayed pigtoe lists three high priority recovery actions: mitigating or eliminating current and future foreseeable threats, enforcing existing state and federal laws and regulations, and protecting known habitats and populations (USFWS 1984b). Details are available in USFWS (1984b).

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I), but nothing specific to the fine-rayed pigtoe.

Research and Monitoring Needs

The recovery plan for the fine-rayed pigtoe recommends that current and future threats be identified (USFWS 1984b). Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to the fine-rayed pigtoe.

7.4.1.1.13. Cracking pearlymussel, *Hemistena lata*

Life History Summary

Throughout its range, the cracking pearlymussel is very rare (Neves 1991c). It is extremely rare in Virginia, largely due to habitat degradation and reduced reproduction in the Clinch and Powell rivers. It is medium-sized, with a maximum length of approximately 90mm (Parmalee and Bogan 1998). Its shell is elongate, elliptical or subrhomboid. The shell is thin but strong. This species is tachytictic (Ortmann 1915). This species is protected, with the status of Federal and State endangered.

Location

The map of habitat for the cracking pearlymussel (Figure 7.35) includes confirmed habitat from Collections (DGIF 2004b) and potential habitat selected using link magnitude and link magnitude of downstream reaches within DGIF's aquatic habitat classification. See Appendix D for more details.

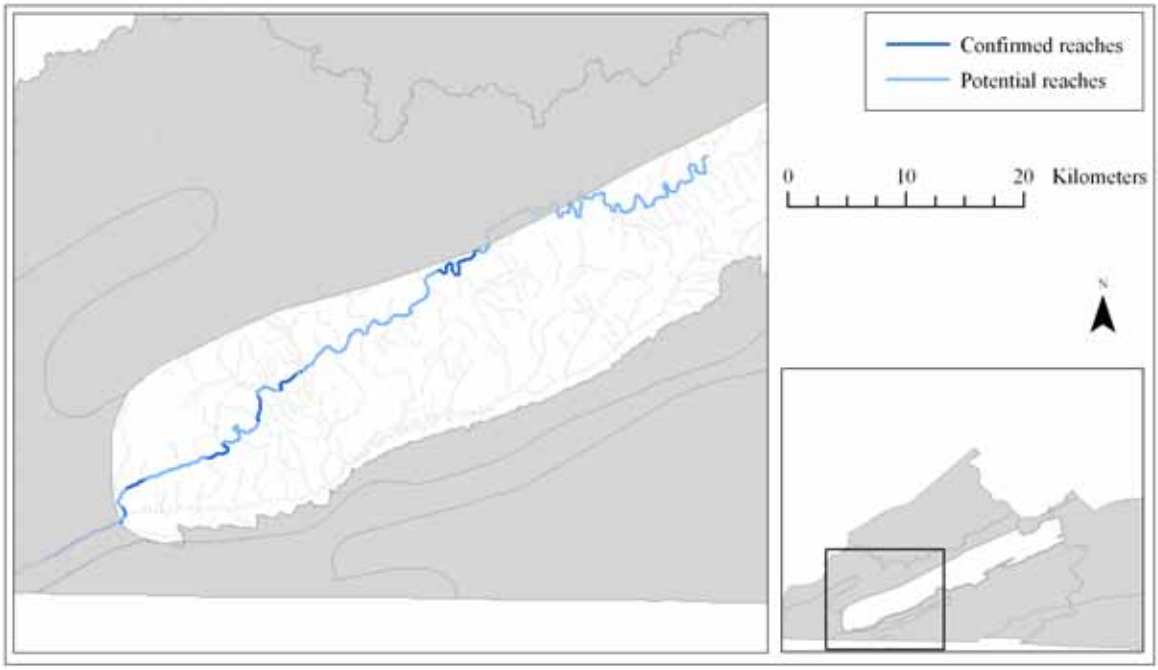

Figure 7.35.Confirmed and potential cracking pearlymussel habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Description of Essential Habitat

The cracking pearlymussel appears to prefer unimpounded stretches of medium-sized rivers. It generally occurs in shallow areas of less than two feet of water and moderate current (Parmalee and Bogan 1998). It is typically buried in mud, sand, or fine gravel. The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in two habitat types (Table 7.33).

Table 7.33. DGIF aquatic habitat types used by the cracking pearlymussel in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	14
Very low gradient large stream connected to another large stream	3

Relative Condition of Habitat

The recovery plan for the cracking pearlymussel describes some issues related to past and current conditions of its habitat (USFWS 1990b). All habitat for this species in this EDU is found in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

Three factors—impoundments, siltation, and water pollution—likely contributed to the decline of the cracking pearlymussel (USFWS 1990b; Neves 1991c). Declines in water quality currently threaten this species (Neves 1991c). Oil and gas drilling and coal mining may also be affecting the cracking pearlymussel. Mussel TAC (2004) did not identify any specific threats for the cracking pearlymussel. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

Any improvement in water quality is likely to positively affect this and many other mussel species (Neves 1991c). The recovery plan for the cracking pearlymussel identified four high priority conservation actions necessary for the species' recovery: continuing to utilize existing legislation and regulations to protect this species and its habitat; developing and presenting educational programs; developing techniques and reintroducing the species to appropriate habitats within its native range; and developing and implementing cryopreservation (USFWS 1990b).

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

Studies are needed to ascertain important life history requirements and traits; to identify areas with reproducing individuals, and search for additional existing populations and habitat (USFWS 1990b; Neves 1991c). Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to the cracking pearlymussel.

7.4.1.1.14. Pink mucket, *Lampsilis abrupta*

Life History Summary

The pink mucket is likely extirpated from Virginia (Neves 1991j). It is most often found in large rivers (Parmalee and Bogan 1998). This species can reach lengths of 110-120mm, and shells are subquadrate or orbicular in shaper and often inflated. It is bradytictic (Ortmann 1912, 1919). Fish hosts are not well known

but may include the sauger *Stizestedion canadense* and freshwater drum *Aplodinotus grunniens* (Fuller 1974). This species is legally protected with the status of Federal and State endangered.

Location

The map of habitat for the pink mucket (Figure 7.36) includes one confirmed reach, based on a collection of a fresh dead specimen at Pendleton Island (B. Watson, DGIF, pers.comm.). Currently this species is believed extirpated.

Description of Essential Habitat

The pink mucket is typically found in riffles of large rivers with depths of < 3ft (1m), rocky substrate, and fast current (Ortman 1919; Hickman 1937). It has only been found in one reach in this EDU (Figure 7.36). That reach was classified under the DGIF aquatic habitat classification as a very low gradient small river connected to another small river (type 441).

Relative Condition of Habitat

The recovery plan for the pink mucket describes some issues related to past and current conditions of its habitat (USFWS 1985). The historical habitat of this species is in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

As a large river species, the pink mucket has been dramatically affected by impoundments (USFWS 1985). It was known to occur in at least 25 rivers historically, but is now known from only 16 rivers. Siltation and degraded water quality were also listed as reasons for this species decline.

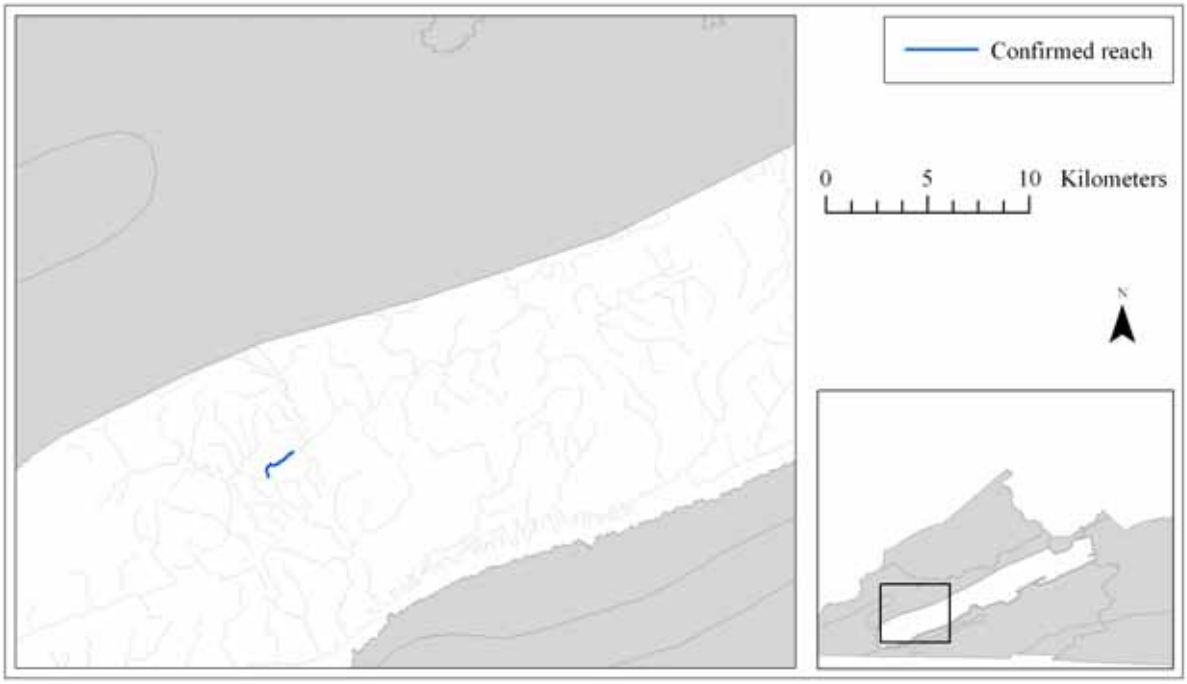

*Figure 7.36.*Confirmed pink mucket habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b). This specimen was freshly dead.

Mussel TAC (2004) did not identify any specific threats for pink mucket. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

The recovery plan for the pink mucket lists one high priority conservation action: the continued enforcement and utilization of existing legislation and regulation (USFWS 1985). Please see the recovery plan for further conservation actions.

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

The recovery plan does not indicate any high priority research or monitoring needs (USFWS 1985). Please see the recovery plan for other research and monitoring needs.

Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to the pink mucket.

7.4.1.1.15. Little-wing pearlymussel, *Pegias fabula*

Life History Summary

The little-wing pearlymussel is very rare throughout its range and extremely rare in Virginia (Ahlstedt 1991a). Its decline appears to be related to habitat degradation and limited reproduction. It is small with a maximum length of about 35mm. Based on evidence collected by Ortmann (1914), this species is bradytictic. Fish hosts are not known for this species though likely hosts include the banded sculpin *Cottus carolinae* and redline darter *Etheostoma rufilineatum* (Ahlstedt 1986). This species is legally protected with the status of Federal and State endangered.

Location

The map of habitat for this species (Figure 7.37) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Within DGIF's aquatic habitat classification, potential habitat was selected based on the link magnitude of the confirmed reach and of its downstream reach, as well as gradient. See Appendix D for more details.

Description of Essential Habitat

The little-wing pearlymussel is a riffle-dwelling species (Ahlstedt 1991a). It is found in headwater, high gradient streams. The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in three habitat types representing small and large streams (Table 7.34).

Table 7.34. DGIF aquatic habitat types used by the little-wing pearlymussel in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small stream connected to another small stream	3
Very low gradient large stream connected to another large stream	1
Moderate gradient large stream connected to another large stream	1

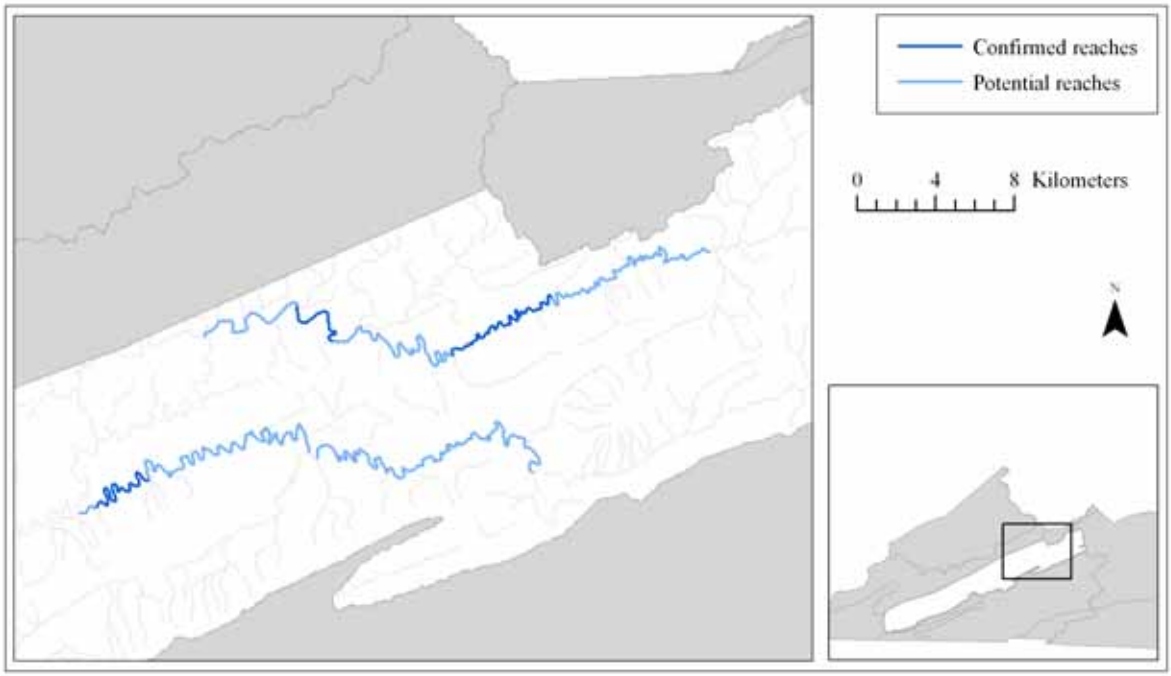

Figure 7.37. Confirmed and potential little-wing pearlymussel habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Relative Condition of Habitat

The recovery plan for the little-wing pearlymussel describes some issues related to past and current habitat conditions (USFWS 1989a). All known habitat for this species is found in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform, *E. coli*, or general standard (benthics), and the sources of impairment are largely unknown or urban, with some instances of agriculture and resource extraction.

Specific Threats and Trends

As with other freshwater mussels, historic declines are thought to be due to impoundments, siltation, and pollution (USFWS 1989a). Some populations in Virginia are believed to be close to extirpation (Ahlstedt 1991a). Others are likely threatened by logging, oil and gas drilling and exploration, and overcollecting.

Mussel TAC (2004) did not identify any specific threats for the little-wing pearlymussel. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

Ahlstedt (1991a) states that, for the continued existence of the little-wing pearlymussel in Virginia, upper reaches of the North Fork of Holston and Clinch rivers must remain pristine. The recovery plan for the little-wing pearlymussel described two necessary high priority conservation actions: continued utilization of existing legislation and regulations for species and habitat protection, and the development and presentation of education programs (USFWS 1989a).

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

The only research project listed as high priority in the little-wing pearlymussel recovery plan is to conduct life history studies necessary for the management of the species (USFWS 1989a). Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J), but did not identify anything specific to little-wing pearlymussel.

7.4.1.1.16. Rough pigtoe, *Pleurobema plenum*

Life History Summary

The rough pigtoe may be extirpated from Virginia and is rare throughout its range (Neves 1991k). It reaches 75-80mm in length, and is inflated and subtriangular in shape (Parmalee and Bogan 1998). This species is tachytictic based on collection of gravid females in May (Ortmann 1919). Fish hosts are unknown (Parmalee and Bogan 1998). This species is legally protected with the status of Federal and State endangered.

Location

The map of rough pigtoe habitat (Figure 7.38) includes a confirmed reach from Collections (DGIF 2004b).

Description of Essential Habitat

This species is mostly found in large rivers; however, it can become established in small or medium-sized rivers, like the upper Clinch (Parmalee and Bogan 1998). It is found in substrates of gravel and sand. The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in one habitat type (Table 7.35).

Relative Condition of Habitat

The recovery plan for the rough pigtoe describes some issues related to past and current conditions of its habitat (USFWS 1984d). The historic habitat for this species is in or downstream of impaired waters (DEQ

Figure 7.38. Confirmed rough pigtoe habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Table 7.35. DGIF aquatic habitat types used by the rough pigtoe in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	1

and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

Although it is not certain, it appears that historic and current declines in the rough pigtoe are due to impoundments, siltation, and pollution (USFWS 1984d). Mussel TAC (2004) did not identify any specific threats for the rough pigtoe. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

The recovery plan for this species recommended utilizing existing legislation and regulations to protect the rough pigtoe and its habitat (USFWS 1984d). Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

A high priority research need identified in the recovery plan for the rough pigtoe is the identification of present and foreseeable future threats (USFWS 1984d). Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J). They did not identify anything specific to rough pigtoe.

7.4.1.1.17. Rough rabbitsfoot, *Quadrula cylindrica strigillata*

Life History Summary

The rough rabbitsfoot is widespread but uncommon throughout its range (Kitchel 1991). Its occurrence in Virginia is localized. The shell of this species is elongate and rhomboid or rectangular in shape, and individuals may reach 120mm (Parmalee and Bogan 1998). This species is tachytictic (Parmalee and Bogan 1998). Yeager and Neves (1986) listed the following fish hosts for this species: whitetail shiner *Notropis galacturus*, spotfin shiner *Notropis spilopterus*, and bigeye chub *Hybopsis amblops*. This species is legally protected with the status of Federal and State endangered.

Location

The map of locations for this species (Figure 7.39) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Potential reaches were selected using link magnitude, downstream link magnitude and gradient in the DGIF aquatic habitat classification. See Appendix D for more details.

Description of Essential Habitat

The rough rabbitsfoot is typically collected in small to medium-sized rivers in clear, shallow water (Parmalee and Bogan 1998). It seems to prefer shoal and riffle areas near banks with sand and gravel substrate. The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in six habitat types (Table 7.36). The majority of occurrences were in small rivers and large streams.

Table 7.36. DGIF aquatic habitat types used by the rough rabbitsfoot in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	29
Very low gradient large stream connected to another large stream	17
Very low gradient small stream connected to another small stream	2
Very low gradient small stream connected to a large stream	1
Low gradient large stream connected to another large stream	1
Low gradient small stream connected to a large stream	1

Relative Condition of Habitat

The recovery plan for the rough rabbitsfoot describes some issues related to past and current conditions of its habitat (USFWS 2003). All habitat for this species in this EDU is found in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

The decline of the rough rabbitsfoot is partially attributable to pollution from mining, other industry, municipalities, and toxic spills (Cairns et al. 1971). Other factors that have universally affected freshwater mussels are impoundment, siltation, and channelization (Kitchel 1991). Current threats to this subspecies include degraded water, degraded substrate quality, and contaminants (USFWS 2003). The restricted range of this and other mussels makes them especially vulnerable to toxic spills and negative effects of genetic isolation.

Mussel TAC (2004) did not identify any specific threats to the rough rabbitsfoot. However, they identified several threats to the Clinch and Powell River drainages (Appendix H).

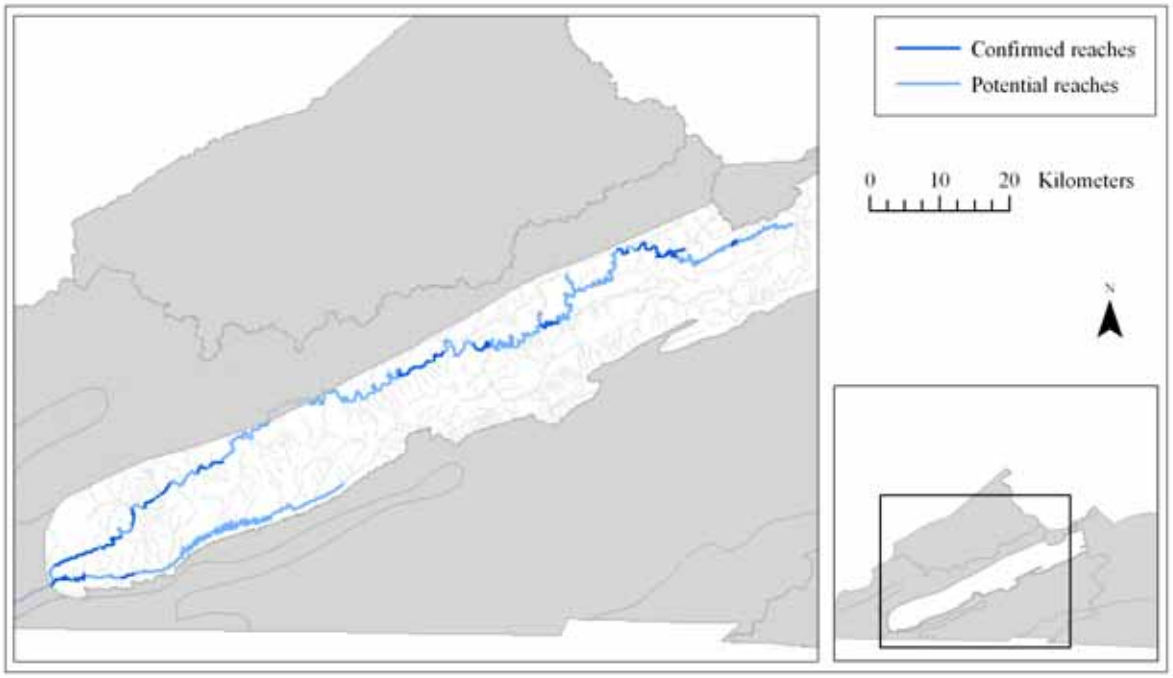

*Figure 7.39.*Confirmed and potential rough rabbitsfoot habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Conservation Actions and Strategies

Kitchel (1991) recommends improvements in land use practices, reduction or elimination of municipal, agricultural, and industrial contaminants, restricted instream construction activities, and the creation of mussel sanctuaries in appropriate sections of the Clinch, Powell, and Holston rivers to insure adequate protection for this species in Virginia. The recovery plan lists five priority conservation actions: utilizing existing legislation and regulations to protect this subspecies and its habitat; developing and presenting education programs; reducing or eliminating existing threats; augmenting or reintroducing where appropriate; and the developing and implementing a cryogenic preservation program (USFWS 2003).

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

The recovery plan that includes this subspecies lists four research and monitoring needs (USFWS 2003). These include determining the species' life history requirements and threats, surveying for additional populations, conducting genetic analyses of the species, and developing and implementing a monitoring program. Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J), but did not identify anything specific to the rough rabbitsfoot.

7.4.1.1.18. Cumberland monkeyface, *Quadrula intermedia*

Life History Summary

The Cumberland monkeyface is extremely rare in Virginia and throughout its range (Neves 1991e). It is described as a relatively flat mussel, subquadrate to subcircular in shape. This species is a short-term brooder (Parmalee and Bogan 1998). Fuller (1974) concluded that the green sunfish *Lepomis cyanellus*, bluegill *L. macrochirus*, and sauger *Stizostedion canadense* were probable fish hosts. This species is legally protected with the status of Federal and State endangered.

Location

The habitat map for the Cumberland monkeyface (Figure 7.40) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Potential reaches were selected in DGIF's aquatic habitat classification using size, connectivity and gradient values. See Appendix D for more details.

Description of Essential Habitat

The Cumberland monkeyface is found in small to medium-sized streams with fast current and silt-free rubble, gravel, or sand substrate (USFWS 1982). The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in two habitat types (Table 7.37).

Table 7.37. DGIF aquatic habitat types used by the Cumberland monkeyface in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient large stream connected to another large stream	6
Very low gradient small river connected to another small river	2

Relative Condition of Habitat

The recovery plan for the Cumberland monkeyface describes some issues related to past and current conditions of its habitat (USFWS 1982). All habitat for this species in this EDU is in or downstream of i

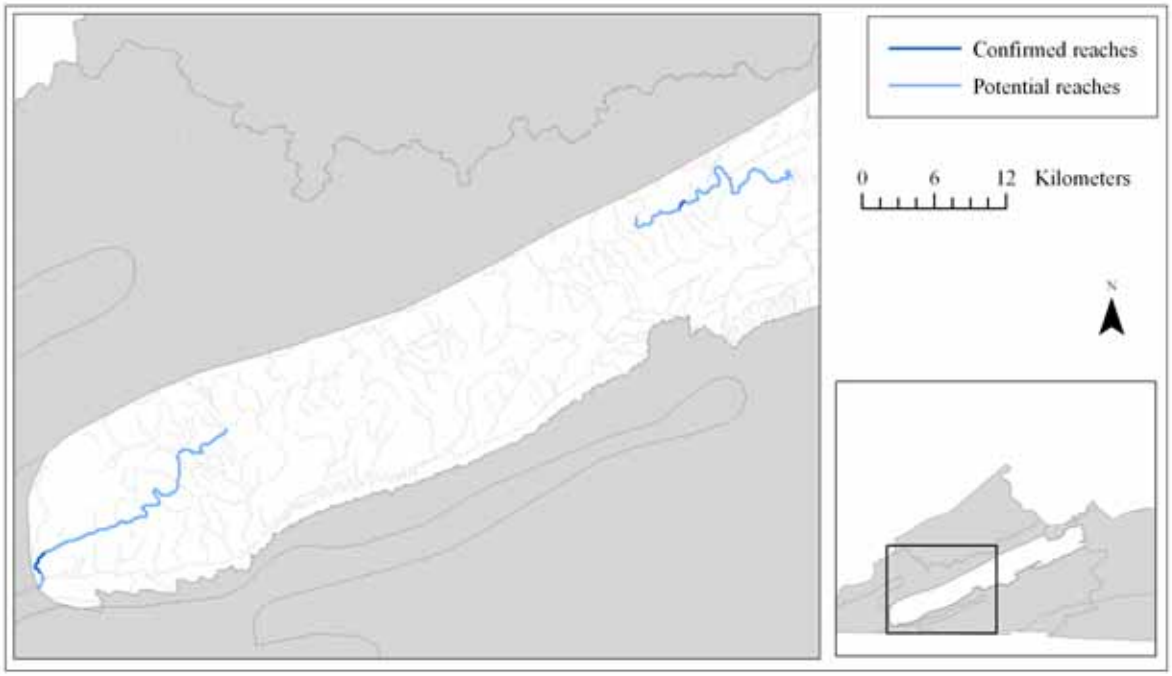

Figure 7.40. Confirmed and potential Cumberland monkeyface habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

The decline of this species in Virginia appears to be due to habitat degradation and non-viable population size (Neves 1991e). The Powell River population is likely threatened by wastes from oil and gas drilling, water quality and sedimentation effects of coal mining, and possibly fecal coliform contamination.

Mussel TAC (2004) did not identify any specific threats to the Cumberland monkeyface. However, it identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

The recovery plan for the Cumberland monkeyface recommended the continued utilization of existing legislation and regulations to protect this species and its habitat (USFWS 1982). Neves (1991e) more specifically recommended improving water quality in the Powell River through the upgrade of sewage treatment plants, the reclamation of mine lands, and the strict enforcement of discharge permits.

Mussel TAC (2004) identified a suite of conservation actions for Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

The recovery plan for this species recommends determining current and future threats as an important task towards recovery of this species (USFWS 1983). Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J), but did not identify anything specific to the Cumberland monkeyface.

7.4.1.1.19. Appalachian monkeyface, *Quadrula sparsa*

Life History Summary

The Appalachian monkeyface is extremely rare in Virginia and rare throughout its range (Neves 1991a). It reaches a maximum length of 80 mm and is triangular to irregularly rhomboid in shape (Parmalee and Bogan 1998). Based on life histories of closely related species, the Appalachian monkeyface is likely tachytictic. This species is legally protected with the status of Federal and State endangered.

Location

The habitat map for the Appalachian monkeyface (Figure 7.41) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Potential reaches were selected in DGIF's aquatic habitat classification using size and connectivity. See Appendix D for more details.

Description of Essential Habitat

The Appalachian monkeyface is a lotic species, found in fast-flowing shallow riffles and runs with silt-free stable substrates of mixed composition (Neves 1991a). The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in two habitat types (Table 7.38).

Table 7.38. DGIF aquatic habitat types used by the Appalachian monkeyface in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient large stream connected to another large stream	6
Very low gradient small river connected to another small river	2

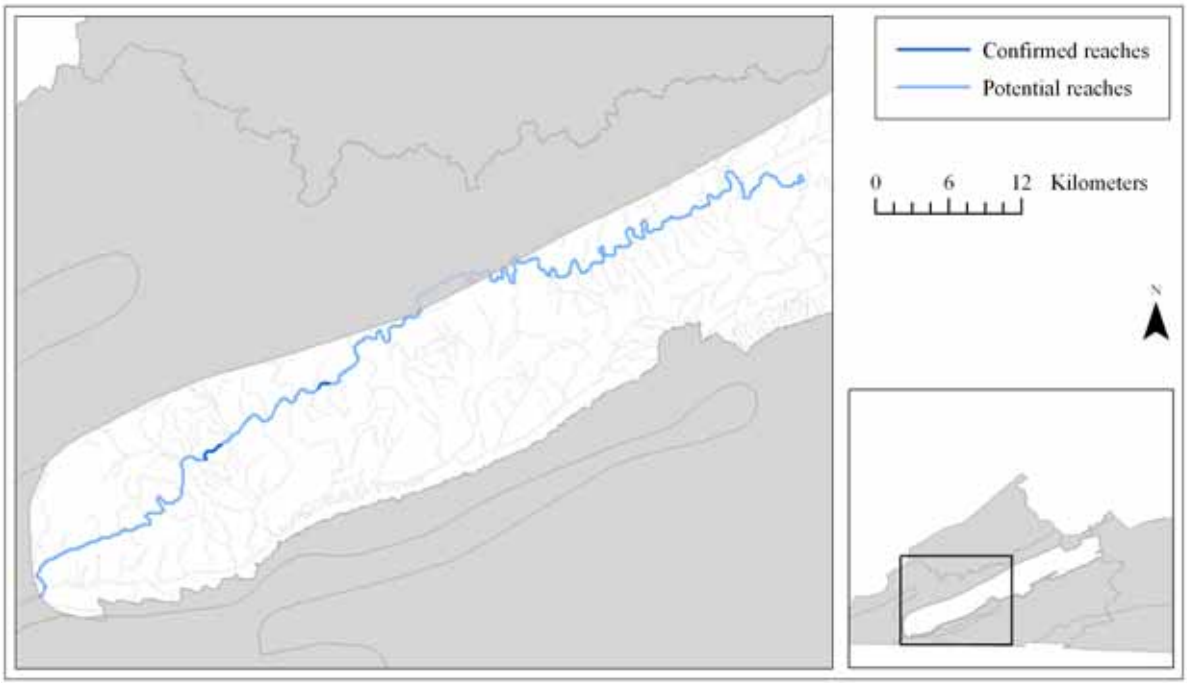

Figure 7.41. Confirmed and potential Appalachian monkeyface habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Relative Condition of Habitat

The recovery plan for the Appalachian monkeyface describes some issues related to past and current conditions of its habitat (USFWS 1983a). All habitat for this species in this EDU is found in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

The decline of this species in Virginia appears to be due to habitat degradation and non-viable population size (Neves 1991a). The Powell River population is likely threatened by wastes from oil and gas drilling, water quality and sedimentation effects of coal mining, and possibly fecal coliform contamination. Mussel TAC (2004) did not identify any specific threats to the Appalachian monkeyface. However, it identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

The recovery plan for this species recommends the continued utilization of existing legislation and regulations to protect this species and its habitat (USFWS 1983a). Neves (1991a) more specifically recommended improving water quality in the Powell River through the upgrade of sewage treatment plants, the reclamation of mine lands, and the strict enforcement of discharge permits. General improvement of the water quality in the Clinch River was also recommended.

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

The USFWS (1983a) recommends determining current and foreseeable future threats as an important task towards recovery of this species. They also recommended the completion of needed life history studies. Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J), but did not identify anything specific to the Appalachian monkeyface.

7.4.1.1.20. Purple bean, *Villosa perpurpurea*

Life History Summary

The purple bean is considered uncommon to rare throughout its range and extremely rare in Virginia (Ahlstedt 1991). It reaches a maximum length of 55mm (Parmalee and Bogan 1998). The shell is elongate and slightly inflated. This species is bradytictic. Fish hosts include sculpin *Cottus* sp., greenside darter *Etheostoma blenniodes*, and fantail darter *E. flabellare* (Watson and Neves 1996). This species is legally protected with the status of Federal and State endangered.

Location

The habitat map for the purple bean (Figure 7.42) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Potential reaches were selected in DGIF's aquatic habitat classification using link magnitude and downstream link magnitude values. See Appendix D for more details.

Description of Essential Habitat

The purple bean is usually found in moderate to fast current in depths < 3ft (1m, Parmalee and Bogan 1998). Typical substrate is coarse sand and gravel with some silt. The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in six habitat types (Table 7.39).

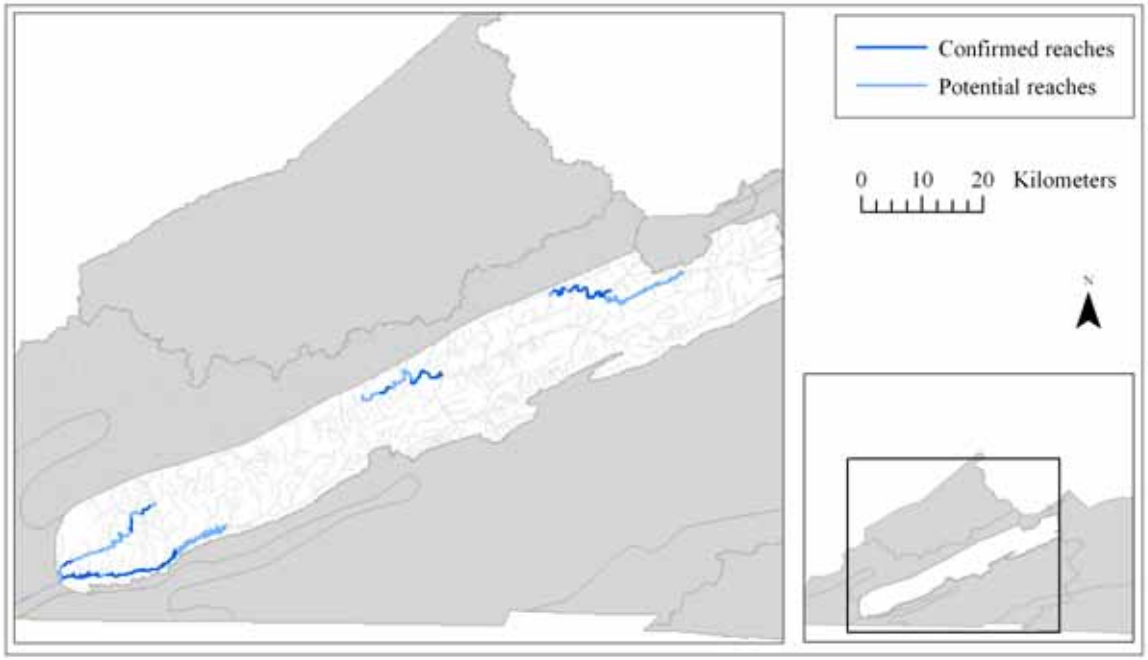

Figure 7.42. Confirmed and potential purple bean habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

Relative Condition of Habitat

The recovery plan for the purple bean describes some issues related to past and current conditions of its habitat (USFWS 2003). All habitat for this species in this EDU is found in or downstream of impaired waters (DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

Factors that have affected all freshwater mussels are impoundment, siltation, and channelization. Current threats to this subspecies include degraded water and substrate quality and contaminants (USFWS 2003). Sources of these threats include logging, agriculture, and oil and gas exploration (Ahlstedt 1991b). The restricted range of this and other mussels makes them especially vulnerable to toxic spills and negative effects of genetic isolation.

Mussel TAC (2004) did not identify any specific threats for the purple bean, but identified several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

The recovery plan lists five priority conservation actions: utilizing existing legislation and regulations to protect this subspecies and its habitat; developing and presenting education programs; reducing or eliminating existing threats; augmenting or reintroducing where appropriate; and developing and implementing a cryogenic preservation program (USFWS 2003). Specifically, Ahlstedt (1991b) recommended improving water quality in the Clinch River and Copper Creek.

Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Table 7.39. DGIF aquatic habitat types used by the purple bean in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient large stream connected to another large stream	9
Very low gradient small river connected to another small river	9
Very low gradient small stream connected to another small stream	7
Low gradient large stream connected to another large stream	1
Low gradient small stream connected to a large stream	1
Very low gradient small stream connected to a large stream	1

Research and Monitoring Needs

The recovery plan that includes this species lists four research and monitoring needs (USFWS 2003). These include determining the species' life history requirements and threats, surveying for additional populations, conducting genetic analyses of the species, and developing and implementing a monitoring program. Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix J).

7.4.1.1.21. Cumberland bean, *Villosa trabalis*

Life History Summary

The Cumberland bean may be extirpated from Virginia (Neves 1991d). It is elongate and inflated, with an irregular oval shape (Parmalee and Bogan 1998). It may reach a maximum length of 55mm. This species is bradytictic. Based on laboratory experiments, the following fish that occur in Virginia were identified as probable hosts: arrow darter *Etheostoma sagitta*, fantail darter *E. flabellare*, Johnny darter *E. nigrum*, rainbow darter *E. caeruleum*, snubnose darter *E. simoterum*, striped darter *E. virgatum*, and stripetail darter *E. kennicotti* (Layzer and Anderson 1991, 1992; J.B. Layzer, pers. comm. in Parmalee and Bogan 1998). This species is legally protected with the status of Federal and State endangered.

Location

The habitat map for the Cumberland bean (Figure 7.43) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Potential reaches were selected in DGIF's aquatic habitat classification using size, connectivity and gradient values. See Appendix D for more details.

Description of Essential Habitat

The Cumberland bean is typically found in riffles of small rivers and streams with gravel or gravel and sand substrate (Parmalee and Bogan 1998). The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Clinch-Powell watershed, this species was found in three habitat types (Table 7.40).

Relative Condition of Habitat

The recovery plan for the Cumberland bean describes some issues related to past and current conditions of its habitat (USFWS 1984a). All habitat for this species in this EDU is in or downstream of impaired waters

Table 7.40. DGIF aquatic habitat types used by the Cumberland bean in the Clinch-Powell watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	4
Very low gradient large stream connected to another large stream	3
Very low gradient small stream connected to a large stream	1

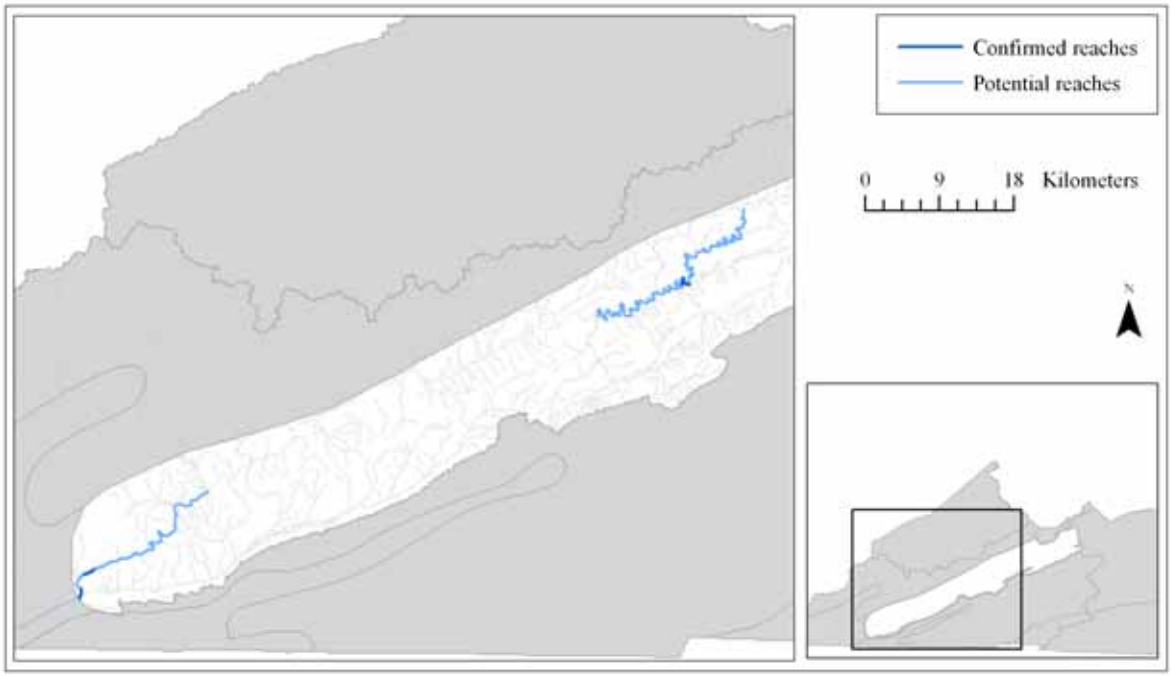

Figure 7.43. Location of confirmed and potential Cumberland bean habitat in the Ridge and Valley-Clinch EDU (DGIF 2004b).

(DEQ and DCR 2004). The impairments are primarily fecal coliform or general standard (benthics), and the sources of impairment are largely unknown, urban, or resource extraction.

Specific Threats and Trends

The decline of the Cumberland bean is not completely understood; however, it is believed to be due to impoundment, siltation and pollution (USFWS 1984a). Mussel TAC (2004) did not identify any specific threats to Cumberland bean, but did identify several threats to the Clinch and Powell River drainages (Appendix H).

Conservation Actions and Strategies

The recovery plan for the Cumberland bean identifies as a high priority the use of existing legislation and regulations to protect this species and its habitat (USFWS 1984). Mussel TAC (2004) identified a suite of conservation actions for the Clinch and Powell River drainages (Appendix I).

Research and Monitoring Needs

The recovery plan for the Cumberland bean identified the determination of current and foreseeable future threats as a high priority research need (USFWS 1984). Mussel TAC (2004) identified several research or monitoring needs for the Clinch and Powell River drainages (Appendix J), but they did not identify anything specific to Cumberland bean.

7.4.1.2. Aquatic SGCN by Habitat Group: Ridge and Valley-Clinch EDU

The Ridge and Valley-Clinch EDU has 92 tiered species. This includes 41 mussels, five snails, 36 fish, four crayfish, one aquatic insect, two amphibians, and three reptiles. These species are distributed among five habitat groups and one group of species with generalist or indeterminate habitat preferences (Tables 7.41-7.46).

Table 7.41. Aquatic species of greatest conservation need in very low gradient small rivers connected to other small rivers (DGIF Classification type 441).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Green blossom pearlymussel	*Epioblasma torulosa gubernaculums*	I	100	1 (6 occurrences; drainage-wide)
Popeye shiner	*Notropis ariommus*	II	85	3
Sheepnose	*Plethobasus cyphyus*	II	75	3
Pyramid pigtoe	*Pleurobema rubrum*	II	100	1 (3 occurrences)
Elktoe	*Alamidonta marginata*	III	84	5
Steelcolor shiner	*Cyprinella whipplei*	III	80	3
Tippecanoe darter	*Etheostoma tippecanoe*	III	78	3 (9 occurrences)
Black sandshell	*Ligumia recta*	III	73	7
River redhorse	*Moxostoma carinatum*	III	73	7
Emerald shiner	*Notropis atherinoides*	III	83	2 (6 occurrences)
Channel darter	*Percina copelandi*	III	75	2 (4 occurrences)
Ohio pigtoe	*Pleurobema cordatum*	III	100	1 (3 occurrences)
Freshwater drum	*Aplodinotus grunniens*	IV	86	3
Elephant-ear	*Elliptio crassidens*	IV	100	2
Fragile papershell	*Leptodea fragilis*	IV	81	4
Dusky darter	*Percina sciera*	IV	67	5
Pimpleback	*Quadrula pustulosa pustulosa*	IV	67	5
Sauger	*Stizostedion canadense*	IV	67	6
Creeper mussel	*Strophitus undulatus*	IV	71	3
Deertoe	*Truncilla truncate*	IV	61	6

Table 7.42. Aquatic species of greatest conservation need in very low and low gradient large streams and small rivers (DGIF Classification types 331, 332, and 441).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Birdwing pearlymussel	*Lemiox rimosus*	I	94	3 (drainage-wide)
Fanshell	*Cyprogenia stegaria*	I	100	2 (drainage-wide)
Dromedary pearlymussel	*Dromus dromas*	I	100	2 (drainage-wide)
Cumberlandian combshell	*Epioblasma brevidens*	I	100	2 (drainage-wide)
Oyster mussel	*Epioblasma capsaeformis*	I	97	4 (drainage-wide)
Shiny pigtoe	*Fusconaia cor*	I	95	3 (drainage-wide)
Fine-rayed pigtoe	*Fusconaia cuneolus*	I	100	2 (drainage-wide)
Cracking pearlymussel	*Hemistena lata*	I	100	2 (drainage-wide)
Rough rabbitsfoot	*Quadrula cylindrica strigillata*	I	92	6 (drainage-wide)
Cumberland monkeyface	*Quadrula intermedia*	I	100	2 (8 occurrences; drainage-wide)
Appalachian monkeyface	*Quadrula sparsa*	I	100	2 (8 occurrences; drainage-wide)
Cumberland bean	*Villosa trabalis*	I	81	3 (8 occurrences)
Spectaclecase	*Cumberlandia monodonta*	II	100	2 (6 occurrences)
Slabside pearlymussel	*Lexingtonia dolabelloides*	II	76	7

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Bluebreast darter	*Etheostoma camurum*	III	84	5
Longsolid	*Fusconaia subrotunda*	III	77	12
Ohio lamprey	*Ichthyomyzon bdellium*	III	77	7
Spiny riversnail	*Io fluvialis*	III	82	7
Pocketbook mussel	*Lampsilis ovata*	IV	77	12
Tangerine darter	*Percina aurantiaca*	IV	70	8

Table 7.43. Aquatic species of greatest conservation need in very low or low gradient small streams, large streams and small rivers (DGIF Classification types 221, 222, 223, 231, 232, 331, 332, and 441).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Purple bean	*Villosa perpurpurea*	I	100	6 (drainage-wide)
Tennessee pigtoe	*Fusconaia barnesiana*	II	85	16
Fluted kidneyshell	*Ptychobranchus subtentum*	II	74	14
Wounded darter	*Etheostoma vulneratum*	III	80	10
Tennessee clubshell	*Pleurobema oviforme*	III	91	13
Streamline chub	*Erimystax dissimilis*	IV	79	11
Blotched chub	*Erimystax insignis*	IV	88	15
Speckled darter	*Etheostoma stigmaeum*	IV	94	9
Banded darter	*Etheostoma zonale*	IV	89	17
Northern studfish	*Fundulus catenatus*	IV	93	8
Cumberland moccasin mussel	*Medionidus conradicus*	IV	84	16
Mirror shiner	*Notropis spectrunculus*	IV	92	7
Mountain madtom	*Noturus eleutherus*	IV	90	6
Logperch	*Percina caprodes*	IV	88	7
Gilt darter	*Percina evides*	IV	86	11
Stargazing minnow	*Phenacobius uranops*	IV	93	12
Stripe-necked musk turtle	*Sternotherus minor peltifer*	IV	100	3 (5 occurrences)
Mountain creekshell mussel	*Villosa vanuxemensis*	IV	86	9

Table 7.44. Aquatic species of greatest conservation need in very low or low gradient small to large streams (DGIF Classification types 221, 222, 223, 231, 232, 331 and 332).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Tan riffleshell	*Epioblasma florentina walkeri*	I	100	4 (5 occurrences)
Duskytail darter	*Etheostoma percnurum*	I	89	3 (9 occurrences; drainage-wide)

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Yellowfin madtom	*Noturus flavipinnis*	I	94	4 (drainage-wide)
Little-wing pearlymussel	*Pegias fabula*	I	100	3 (5 occurrences)
Blotchside darter	*Percina burtoni*	II	85	6
Longhead darter	*Percina macrocephala*	II	100	3 (8 occurrences)
Slippershell mussel	*Alasmidonta marginiata*	III	72	6
Mountain brook lamprey	*Ichthyomyzon greeleyi*	III	91	4
Swannanoa darter	*Etheostoma swannanoa*	IV	94	5
Northern map turtle	*Graptemys geographica*	IV	79	6
Mountain shiner	*Lythrurus lirus*	IV	78	12
Sawfin shiner	*Notropis* sp. 4	IV	80	6
Stonecat	*Noturus flavus*	IV	75	7

Table 7.45. Aquatic species of greatest conservation need in headwaters and small streams. (DGIF Classification types 113, 114, 122, 123, 124, 134, 221, 222, 223, and 232).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Eastern hellbender	*Cryptobranchus alleganiensis alleganiensis*	II	86	8
Tennessee heelsplitter	*Lasmigona holstonia*	II	94	16
Common mudpuppy	*Necturus maculosus maculosus*	III	100	2 (5 occurrences)
Clinch River crayfish	*Cambarus angularis*	IV	100	8
Crayfish	*Cambarus longirostris*	IV	100	5
Black sculpin	*Cottus baileyi*	IV	100	3 (6 occurrences)
Onyx rocksnail	*Leptoxis praerosa*	IV	80	4
Pagoda hornsnail	*Pleurocera uncialis uncialis*	IV	92	4

Table 7.46. Aquatic species of greatest conservation need: generalists and those with unknown habitat requirements based on DGIF habitat classification.

Common Name	Scientific Name	Tier	Number of Types Used (DGIF Aquatic Classification)
Ashy darter	*Etheostoma cinereum*	I	1 (1 occurrence)
Pink mucket	*Lampsilis abrupta*	I	1 (1 occurrence)
Rough pigtoe	*Pleurobema plenum*	I	1 (1 occurrence)
Western sand darter	*Ammocrypta clara*	II	2 (2 occurrences)
Coal elimia	*Elimia aterina*	II	NA
Snuffbox	*Epioblasma triquetra*	II	NA
A dace	*Phoxinus* sp. 1	II	NA
Cherokee clubtail	*Stenogomphurus consanguis*	II	NA
Clinch sculpin	*Cottus* sp. 4	III	NA
Ohio pigtoe	*Pleurobema cordatum*	III	NA

Common Name	Scientific Name	Tier	Number of Types Used (DGIF Aquatic Classification)
Brown walker	*Pomatiopsis cincinnatiensis*	III	NA
Rainbow darter	*Etheostoma caeruleum*	IV	1 (1 occurrence)
Brook silverside	*Labidesthes sicculus*	IV	3 (5 occurrences)
A crayfish	*Orconectes erichsonianus*	IV	NA
Sturgeon crayfish	*Orconectes forceps*	IV	1 (1 occurrence)
Eastern spiny softshell	*Palone spinifera spinifera*	IV	3 (4 occurrences)
Bullhead minnow	*Pimephales vigilax*	IV	2 (3 occurrences)
Three-ridge valvata snail	*Valvata tricarinata*	IV	2 (2 occurrences)

7.4.1.2.1. Relative Condition of Habitat

Approximately 12% of the riverine habitat in the Ridge and Valley-Clinch EDU is impaired (DEQ and DCR 2004). Most of the impairment is caused by fecal coliform or *E. coli* from urban or unknown sources. Nearly 28% of the land cover in this EDU is agricultural and 1.5% is considered developed (USGS 1992). Within the state, agricultural land cover ranges from 2 to 41%, and developed land use ranges from 0.2 to 15% (USGS 1992).

Threats, conservation actions, and research and monitoring needs for the Tier II through Tier IV species are given in Appendices H, I, and J. Mussel TAC (2004) and Fish TAC (2004) provided this information within habitat groups selected at the workshops. The level of detail within these groups does not correspond to that used in the DGIF aquatic habitat classification.

7.4.2. Ridge and Valley-Holston EDU

The Ridge and Valley-Holston River EDU (Figure 7.44) is part of the Tennessee-Cumberland freshwater ecoregion, which is considered "globally outstanding" in terms of biological distinctiveness (Abell et al. 2000). Abell et al. (2000) also considered this freshwater ecoregion to have the conservation status of "Endangered." The Tennessee drainage contains the most diverse fish assemblage in North America (Jenkins and Burkhead 1994). There is a high level of endemism in this freshwater ecoregion, with 29% of the fish, 16% of the mussels, and 62% of the crayfish considered to be endemic (Abell et al. 2000).

The Holston River has three primary branches in Virginia: the South, Middle, and North Forks. The Holston River itself does not flow in Virginia. The South Fork and Middle Fork join and then merge with the North Fork just a few kilometers south of the border with Tennessee. Most of the Holston in Virginia drains the Northern Ridge and Valley ecoregion, with a few tributaries draining the Blue Ridge and Southern Cumberland Mountain ecoregions.

7.4.2.1. Tier I Species in the Ridge and Valley-Holston EDU

7.4.2.1.1. Spotfin chub, *Erimonax monachus*

Life History Summary

In 1984, Jenkins and Burkhead published an extensive description of the life history and distribution of the spotfin chub (summarized in Jenkins and Burkhead 1994). The spotfin chub is a benthic insectivore at all life stages. The majority of its diet is composed of midge, blackfly, and mayfly larvae. Most individuals reach sexual maturity at two years. Males are generally larger than females. The breeding season may extend from mid-May to mid-August. It is a crevice spawner. This species is legally protected with the status of Federal and State threatened.

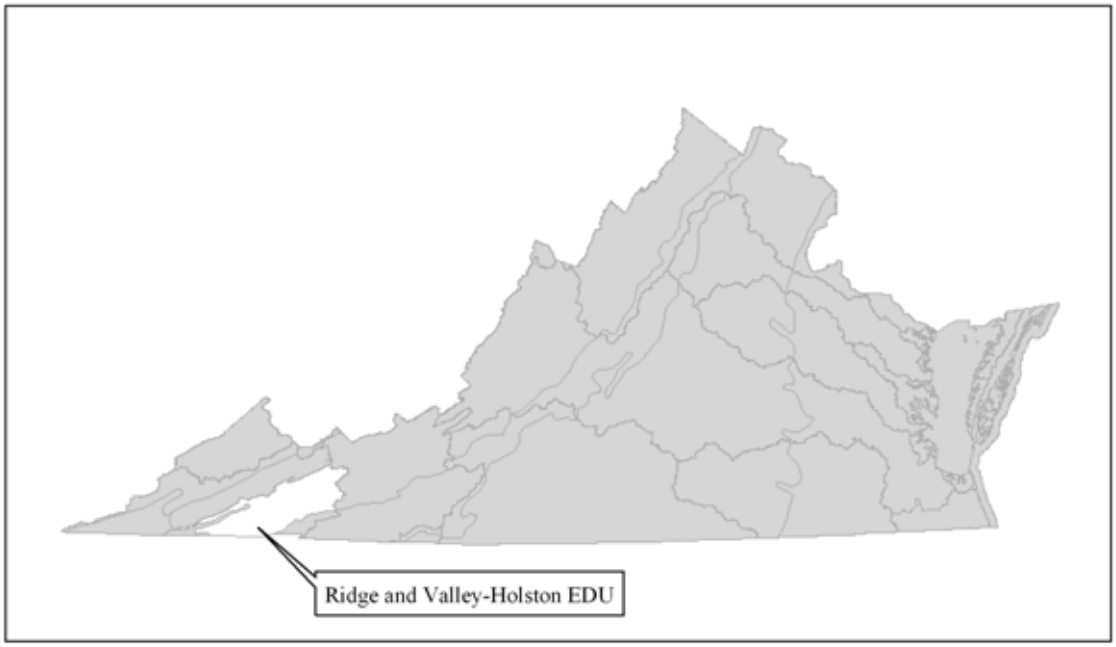

Figure 7.44. Location of the Ridge and Valley-Holston EDU.

Location

The spotfin chub has disjunct and localized populations in Virginia. The habitat map for the spotfin chub (Figure 7.45) includes confirmed reaches from Collections (DGIF 2004b), potential reaches and critical habitat (USFWS 2004). Potential reaches were selected in DGIF's aquatic habitat classification using reach size and connectivity. See Appendix D for more details.

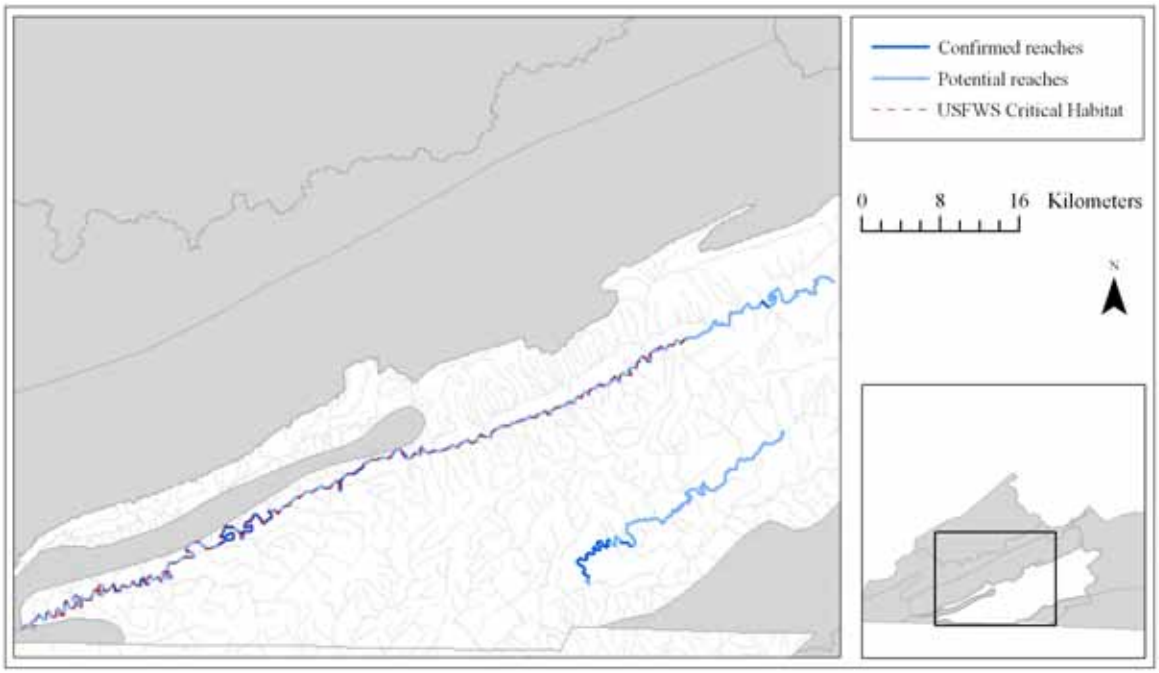

Figure 7.45. Location of confirmed and potential habitat and USFWS critical habitat for the spotfin chub in the Ridge and Valley-Holston EDU (DGIF 2004b).

Description of Essential Habitat

The spotfin chub is found in medium streams to medium rivers with cool to warm, clear water and moderate gradient (Burkhead and Jenkins 1991; Jenkins and Burkhead 1994). It tends to prefer larger sized substrates with little silt. In the Holston watershed, this species was found in four habitat types (Table 7.47). Most occurrences were in small rivers and large streams.

Table 7.47. DGIF aquatic habitat types used by the spotfin chub in the Holston River watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	10
Very low gradient large stream connected to another large stream	5
Low gradient small river connected to another small river	1
Low gradient small stream connected to another small stream	1

Relative Condition of Habitat

The recovery plan for the spotfin chub discusses past and recent issues regarding habitat quality (USFWS 1983f). Most of the known habitat in the North Fork Holston has a VDH fish consumption advisory for mercury contamination (DEQ and DCR 2004). The source of the contamination is the Olin Matheson Plant site. The remaining habitat is downstream of impaired reaches. These streams are impaired by fecal coliform and general standard (benthics) from unknown, urban, or agricultural sources.

Specific Threats and Trends

Siltation, pollution, and impoundment have reduced populations of the spotfin chub and continue to threaten its existence (USFWS 1983f; Burkhead and Jenkins 1991). Fish TAC (2004) did not identify any specific threats to the spotfin chub, but did identify threats to the Holston River drainages (Appendix H).

Conservation Actions and Strategies

No high priority conservation actions were listed in the recovery plan for the spotfin chub (USFWS 1983f). However, Burkhead and Jenkins (1991) indicated that, because the populations in Virginia are disjunct and generally low in abundance, each population is important to the long-term survival of the species. Fish TAC (2004) identified a suite of conservation actions for the Holston River drainages (Appendix I).

Research and Monitoring Needs

Burkhead and Jenkins (1991) recommended monitoring of the population in the North Fork of Holston River to assess recolonization. Fish TAC (2004) identified several research or monitoring needs for the Holston River drainages (Appendix J) but none specific to the spotfin chub.

7.4.2.1.2. Sharphead darter, *Etheostoma acuticeps*

Life History Summary

The sharphead darter is endemic to the upper Tennessee watershed. In Virginia, it is extremely localized (Smogor et al. 2002). It is largely insectivorous, feeding on mayfly, midge, blackfly, caddisfly and other larvae (Jenkins and Burkhead 1975; Bryant 1979). Individuals may live three years, reaching maturity at one year. Males are larger than females, with the largest specimen from Virginia reaching 52mm (Jenkins and Burkhead 1975). This species is believed to spawn between late June and mid-August in areas with fast current, though spawning has never been observed. This species is legally protected with the status of State endangered. It has also been designated a species of concern by the Virginia Field Office of USFWS.

Location

The habitat map for the sharphead darter (Figure 7.46) includes confirmed reaches fromCollections (DGIF 2004b) and potential reaches. Potential reaches were selected in DGIF's aquatic habitat classification using reach size, connectivity and gradient values.

Description of Essential Habitat

In the South Fork Holston River, the sharphead darter appears to prefer fast-moving runs and chutes (Jenkins and Burkhead 1994). It generally inhabits large streams and rivers of cool to warm water with moderate gradient (Jenkins and Burkhead 1975; Bryant 1979). It tends to prefer clear to slightly turbid waters. The DGIF aquatic habitat classification was used to examine patterns in habitat use and distribution. In the Holston watershed, this species was found in three habitat types (Table 7.48).

Relative Condition of Habitat

The recovery plan for the sharphead darter discusses past and recent issues related to habitat quality (Smogor et al. 2002). All habitat for this species in this EDU is within stream reaches impaired by total fecal coliform from unknown sources (DEQ and DCR 2004).

Specific Threats and Trends

Impoundment and siltation have dramatically reduced or even eliminated populations of sharphead darter (Burkhead and Jenkins 1991). Siltation and the release of cold tailwaters continue to threaten the sharphead darter and its recovery. Fish TAC (2004) did not identify any specific threats for the sharphead darter, but did identify several threats to the Holston River drainages (Appendix H).

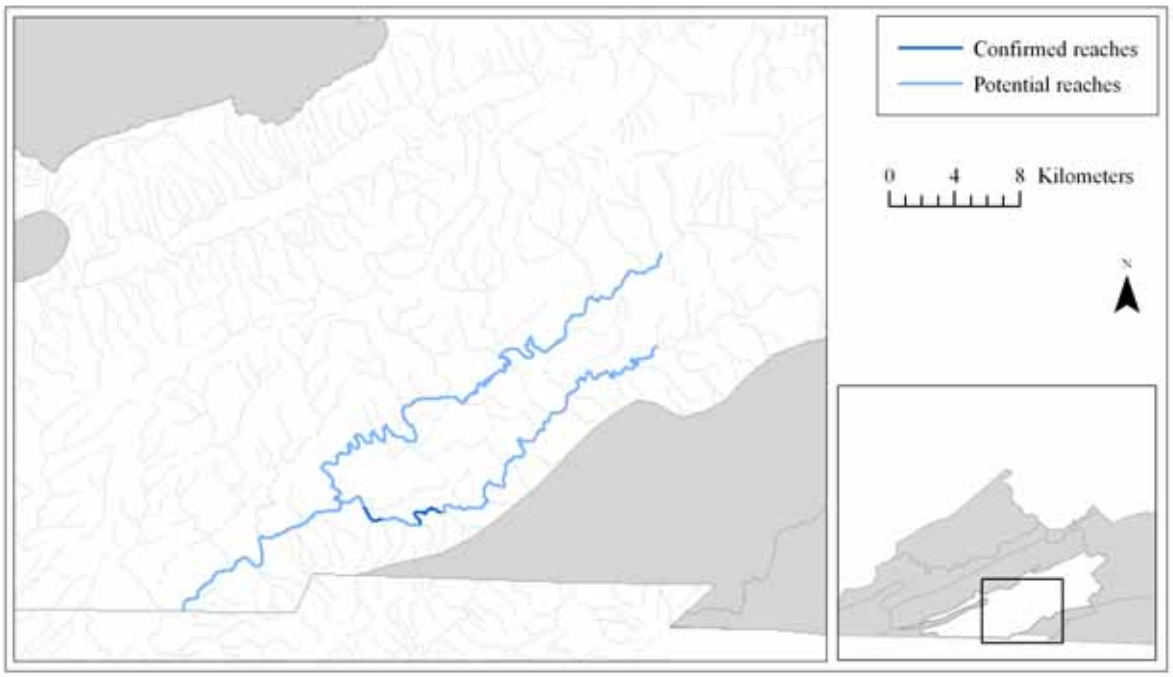

Figure 7.46. Location of confirmed and potential sharphead darter habitat in the Ridge and Valley-Holston EDU (DGIF 2004b).

Table 7.48. DGIF aquatic habitat types used by the sharphead darter in the Holston watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient large stream connected to a small river	1
Very low gradient small river connected to another small river	1
Very low gradient large stream connected to another large stream	1

Conservation Actions and Strategies

Burkhead and Jenkins (1991) recommend the reduction of silt inputs, thorough review of discharge permits, and the identification and reduction of other types of pollution in the South Fork of Holston River. They also recommended the possible introduction of the sharphead darter from the Nolichucky River in Tennnessee, with some concern about possible interspecific competition with the redline darter *Etheostoma rufilineatum* and sculpins.

The DGIF recovery plan recommended five priority actions, four of which represent research and monitoring needs (Smogor et al. 2002). However, the top priority listed is the protection, maintenance, and enhancement of existing populations and habitats.

Fish TAC (2004) identified a suite of conservation actions for the Holston River drainages (Appendix I).

Research and Monitoring Needs

The DGIF recovery plan indicated four research or monitoring needs for the sharphead darter (Smogor et al. 2002). These include conducting life history research; determining the feasibility of reintroduction in the South Fork of Holston River watershed; biennial monitoring of extant and, if applicable, introduced populations; and at least biennial review and assessment of all recovery plan actions.

Fish TAC (2004) identified several research or monitoring needs for the Holston River drainages (Appendix J). They did not identify anything specific to the sharphead darter.

7.4.2.1.3. Yellowfin madtom, *Noturus flavipinnis*

Two life history studies have been completed on the yellowfin madtom (Jenkins 1975; Shute 1984). This madtom eats mostly aquatic insect larvae during both day and night. Its life expectancy is about five years. Spawning occurs from about mid-May to Mid-July. This species is legally protected with the status of Federal and State threatened.

Location

This species is endemic to the Ridge and Valley region of the Tennessee drainage. The only known location for the yellowfin madtom in the Holston drainage is from 1888, when it was collected above Saltville (USFWS 1983h). It is likely extirpated from this drainage.

Description of Essential Habitat

The yellowfin madtom is found in small streams to medium or large rivers (Jenkins and Burkhead 1994). They are found in warm water and the warm-cool water transition. This madtom prefers quiet water usually pools and backwaters beside runs and riffles. Preferred cover is large, flat rocks, under which nests are spawned and defended (Dinkins and Shute 1996).

Relative Condition of Habitat

This species may be extirpated from the Holston drainage. Therefore, we have no current data on relative condition of habitat.

Specific Threats and Trends

This species seems to be most affected by habitat degradation from siltation, agricultural runoff, and impoundment (Burkhead and Jenkins 1991). Fish TAC (2004) did not identify any specific threats to the yellowfin madtom. However, they identified several threats to the Holston River drainages (Appendix H).

Conservation Actions and Strategies

The USFWS (1983h) recovery plan for the yellowfin madtom listed several actions necessary for the recovery of the species. These included research and monitoring needs, which are listed in the next section. The highest priority action listed in this plan was to utilize existing legislation and regulations to protect species and habitat. One conservation action from the recovery plan was to preserve populations and currently occupied habitat. Also, once feasibility was determined, this species should be introduced into its historic range. Lastly, sites should be located and techniques developed and implemented for habitat improvement.

Fish TAC (2004) identified a suite of conservation actions for the Holston River drainages (Appendix I).

Research and Monitoring Needs

The yellowfin madtom recovery plan lists several research or monitoring projects necessary for the recovery of the species (USFWS 1983h). One of the projects is to determine the feasibility of reestablishing the species in its native range. The next is to conduct life history studies as needed. The document also discusses the need to identify areas for habitat improvement. Monitoring tasks included monitoring population levels and habitat conditions as well as the success of the recovery plan.

Fish TAC (2004) identified several research or monitoring needs for the Holston River drainages (Appendix J), but nothing specific to the yellowfin madtom.

7.4.2.1.4. Tennessee dace, *Phoxinus tennesseensis*

Life History Summary

The Tennessee dace has been shown to eat mostly living and decaying plant material (Starnes and Jenkins 1988). Maturity is not reached until after the first year, and its life span is likely three years (Burkhead and Jenkins 1991). The largest known specimen in Virginia was 58mm. This species breeds in May (Jenkins and Burkhead 1994). This species is legally protected with the status of State endangered. It has also been designated a species of concern by the Virginia Field office of USFWS.

Location

The habitat map for the Tennessee dace (Figure 7.47) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Potential reaches were selected in DGIF's aquatic habitat classification using link magnitude values. See Appendix D for more details.

Description of Essential Habitat

The Tennessee dace occurs in clear, small, cool to cold creeks with rock, gravel, or silt substrates (Jenkins and Burkhead 1994). It typically prefers wooded reaches though a large population was found in a reach surrounded by pasture. Studies of habitat use in Lick Creek and Lynn Camp Creek only found the Tennessee dace in pools (Underwood and Dolloff 1999). It was not found in any of the sampled riffles. Also, it is can be found in standing pools in dry streams (M.J. Pinder, DGIF, pers.comm.).

In the Ridge and Valley-Holston EDU, this species was found in five habitat types (Table 7.49).

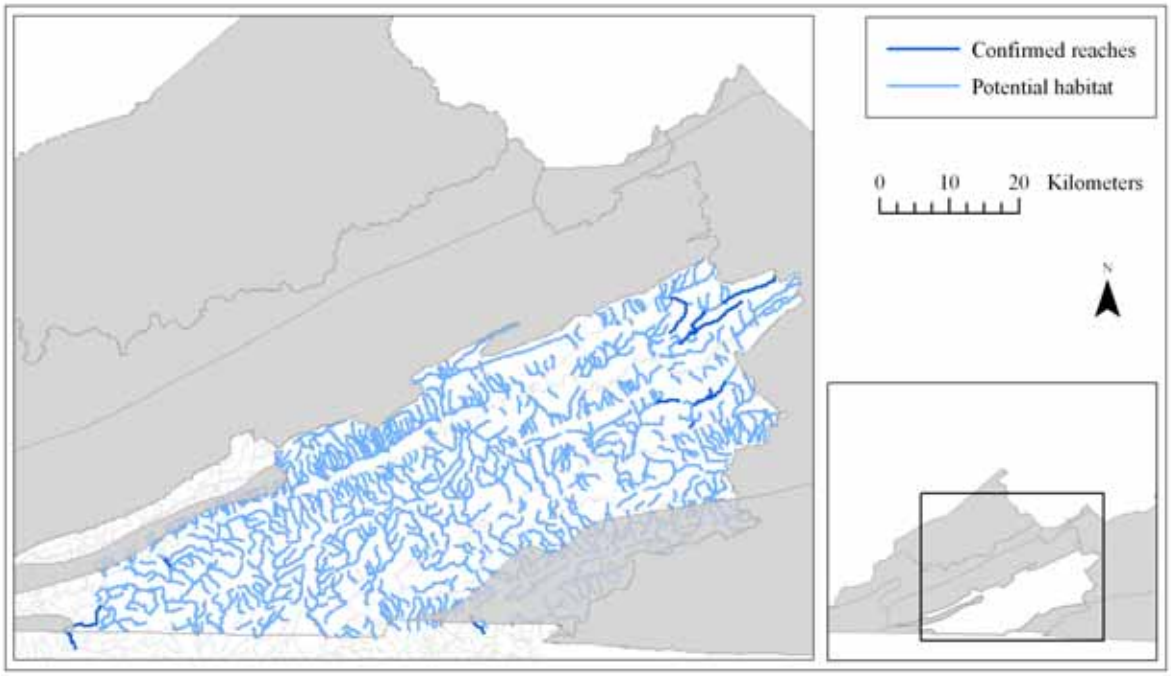

Figure 7.47. Location of confirmed and potential Tennessee dace habitat in the Ridge and Valley-Holston EDU (DGIF 2004b).

Relative Condition of Habitat

Only one reach of Tennessee dace habitat is impaired (DEQ and DCR 2004): Laurel Creek is impaired by general standard (benthics) and fecal coliform. Sources are unknown. The draft recovery plan for the Tennessee dace indicated other habitat-related threats, including channelization, stream modification, and siltation (DGIF 2001).

Specific Threats and Trends

Populations of the Tennessee dace have been reduced due to habitat destruction and degradation (DGIF 2001). Current threats include channelization, impoundment, excessive siltation through removal of riparian vegetation or construction, flow impermanence, overcollection via bait seining, and introduction of the mountain redbelly dace *Phoxinus oreas* (Burkhead and Jenkins 1991; DGIF 2001).

Fish TAC (2004) did not identify any specific threats for the Tennessee dace. However, they identified several threats to the Holston River drainages (Appendix H).

Conservation Actions and Strategies

The DGIF draft recovery plan for the Tennessee dace recommended the protection, maintenance, and enhancement of existing populations and habitats as its top priority conservation action (DGIF 2001). More specifically, it identifies a few research and monitoring projects and two actions. The actions were to eliminate or minimize threats and solicit widespread support for the recovery plan. More detailed actions include protecting current habitats from channelization and impoundment, prohibiting activities that jeopardize the stability of the riparian corridor, and prohibiting bait seining and bait fishing in streams containing the Tennessee dace (Burkhead and Jenkins 1991; DGIF 2001).

Fish TAC (2004) identified a suite of conservation actions for the Holston River drainages (Appendix I).

Table 7.49. DGIF aquatic habitat types used by the Tennessee dace in the Holston watershed.

Aquatic Habitat Type	Number of Reaches
Low gradient small stream connected to another small stream	7
Low gradient headwater connected to a small stream	3
Moderate gradient headwater connected to a small stream	3
Moderate gradient headwater connected to another headwater	2
High gradient headwater connected to a small stream	1

Research and Monitoring Needs

Several research and monitoring needs have been identified for the Tennessee dace. These include monitoring existing populations and habitats; identifying current and foreseeable threats; investigating the effect of trout stocking; and examining the feasibility of reintroducing the Tennessee dace into watersheds within its historic range (Burkhead and Jenkins 1991; DGIF 2001). Fish TAC (2004) identified several research or monitoring needs for the Holston River drainage (Appendix J), but nothing specific to the Tennessee dace.

7.4.2.1.5. Tan riffleshell, *Epioblasma florentina walkeri*

Life History Summary

The tan riffleshell is extremely rare throughout its range. Its decline in Virginia is believed to be due to habitat degradation (Dennis 1991c). It is a relatively small mussel, rarely exceeding 60mm in length (Parmalee and Bogan 1998). It is obovate or irregularly elliptical. There is little life history information for this subspecies. Based on the life history of related *Epioblasma* species, it is probably bradytictic. Watson and Neves (1996) found that the greenside darter *Etheostoma blennioides*, fantail darter *E. flabellare*, redline darter *E. rufilineatum*, and sculpin *Cottus* sp. are fish hosts for this subspecies. This species is legally protected with the status of Federal and State endangered.

Location

The habitat map for the tan riffleshell (Figure 7.48) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Potential reaches were selected in DGIF's aquatic habitat classification using reach size, connectivity and gradient values. See Appendix D for more details.

Description of Essential Habitat

This subspecies occurs in headwaters and small and medium-sized streams of the Tennessee drainage in substrates of coarse sand, gravel and some silt (Parmalee and Bogan 1998). They prefer areas with current and depth of < 1m. In the Holston watershed, this species was found in one habitat type (Table 7.50).

Relative Condition of Habitat

The habitat for the tan riffleshell lies within reaches of the Ridge and Valley-Holston EDU that have been listed as impaired by the DEQ and DCR (2004). The impairments include fecal coliform and general standard (benthics). The sources of the impairment include the Chilhowie sewage treatment plant, non-point source agriculture, and unknown. The recovery plan for this species also indicates some past and recent habitat quality concerns (USFWS 1984e).

Table 7.50. DGIF aquatic habitat types used by the tan riffleshell in the Holston watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient large stream connected to another large stream	4

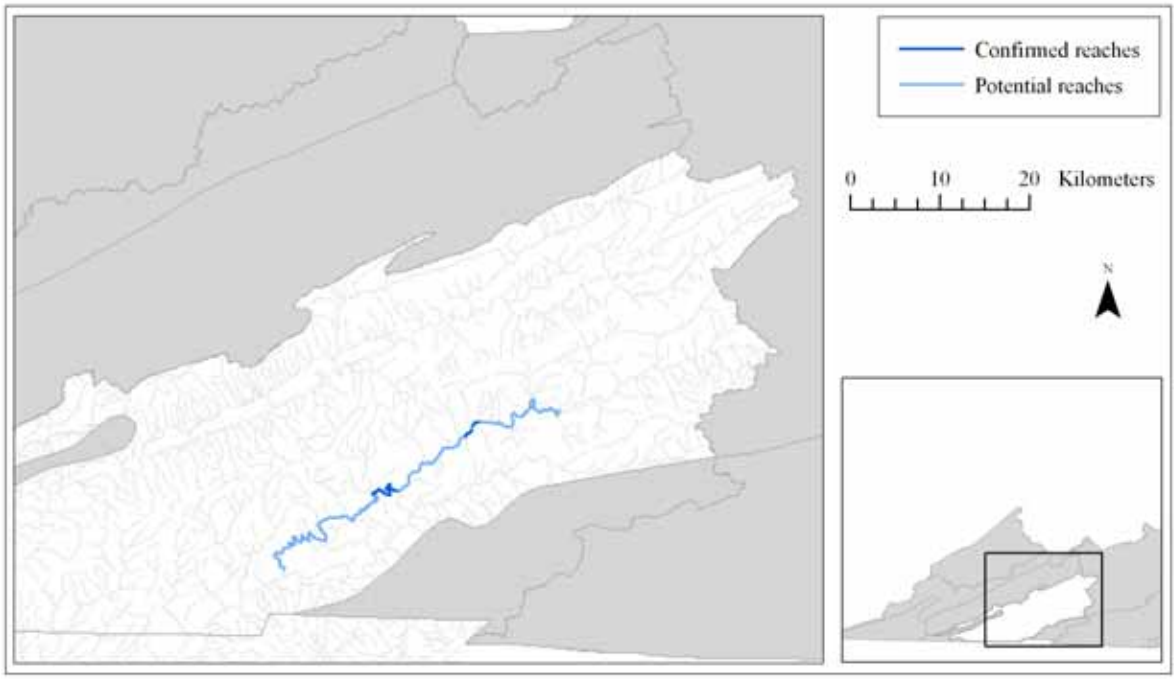

Figure 7.48. Location of confirmed and potential tan riffleshell habitat in the Ridge and Valley-Holston EDU (DGIF 2004b).

Specific Threats and Trends

The greatest threats to the tan riffleshell in Virginia are channelization of the Middle Fork of the Holston River and industrial development in Marion and Chilhowie (Dennis 1991c). Additional current threats include siltation from erosion, agriculture, construction, and channelization; effluent pollution from industries and municipalities; and agricultural and urban runoff (USFWS 1984e; Dennis 1991c). Mussel TAC (2004) did not identify any specific threats to the tan riffleshell. However, they identified several threats to the Holston River drainage (Appendix H).

Conservation Actions and Strategies

The recovery plan for the tan riffleshell lists three high priority conservation actions for recovery (USFWS 1984e). These include preserving the population and its habitat in the Middle Fork Holston River; coordinating with governmental agencies to determine the potential effects of ongoing and proposed projects on this subspecies and its habitat; and recommending corrective measures to entities responsible for threats to the population. Dennis (1991c) stresses the importance of habitat protection as well. In addition, Mussel TAC (2004) identified a suite of conservation actions for the Holston River drainage (Appendix I).

Research and Monitoring Needs

Dennis (1991c) cautioned that biological research may adversely affect the tan riffleshell. However, the recovery plan indicates the need for some studies (USFWS 1984e). In particular, it recommends determining the species current distribution and range, describing habitat requirements for all life stages, documenting the effects of threats, and conducting life history research. Mussel TAC (2004) identified several research or monitoring needs for the Holston River drainage (Appendix J), but nothing specific to tan riffleshell.

7.4.2.1.6. Shiny pigtoe, *Fusconaia cor*

Life History Summary

The shiny pigtoe is very rare in Virginia and rare throughout its range (Neves 1991l). Its decline is believed to be due to habitat degradation. Adult size ranges from 60-80mm and the shell is typically subtriangular in shape (Neves 1991l; Parmalee and Bogan 1998). This mussel is tachytictic (Kitchel 1985). Kitchel (1985) listed the following fish as hosts: telescope shiner *Notropis telescopus*, warpaint shiner *Luxilus coccogenis*, and common shiner *L. cornutus*. This species is legally protected with the status of Federal and State endangered.

Location

The habitat map for the shiny pigtoe (Figure 7.49) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Potential reaches were selected in DGIF's aquatic habitat classification using reach size and connectivity values. See Appendix D for more details.

Description of Essential Habitat

The shiny pigtoe occurs in fords, shoals, and other shallow areas of riverine habitats with moderate to swift current (Bogan and Parmalee 1983). It can be found in stable substrates with anything from sand to cobbles. In the Holston watershed, this species was found in five habitat types (Table 7.51).

Relative Condition of Habitat

One segment of known habitat for the shiny pigtoe is listed with a VDH fish advisory for mercury contamination (DEQ and DCR 2004). The source of the contamination is the Olin Matheson Plant site. The remaining known habitat for this species are within or immediately downstream of impaired reaches. The impairments include fecal coliform, general standard (benthics), and *E. coli*. The sources for impairment

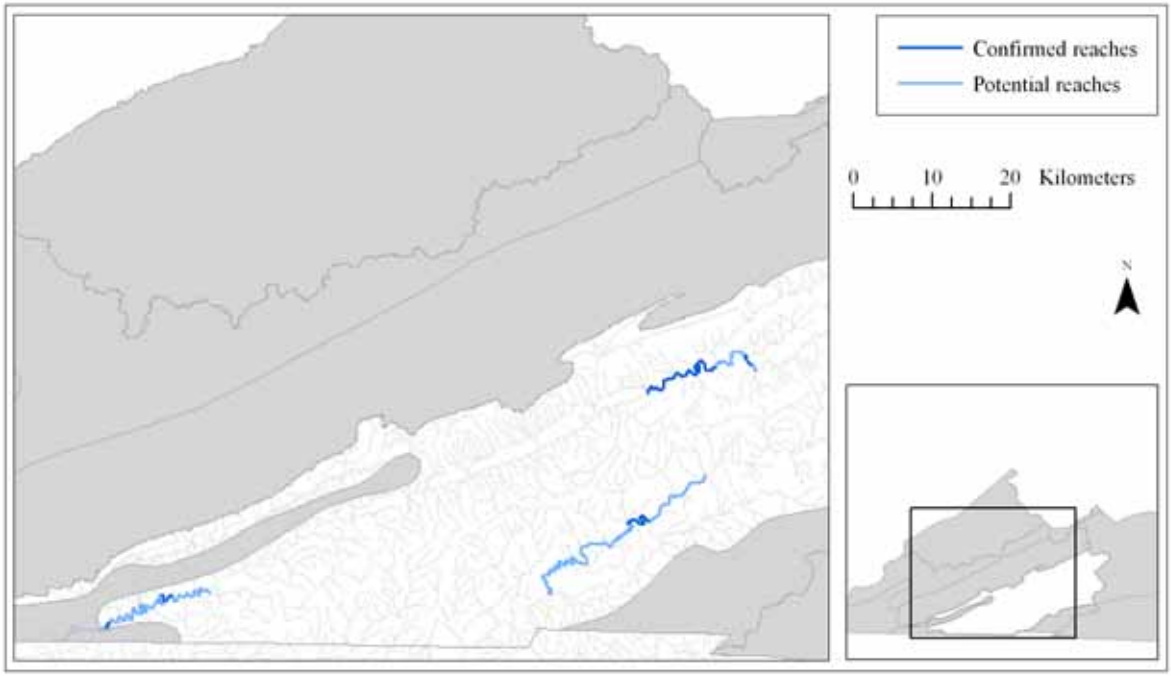

Figure 7.49. Location of confirmed and potential shiny pigtoe habitat in the Ridge and Valley-Holston EDU (DGIF 2004b).

Table 7.51. DGIF aquatic habitat types used by the shiny pigtoe in the Holston River watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient large stream connected to another large stream	7
Low gradient large stream connected to another large stream	1
Very low gradient small river connected to another small river	1
Low gradient small river connected to another small river	1
Low gradient small stream connected to another small stream	1

include the Chilhowie sewage treatment plant, non-point source agriculture, and other, unknown sources. The recovery plan for the shiny pigtoe also provides some information on past and recent habitat quality issues (USFWS 1983e).

Specific Threats and Trends

The recovery plan for the shiny pigtoe identified impoundments, siltation, and general water pollution as contributing factors in the decline of this species (USFWS 1983e). Current threats include the water quality and sedimentation effects of mining activities, general water quality degradation (especially fecal coliform levels), and catastrophic toxic spills (Neves 1991l). Mussel TAC (2004) did not identify any specific threats to the shiny pigtoe. However, they identified several threats to the Holston River drainage (Appendix H).

Conservation Actions and Strategies

Neves (1991l) recommended the strict enforcement of existing water quality regulations to improve water and habitat quality. The recovery plan for the shiny pigtoe recommended two high priority conservation actions (USFWS 1983e). These were to protect existing populations and habitats and mitigate or eliminate current threats. Mussel TAC (2004) identified a suite of conservation actions for the Holston River drainage (Appendix I).

Research and Monitoring Needs

The U.S. Fish and Wildlife Service (1983e) recommended that life history studies be completed. Mussel TAC (2004) identified several research or monitoring needs for the Holston River drainage (Appendix J), but nothing specific to the shiny pigtoe.

7.4.2.1.7. Little-wing pearlymussel, *Pegias fabula*

Life History Summary

The little-wing pearlymussel is very rare throughout its range and extremely rare in Virginia (Ahlstedt 1991a). Its decline appears to be related to habitat degradation and limited reproduction. It is small, with a maximum length of about 35mm. Based on evidence collected by Ortmann (1914), this species is bradytictic. Fish hosts are not known for this species, though likely hosts include banded sculpin *Cottus carolinae* and the redline darter *Etheostoma rufilineatum* (Ahlstedt 1986). This species is legally protected with the status of Federal and State endangered.

Location

The habitat map for the little-wing pearly mussel (Figure 7.50) includes confirmed reaches from Collections (DGIF 2004b) and potential reaches. Potential reaches were selected in DGIF's aquatic habitat classification using reach size and gradient values. See Appendix D for more details.

Description of Essential Habitat

The little-wing pearlymussel is a riffle-dwelling species (Ahlstedt 1991a). It is found in headwaters and high gradient streams. In the Holston watershed, this species was found in three habitat types (Table 7.52).

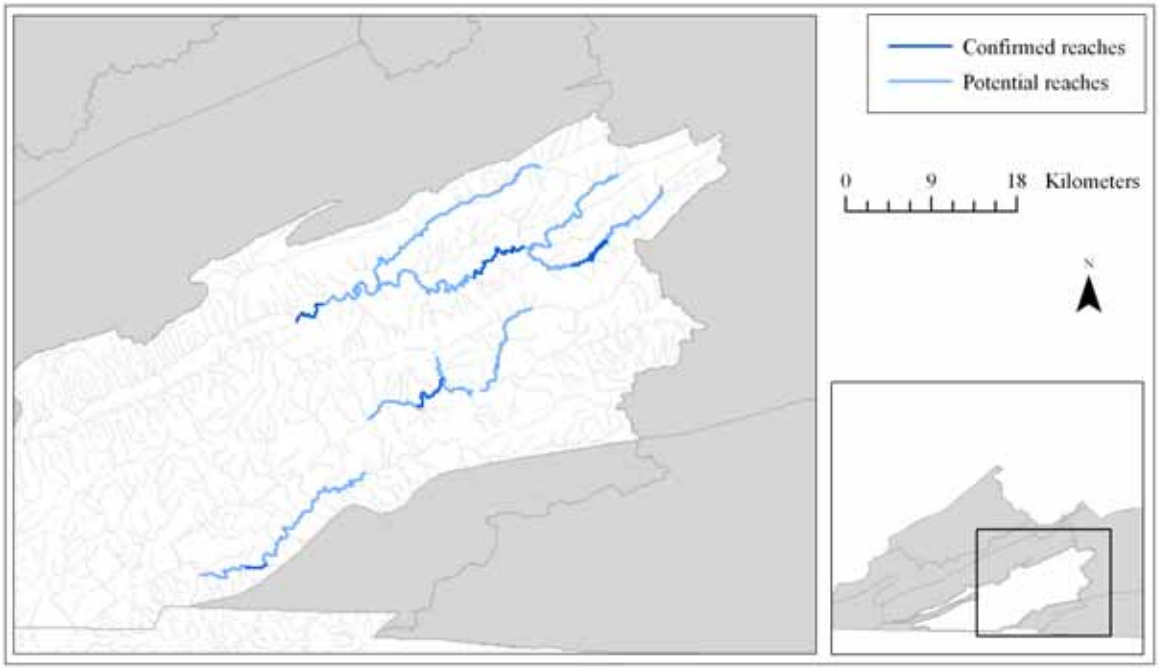

Figure 7.50. Location of confirmed and potential little-wing pearlymussel habitat in the Ridge and Valley-Holston EDU (DGIF 2004b).

Relative Condition of Habitat

All known habitat of the little-wing pearlymussel in this EDU is within or downstream of impaired stream segments (DEQ and DCR 2004). The causes of impairment are fecal coliform, *E. coli*, and general standard (benthics). The sources of impairment are listed as either agricultural (non-point source) or unknown. The recovery plan for this species discusses other past or current issues related to habitat quality affecting this species (USFWS 1989a).

Specific Threats and Trends

As with other freshwater mussels, historic declines are thought to be due to impoundments, siltation, and pollution (USFWS 1989a). Some populations in Virginia are believed to be close to extirpation (Ahlstedt 1991a). Others are likely threatened by logging, oil and gas drilling and exploration, and overcollecting.

Mussel TAC (2004) did not identify any specific threats for the little-wing pearlymussel, but did identify several threats to the Holston River drainage (Appendix H).

Conservation Actions and Strategies

Ahlstedt (1991a) states that for the continued existence of the little-wing pearlymussel in Virginia, upper reaches of the North Fork of Holston and Clinch rivers must remain pristine. The recovery plan for the little-wing pearlymussel described two necessary high priority conservation actions: the continued

Table 7.52. DGIF aquatic habitat types used by the little winged-pearlymussel in the Holston watershed.

Aquatic Habitat Type	Number of Reaches
Very low gradient large stream connected to another large stream	7
Very low gradient small stream connected to another small stream	2
Low gradient small stream connected to another small stream	2

utilization of existing legislation and regulations for species and habitat protection, and the development and presentation of an education program (USFWS 1989a).

Mussel TAC (2004) identified a suite of conservation actions for the Holston River drainage (Appendix I).

Research and Monitoring Needs

The only research project listed as high priority in the little-wing pearlymussel recovery plan is to conduct life history studies necessary for the management of the species (USFWS 1989a). Mussel TAC (2004) identified several research or monitoring needs for the Holston River drainages (Appendix J), but nothing specific to the little-wing pearlymussel.

7.4.2.1.8. Bottle hornsnail, *Pleurocera gradata*

Life History Summary

Little is known about the life history of the bottle hornsnail.

Location

The bottle hornsnail is only known from one location in the Holston River in Washington County (Stewart and Dillon 2004). It has not been seen in over 100 years.

Description of Essential Habitat

The essential habitat of the bottle hornsnail is unknown.

Location

The bottle hornsnail is endemic to the Holston drainage; however, we do not have any recently documented locations.

Relative Condition of Habitat

Because of the lack of specific location data for this species, we could not assess relative condition of habitat.

Specific Threats and Trends

Specific threats and trends for the bottle hornsnail are unknown.

Conservation Actions and Strategies

Specific conservation actions and strategies for the bottle hornsnail are unknown.

Research and Monitoring Needs

While this species may be extirpated, targeted field surveys are necessary to determine its status (Stewart and Dillon 2004). If populations are found, life history studies are needed.

7.4.2.1.9. Rough rabbitsfoot, *Quadrula cylindrica strigillata*

Life History Summary

The rough rabbitsfoot is widespread but uncommon throughout its range (Kitchel 1991). Its occurrence in Virginia is localized. The shell of this species is elongate and rhomboid or rectangular in shape, and

individuals may reach 120mm (Parmalee and Bogan 1998). This species is tachytictic (Parmalee and Bogan 1998). Yeager and Neves (1986) identified the following fish hosts for this species: whitetail shiner *Notropis galacturus*, spotfin shiner *Notropis spilopterus*, and bigeye chub *Hybopsis amblops*. This species is legally protected with the status of Federal and State endangered.

Location

The habitat map for the rough rabbitsfoot (Figure 7.51) includes Stream Conservation Units (DCR-NH 2005).

Description of Essential Habitat

The rough rabbitsfoot is typically collected in small to medium-sized rivers in clear, shallow water (Parmalee and Bogan 1998). It seems to prefer shoal and riffle areas near banks with sand and gravel substrate. In the Holston watershed, this species was found in two habitat types (Table 7.53).

Relative Condition of Habitat

A large portion of the Stream Conservation Unit (DCR-DNH 2005) for the rough rabbitsfoot in this EDU is listed as impaired by the DEQ and DCR (2004). The reason is the VDH fish consumption advisory for mercury contamination (DEQ and DCR 2004). The contamination source is the Olin Matheson Plant site.

Specific Threats and Trends

The decline of the rough rabbitsfoot is partially attributable to pollution from mining and other industry, municipalities, and toxic spills (Cairns et al. 1971). Other factors that have universally affected freshwater mussels are impoundment, siltation, and channelization (Kitchel 1991). Current threats to this subspecies include degraded water and substrate quality and contaminants (USFWS 2003). The restricted range of this and other mussels makes them especially vulnerable to toxic spills and negative effects of genetic isolation.

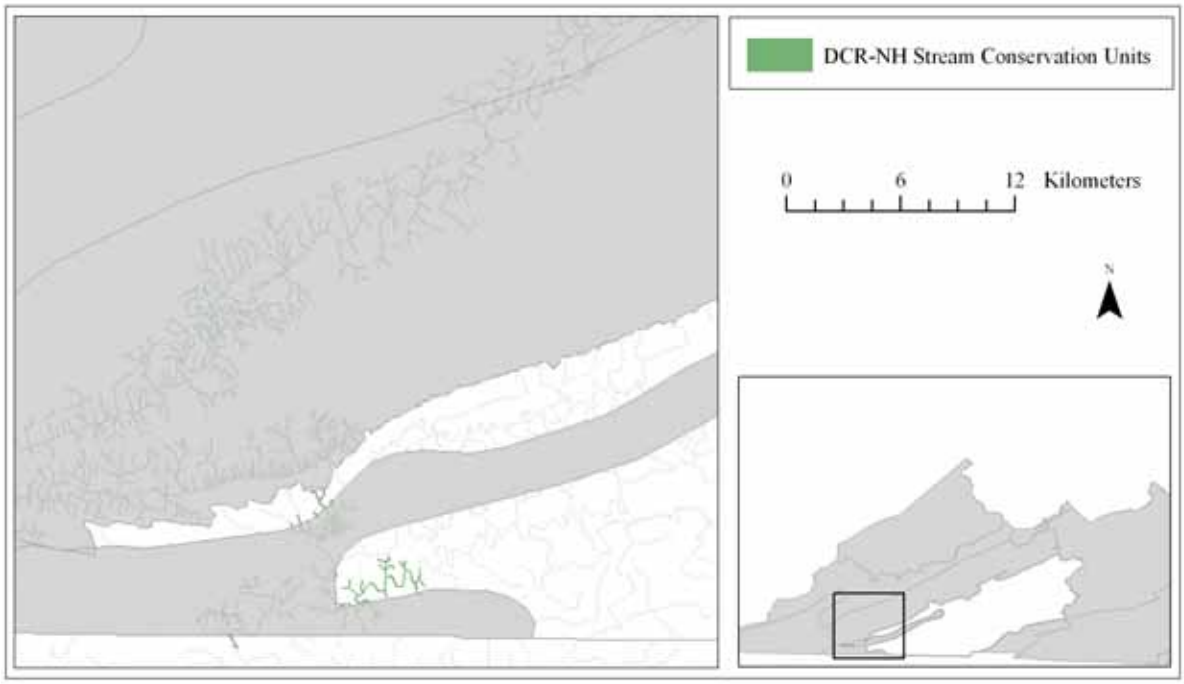

Figure 7.51. Location of the Stream Conservation Unit containing the rough rabbitsfoot habitat in the Ridge and Valley-Holston EDU (DCR-NH 2005).

Table 7.53. DGIF aquatic habitat types used by the rough rabbitsfoot in the Holston watershed.

Aquatic Habitat Type	Number of Reaches
Low gradient large stream connected to another large stream	1
Very low gradient small stream connected to another small stream	1

Mussel TAC (2004) did not identify any specific threats for the rough rabbitsfoot. However, they identified several threats to the Holston River drainage (Appendix H).

Conservation Actions and Strategies

Kitchel (1991) recommended improvements in land use practices, reduction or elimination of municipal, agricultural, and industrial contaminants, restricted instream construction activities, and the creation of mussel sanctuaries in appropriate sections of the Clinch, Powell, and Holston rivers to insure adequate protection for this species in Virginia. The recovery plan lists five priority conservation actions: utilizing existing legislation and regulations to protect this subspecies and its habitat; developing and presenting education programs; reducing or eliminating existing threats; augmenting or reintroducing where appropriate; and developing and implementing a cryogenic preservation program (USFWS 2003).

Mussel TAC (2004) identified a suite of conservation actions for the Holston River drainage (Appendix I).

Research and Monitoring Needs

The recovery plan that includes this subspecies lists four research and monitoring needs (USFWS 2003). These include determining the species' life history requirements and threats; surveying for additional populations; conducting genetic analyses of the species; and developing and implementing a monitoring program.

Mussel TAC (2004) identified several research or monitoring needs for the Holston River drainage (Appendix J), but nothing specific to the rough rabbitsfoot.

7.4.2.2. Aquatic SGCN by Habitat Group: Ridge and Valley-Holston EDU

There are 62 tiered species in this EDU: 32 fish, 17 mussels, three snails, two insects, and four crayfish. There are also two amphibians and two reptiles with aquatic habitat preferences. There are five habitat groups and one group of species with generalist or indeterminate habitat preference (Tables 7.54-7.59).

Table 7.54. Aquatic species of greatest conservation need in very low and low gradient large streams and small rivers (DGIF Classification types 331, 332, 341, 441, and 442).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types used (DGIF Aquatic Classification)
Spotfin chub	*Erimonax monachus*	I	94	4 (drainage-wide)
Sharphead darter	*Etheostoma acuticeps*	I	100	3 (3 occurrences)
Slabside pearlymussel	*Lexingtonia dolabelloides*	II	73	8
Popeye shiner	*Notropis ariommus*	II	73	11
Bluebreast darter	*Etheostoma camurum*	III	73	8
Wounded darter	*Etheostoma vulnertum*	III	69	9
Streamline chub	*Erimystax dissimilis*	IV	85	12
Blotched chub	*Erimystax insignis*	IV	80	6
Banded darter	*Etheostoma zonale*	IV	66	20
Pocketbook mussel	*Lampsilis ovata*	IV	100	2 (9 occurrences)

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types used (DGIF Aquatic Classification)
Mountain madtom	*Noturus eleutherus*	IV	89	3 (9 occurrences)
Tangerine darter	*Percina aurantiaca*	IV	75	9
Logperch	*Percina caprodes*	IV	64	12
Gilt darter	*Percina evides*	IV	74	12
Stargazing minnow	*Phenacobius uranops*	IV	74	16

Table 7.55. Aquatic species of greatest conservation need in very low and low gradient large streams (DGIF Classification types 331 and 332).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types used (DGIF Aquatic Classification)
Tan riffleshell	*Epioblasma florentina walkeri*	I	100	1 (4 occurrences)
Shiny pigtoe	*Fusconaia cor*	I	73	5
Longhead darter	*Percina macrocephala*	II	100	2 (9 occurrences)
Fluted kidneyshell	*Ptychobranchus subtentum*	II	84	5
Purple lilliput	*Toxolasma lividus*	II	100	1 (2 occurrences)
Elktoe	*Alasmidonta marginata*	III	100	1 (4 occurrences)
River redhorse	*Moxostoma carinatum*	III	71	5
Northern map turtle	*Graptemys geographica*	IV	83	3
Creeper mussel	*Strophitus undulatus*	IV	100	1 (3 occurrences)

Table 7.56. Aquatic species of greatest conservation need in very low and low gradient small to large streams (DGIF Classification types 221 222, 232, 331, and 332).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types used (DGIF Aquatic Classification)
Little-wing pearlymussel	*Pegias fabula*	I	100	3
Slippershell	*Alasmidonta viridis*	II	100	3
Tennessee pigtoe	*Fusconaia barnesiana*	II	86	9
Tennessee heelsplitter	*Lasmigona holstonia*	II	100	3 (5 occurrences)
Ohio lamprey	*Ichthyomyzon bdellium*	III	100	4 (6 occurrences)
Mountain brook lamprey	*Ichthyomyzon greeleyi*	III	100	3
Tennessee clubshell	*Pleurobema oviforme*	III	85	9
Swannonoa darter	*Etheostoma Swannanoa*	IV	85	7
Cumberland moccasin	*Medionidus conradicus*	IV	83	9
Mirror shiner	*Notropis spectrunculus*	IV	88	5
Stonecat	*Noturus flavus*	IV	100	2 (3 occurrences)

Table 7.57. Aquatic species of greatest conservation need in low to high gradient headwater and small streams (DGIF Classification types 113, 114, 122, 123, 124, 134, 221, 222, 223, and 232).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types used (DGIF Aquatic Classification)
Tennessee dace	*Phoxinus tennesseensis*	I	100	6
Eastern hellbender	*Cryptobranchus alleganiensis*	II	100	6 (9 occurrences)
Black sculpin	*Cottus baileyi*	IV	91	11
American brook lamprey	*Lampetra appendix*	IV	100	3 (9 occurrences)

Table 7.58. Aquatic species of greatest conservation need in very low and low gradient small streams to small rivers (DGIF Classification types 221, 222, 231, 232, 242, 331, 332, 342, 441, and 442).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types used (DGIF Aquatic Classification)
Blotchside darter	*Percina burtoni*	II	95	8
Northern studfish	*Fundulus catenatus*	IV	85	16
Mountain creekshell mussel	*Villosa vanuxemensis*	IV	88	12

Table 7.59. Aquatic species of greatest conservation need: generalists and those with unknown habitat requirements based on DGIF habitat classification.

Common Name	Scientific Name	Tier	Number of Types Used (DGIF Aquatic classification)
Yellowfin madtom	*Noturus flavipinnis*	I	NA
Bottle hornsnail	*Pleurocera gradate*	I	NA
Rough rabbitsfoot	*Quadrula cylindrica*	I	2 (2 occurrences)
Coal elimia	*Elimia aterina*	II	NA
Greenfin darter	*Etheostoma chlorobranchium*	II	1 (1 occurrence)
Cherokee clubtail	*Gomphus consanguis*	II	1 (1 occurrence)
Holston sculpin	*Cottus* sp. 5	III	NA
Longsolid	*Fusconaia subrotunda*	III	1 (2 occurrences)
Spiny riversnail	*Io fluvialis*	III	NA
Common mudpuppy	*Necturus maculosus maculosus*	III	2 (2 occurrences)
Fatlips minnow	*Phenacobius crassilabrum*	III	8
Eastern softshell	*Apalone spinifera spinifera*	IV	3 (6 occurrences)
Clinch River crayfish	*Cambarus angularis*	IV	NA
A crayfish	*Cambarus longirostris*	IV	NA
Speckled darter	*Etheostoma stigmaeum*	IV	1 (1 occurrence)
Sable clubtail dragonfly	*Gomphus rogersi*	IV	1 (1 occurrence)
Onyx rocksnail	*Leptoxis praerosa*	IV	2 (2 occurrences)
Sawfin shiner	*Notropis* sp. 4	IV	4 (6 occurrences)
A crayfish	*Orconectes erichsonianus*	IV	NA
Sturgeon crayfish	*Orconectes forceps*	IV	1 (1 occurrence)
Bullhead minnow	*Pimephales vigilax*	IV	1 (1 occurrence)
Pagoda hornsnail	*Pleurocera uncialis uncialis*	IV	1 (1 occurrence)
Sauger	*Stizostedion canadense*	IV	NA

7.4.2.2.1. Relative Condition of Habitat

About 14% of the riverine habitat in the Ridge and Valley-Holston EDU is impaired (DEQ and DCR 2004). The impairments are largely either fecal coliform or general standard (benthics), caused by agricultural or urban sources. There is also a large section of the North Fork Holston that is impaired by a fish consumption advisory due to mercury contamination in fish tissue from the Olin Matheson Plant. About 26% of the land cover in this EDU is agricultural, and nearly 3% is developed (USGS 1992). Within the state, agricultural land cover ranges from 2 to 41%, and developed land use ranges from 0.2 to 15% (USGS 1992).

Threats, conservation actions, and research and monitoring needs for the Tier II through Tier IV species are given in Appendices H, I, and J. Mussel TAC (2004) and Fish TAC (2004) provided this information within habitat groups decided upon at the workshops. The level of detail within these groups does not correspond to that used in the DGIF aquatic habitat classification.

7.4.3. Ridge and Valley-New EDU

The Ridge and Valley-New EDU is part of the Teays-Old Ohio freshwater ecoregion (Abell et al. 2000) (Figure 7.52). The Teays-Old Ohio is considered "globally outstanding" because of the large number of species found here, second only to the Tennessee-Cumberland freshwater ecoregion. The level of endemism is considered moderately high, with 12% of fish, 14% of mussels, and 47% of crayfish found nowhere else. Abell et al. (2000) consider this region to have a conservation status of "Vulnerable."

The headwaters of the New River originate in North Carolina. The river then cuts north across Virginia and then enters West Virginia (Jenkins and Burkhead 1994). Approximately 245km flow through Virginia. Most of the drainage is located in the Ridge and Valley or Blue Ridge ecoregions.

Figure 7.52. Location of the Ridge and Valley-New EDU.

7.4.3.1. Tier I Species in the Ridge and Valley-New EDU

7.4.3.1.1. Kosztarab's common stonefly, *Acroneuria kosztarabi*

Life History Summary

Little is known of the life history of this species. It was only fully described in Kondratieff and Kirchner (1993). This species has been designated a species of concern by the Virginia Field Office of USFWS.

Location

This species was found in Station Spring Creek, Burkes Garden, Tazewell County, Virginia (Kondratieff and Kirchner 1993). However, details are not sufficient for map production, and we have no confirmed locations or Conservation Sites for this species.

Description of Essential Habitat

Not enough is known of this species or its possible distribution to determine essential habitat. However, Burkes Garden is a relatively high elevation valley (939m) (Kondratieff and Kirchner 1993), so it may require high elevations.

Relative Condition of Habitat

Station Spring Creek, the only known location for this species, has not been listed as impaired (DEQ and DCR 2004). There is no other information available for habitat quality.

Specific Threats and Trends

No threats have been identified for Kosztarab's common stonefly.

Conservation Actions and Strategies

No conservation actions have been identified for Kosztarab's common stonefly.

Research and Monitoring Needs

Information is needed on the life history, distribution, habitat requirements, threats and conservation actions for this species.

7.4.3.1.2. Big stripetail stonefly, *Isoperla major*

Life History Summary

The life history of the big stripetail stonefly is virtually unknown and may be unique due to its preference for stenothermic habitat (Kondratieff and Kirchner 1991). This species has been designated a species of concern by the Virginia Field Office of USFWS.

Location

The big stripetail stonefly is known only from a spring on Beartown Mountain near Burkes Garden, Virginia (Kondratieff and Kirchner 1991). The map for the big stripetail stonefly (Figure 7.53) includes a Conservation Site (DCR-NH 2005).

Figure 7.53. Location of a DCR-NH conservation site containing big stripetail stonefly habitat in the Ridge and Valley-New EDU (DCR-NH 2005).

Description of Essential Habitat

The only locality from which this stonefly is known is a spring with a relatively constant temperature. The spring is at an elevation of approximately 1430ft (436m) (Kondratieff and Kirchner 1991). Nymphs were only found under mossy cobble near the spring's source.

Relative Condition of Habitat

The locality for this species is on a cattle ranch (Kondratieff and Kirchner 1991). Therefore, the habitat is subjected to trampling year round. Few riparian trees or shrubs remain.

Specific Threats and Trends

One specific threat to the big stripetail stonefly is habitat destruction and degradation from livestock trampling (Kondratieff and Kirchner 1991).
Conservation Actions and Strategies

Kondratieff and Kirchner (1991) recommends protection of the spring, either through its incorporation into the Beartown Wilderness Area of Jefferson National Forest, purchase or lease of the property by another conservation entity, or a cooperative agreement with the landowner to protect and improve the site.

Research and Monitoring Needs

Kondratieff and Kirchner (1991) indicate that attempts should be made to locate other populations.

7.4.3.2. Aquatic SGCN by Habitat Group: Ridge and Valley-New EDU

There are 20 tiered species in this EDU. Two are aquatic insects, ten are fish, three are mussels, one is a snail, three are crayfish, and one is an amphibian. Only two habitat groups could be identified (Tables 7.60 and 7.61). The remaining species are included in an unknown or generalist category (Table 7.62).

Table 7.60. Aquatic species of greatest conservation need in very low gradient large streams, small rivers, and large rivers (DGIF Classification type 331, 351, 441 and 551).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Logperch	*Percina caprodes*	IV	83	4
Appalachia darter	*Percina gymnocephala*	IV	80	6
Sharpnose darter	*Percina oxyrhynchus*	IV	71	7
Pistolgrip	*Tritogonia verrucosa*	IV	100	1

Table 7.61. Aquatic species of greatest conservation need in very low to moderate gradient small streams, large streams, and small rivers (DGIF Classification type 221, 222, 223, 232, 331, and 441).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Candy darter	*Etheostoma osburni*	II	74	10
New River shiner	*Notropis scabriceps*	IV	80	7

Table 7.62. Aquatic species of greatest conservation need: generalists and those with unknown habitat requirements based on DGIF habitat classification.

Common Name	Scientific Name	Tier	Number of Types Used (DGIF Aquatic Classification)
Kosztarab's common stonefly	*Acroneuria kosztarabi*	I	NA
Big stripetail stonefly	*Isoperla major*	I	NA
A crayfish	*Cambarus veteranus*	II	2 (2 occurrences)
Eastern hellbender	*Cryptobranchus alleganiensis*	II	3 (6 occurrences)
Tennessee heelsplitter	*Lasmigona holstonia*	II	3 (4 occurrences)
Green floater	*Lasmigona subviridis*	II	1 (1 occurrence)
Bluestone sculpin	*Cottus* sp. 1	III	2 (2 occurrences)
Kanawha darter	*Etheostoma kanawhae*	III	2 (3 occurrences)
Kanawha minnow	*Phenacobius teretulus*	III	3 (3 occurrences)
New River riffle crayfish	*Cambarus chasmodactylus*	IV	9
Scioto crayfish	*Cambarus sciotensis*	IV	10
Rainbow darter	*Etheostoma caeruleum*	IV	4 (4 occurrences)
Seep mudalia	*Leptoxis delatata*	IV	NA
Sand shiner	*Nortopis stramineus*	IV	1 (1 occurrence)

Relative Condition of Habitat

In this EDU, 10% of the riverine habitat is impaired (DEQ and DCR 2004). Most of the impairment is listed as bacteria or fecal coliform from non-point source agriculture, urban, or wildlife sources. Approximately 32% of the Ridge and Valley-New EDU is agricultural land, and about 2.5% is developed (USGS 1992). Within the state, agricultural land cover ranges from 2 to 41%, and developed land use ranges from 0.2 to 15% (USGS 1992).

Threats, conservation actions, and research and monitoring needs for the Tier II through Tier IV species are given in Appendices H, I, and J. Mussel TAC (2004) and Fish TAC (2004) provided this information within habitat groups selected at the workshops. The level of detail within these groups does not correspond to that used in the DGIF aquatic habitat classification.

7.4.4. Ridge and Valley-Big Sandy EDU

The Ridge and Valley-Big Sandy EDU is part of the Teays-Old Ohio freshwater ecoregion (Abell et al. 2000). The Teays-Old Ohio is considered "globally outstanding" because of the large number of species found here, second only to the Tennessee-Cumberland freshwater ecoregion. The level of endemism is considered moderately high, with 12% of fish, 14% of mussels, and 47% of crayfish found nowhere else. Abell et al. (2000) consider this region to have a conservation status of "Vulnerable."

Only a small section of the Big Sandy drains the Ridge and Valley (Figure 7.54). A larger portion drains the Northern Cumberland Mountain ecoregion. The Big Sandy flows north and west to the Ohio River.

7.4.4.1. Tier I Species in the Ridge and Valley-Big Sandy EDU

There are no documented occurrences of any Tier I species in the Ridge and Valley-Big Sandy EDU.

7.4.4.2. Aquatic SGCN by Habitat Group: Ridge and Valley-Big Sandy EDU

There is little data for the tiered species in the Ridge and Valley-Big Sandy EDU. Therefore, no habitat groups could be identified (Table 7.63).

7.4.4.2.1. Relative Condition of Habitat

There are no impaired waters within the Ridge and Valley-Big Sandy EDU (DEQ and DCR 2004). Only 7% of the land cover in this EDU is agricultural, and 0.2% is developed (USGS 1992). Within the state, agricultural land cover ranges from 2 to 41%, and developed land use ranges from 0.2 to 15% (USGS 1992).

Threats, conservation actions, and research and monitoring needs for the Tier II through Tier IV species are given in Appendices H, I, and J. Mussel TAC (2004) and Fish TAC (2004) provided this information within habitat groups decided upon at the workshops. The level of detail within these groups does not correspond to that used in the DGIF aquatic habitat classification.

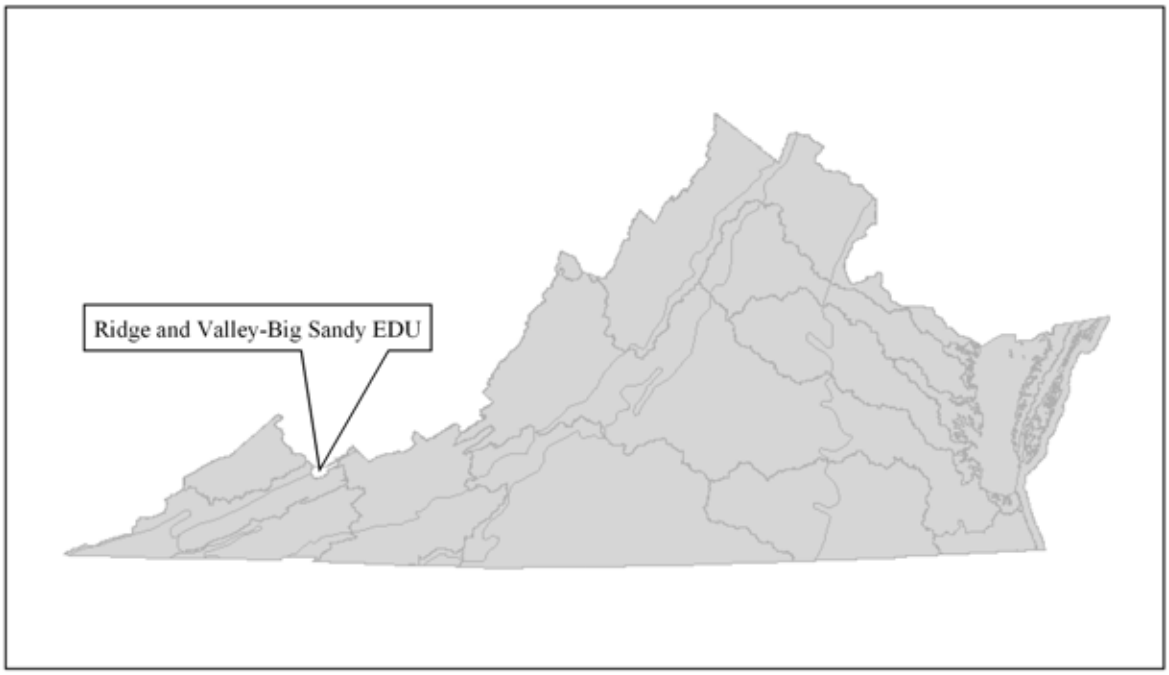

Figure 7.54. Location of the Ridge and Valley-Big Sandy EDU.

Table 7.63. Aquatic species of greatest conservation need: generalists and those with unknown habitat requirements based on DGIF habitat classification.

Common Name	Scientific Name	Tier	Number of Types Used (DGIF Aquatic Classification)
A crayfish	*Cambarus veteranus*	II	NA
Rainbow darter	*Etheostoma caeruleum*	IV	2 (3 occurrences)
Banded darter	*Etheostoma zonale*	IV	NA
Sand shiner	*Notropis stramineus*	IV	NA
Logperch	*Percina caprodes*	IV	NA
Blackside darter	*Percina maculate*	IV	NA
Sharpnose darter	*Percina oxyrhynchus*	IV	NA

7.4.5. Ridge and Valley- Roanoke EDU

The headwaters of the Roanoke River drain the Northern Ridge and Valley and Blue Ridge Mountains of Virginia (Figure 7.55). The Roanoke drains the Piedmont and then crosses into North Carolina before entering the Mid-Atlantic Coastal Plain. Several rivers within the drainage are significant on their own and include the Dan, Smith, Mayo, and Banister Rivers.

The Roanoke joins the Pee Dee and Chowan drainages to form the South Atlantic freshwater ecoregion, which is considered "globally outstanding" in terms of biological distinctiveness (Abell et al. 2000). The South Atlantic freshwater ecoregion is home to 48 endemic aquatic species including fish, mussels, and amphibians.

7.4.5.1. Tier I Species in the Ridge and Valley-Roanoke EDU

7.4.5.1.1. Roanoke logperch, *Percina rex*

Life History Summary

The Roanoke logperch is a Federal and State endangered species found only in the Roanoke and Nottoway river systems of Virginia. It is usually rare or uncommon. The populations are disjunct, separated by large stretches of unsuitable river habitat or impoundments (Burkhead and Jenkins 1991). It feeds on immature benthic invertebrates and exhibits the feeding behavior of flipping rocks to expose prey items (Jenkins and Burkhead 1994). The Roanoke logperch spawns in spring and early summer. Recent work by Rosenberger and Angermeier (2003) revealed that throughout its life, the Roanoke logperch inhabits a changing and varied array of habitats. A preference for relatively silt-free substrates and its restricted distribution have made it vulnerable to extinction. This species is protected with the status of Federal and State endangered.

Location

The map of Roanoke logperch habitat (Figure 7.56) includes confirmed reaches based on Collections (DGIF 2004b) and potential reaches using stream size, connectivity, gradient and reach elevation in the DGIF aquatic habitat classification. See Appendix D for more details.

Description of Essential Habitat

The most "essential" aspect of the Roanoke logperch habitat is silt-free, unembedded substrate including clean sand as well as larger particles. (P. L. Angermeier, VCFWRU, pers. comm.). In the Roanoke River, this species occupies warm, moderate to large streams and small rivers. Rosenberger and Angermeier (2003) found that there were shifts in habitat use across life stages and between drainages. Adult and subadult logperch were found in runs, riffles, and pools, in order of preference, while YOY were found exclusively in backwaters and secondary channels. Adults were observed in the deepest water (mean of 52.5cm) of significantly higher velocity than subadults or YOY.

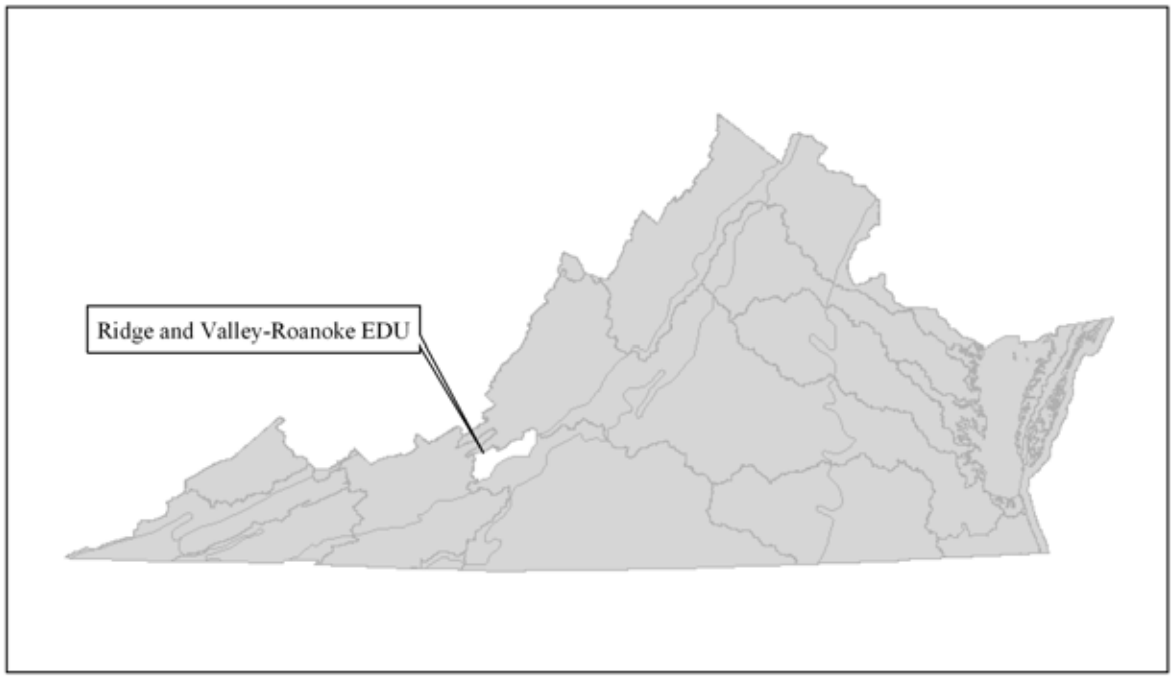

Figure 7.55. Location of the Ridge and Valley-Roanoke EDU.

The Roanoke logperch is intolerant of moderately- to heavily-silted areas except in winter periods of inactivity (Jenkins and Burkhead 1994). In the warmer months, the adults are usually on gravel and rubble in runs and riffles, occasionally pools. When the water temperature drops below 8°C, this species becomes

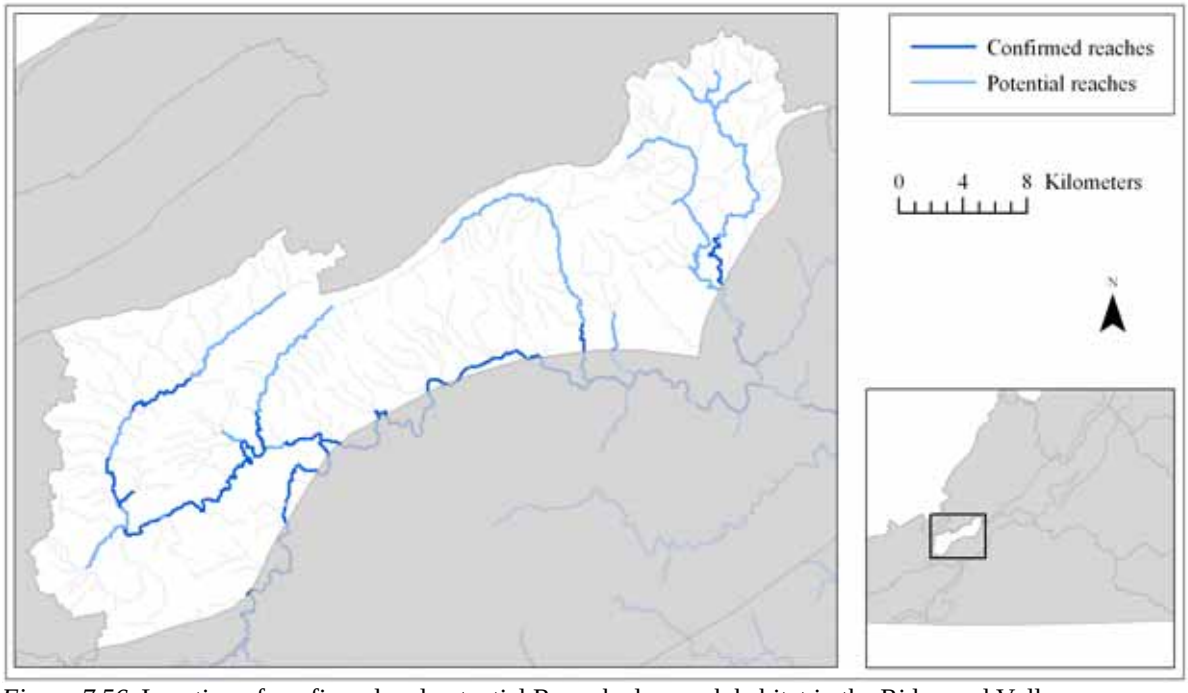

Figure 7.56. Location of confirmed and potential Roanoke logperch habitat in the Ridge and Valley-Roanoke EDU (DGIF 2004b).

quiescent under rocks in pools (Jenkins and Burkhead 1994). Prior to spawning, the adults segregate, with the males going to the riffles and the females to deeper runs (Jenkins and Burkhead 1994).

The DGIF aquatic habitat classification was also used to identify the diversity of habitat types used by the Roanoke logperch and to assess patterns of distribution. All of the specimens were collected from reaches characterized as small or large streams with very low to moderate gradient across the length of the reach. In the Ridge and Valley-Roanoke EDU, this species was found in six habitat types (Table 7.64).

Specific Threats and Trends

Burkhead and Jenkins (1991) list channelization, siltation, chronic pollution of various types, catastrophic chemical spills, impoundment and dewatering as major stresses to this species. . In addition, a report by Wheeler et al. (2003) indicates many potential direct and indirect effects, including those mentioned above, of the construction of I-73 on the Roanoke logperch and other aquatic biota. No species specific threats were listed by the Fish TAC (2004) for the Roanoke logperch. A summary of the stresses and sources of stress identified for the Roanoke River drainage is available in Appendix H.

Relative Condition of Habitat

All but three sections of known habitat for the Roanoke logperch are within or immediately downstream of impaired stream segments (DEQ and DCR 2004). The causes of impairment are mostly bacteria and temperature, with a couple of sections listed for PCB contaminated fish tissue. The sources of these impairments include non-point source urban, agriculture, and wildlife or unknown. The source for the PCB contamination is unknown. The recovery plan for this species discusses past and recent habitat issues (USFWS 1992).

Conservation Actions and Strategies

Burkhead and Jenkins (1991) list several specific conservation actions and generally recommend long-term bank stabilization and better monitoring and enforcement of regulations regarding silt control in construction projects to reduce sedimentation. They also recommend the review of discharge permits to evaluate cumulative concentration of effluents in the Roanoke drainage. The recovery plan identified four actions needed to meet recovery objectives (USFWS 1992). These include: using existing legislation to protect it; developing educational programs and other resources to inform the public about the species and its status; determining feasibility of re-establishing or reintroducing populations where appropriate; and implementing measures to reduce sedimentation and other identified threats. More conservation actions related to threats to the Roanoke River drainage were identified by Fish TAC (2004) (Appendix I).

Research and Monitoring Needs

Three research or monitoring activities were identified by USFWS to meet the recovery objectives listed in this species' recovery plan (USFWS 1992). These include surveys for additional populations and habitats for possible reintroduction; characterization of the species habitat requirements and population viability including monitoring of threats; and surveys to monitor population levels and habitat conditions.

Table 7.64. DGIF aquatic habitat types used by the Roanoke logperch in the Ridge and Valley-Roanoke EDU.

Aquatic Habitat Type	Number of Reaches
Very low gradient large stream connected to another large stream	17
Low gradient small stream connected to another small stream	11
Low gradient large stream connected to another large stream	2
Low gradient small stream connected to a large stream	2
Moderate gradient small stream connected to another small stream	1
Moderate gradient small stream connected to a large stream	1

7.4.5.2. Aquatic SGCN by Habitat Group: Ridge and Valley-Roanoke EDU

There are 10 tiered species documented in this EDU, seven fish and three mussels. They are distributed among three habitat groups, including one for generalists and species for which habitat group membership could not be determined (Tables 7.65-7.67).

Table 7.65. Aquatic species of greatest conservation need with migratory habits. These species use a range of habitats from large tidal rivers to small streams. In the Ridge and Valley, the American eel was found in very low gradient large streams.

Common Name	Scientific Name	Tier
American eel	*Anguilla rostrata*	IV

Table 7.66. Aquatic species of greatest conservation need in very low to moderate gradient small and large streams (DGIF Classification types 222, 223, 232, 233, 331, and 332).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Roanoke logperch	*Percina rex*	I	100	6
Roanoke bass	*Ambloplites cavifrons*	II	100	3 (5 occurrences)
Orangefin madtom	*Noturus gilberti*	II	94	6
Bigeye jumprock	*Moxostoma ariommum*	III	83	8
Riverweed darter	*Etheostoma podostmeone*	IV	92	13
Roanoke hog sucker	*Hypentelium roanokense*	IV	86	10

Table 7.67. Aquatic species of greatest conservation need: generalists and those with unknown habitat requirements based on DGIF habitat classification.

Common name	Scientific name	Tier	Number of Types Used (DGIF Aquatic Classification)
Notched rainbow	*Villosa constricta*	III	1 (1 occurrence)
Triangle floater	*Alasmidota undulata*	IV	NA
Creeper mussel	*Strophitus undulatus*	IV	NA

7.4.5.2.1. Relative Condition of Habitat

About 14% of the riverine habitat in this EDU is listed as impaired by DEQ and DCR (2004). The majority of the impairments are bacterial from urban sources. A fair number of the impairments are due to temperature from unknown sources. Approximately 17% of the land cover in this EDU is agricultural, while nearly 10% is developed (USGS 1992). Within the state, agricultural land cover ranges from 2 to 41%, and developed land use ranges from 0.2 to 15% (USGS 1992).

Threats, conservation actions, and research and monitoring needs for the Tier II through Tier IV species are given in Appendices H, I, and J. Mussel TAC (2004) and Fish TAC (2004) provided this information within habitat groups selected at the workshops. The level of detail within these groups does not correspond to that used in the DGIF aquatic habitat classification.

7.4.6. Ridge and Valley- James EDU

The James River drainage occurs almost wholly within Virginia and covers over 25% of the land area of the state (Jenkins and Burkhead 1994). It crosses the Ridge and Valley, Blue Ridge, Piedmont, and Coastal Plain. The Ridge and Valley-James EDU (Figure 7.57) is found within the Chesapeake Bay freshwater ecoregion (Abell et al. 2000). As its name implies, this ecoregion encompasses all of the drainages of the

Chesapeake Bay. This freshwater ecoregion supports four endemic mussel species and seven endemic fish species, including the roughhead shiner *Notropis semperasper*, found only in the headwaters of the James River. It is also home to several migratory fish including American shad *Alosa sapidissima*, alewife *A. pseudoharengus*, and American eel *Anguilla rostrata*. Abell et al. (2000) list the Chesapeake Bay freshwater ecoregion as "continentally outstanding" in terms of biological distinctiveness.

7.4.6.1. Tier I Species in the Ridge and Valley-James EDU

7.4.6.1.1. James spinymussel, *Pleurobema collina*

Life History Summary

Most of the work regarding the Federal and State endangered James spinymussel has involved the James River drainage population. It is a short-term brooder. Hove (1990) identified several fish hosts for this species from work in Craig Creek including the rosyside dace *Clinostomus funduloides*, bluehead chub *Nocomis leptocephalus*, mountain redbelly dace *Phoxinus oreas*, blacknose dace *Rhinichthys atratulus*, central stoneroller *Campostoma anomalum*, rosefin shiner *Lythrurus ardens*, satinfin shiner *Cyprinella analostana*, and swallowtail shiner *Notropis procne*. In the James River drainage, this species occupies a wide range of habitats, which suggests that it used to be much more widespread, and that its current rarity is due to decline from habitat loss or other external threats, rather than an innate feature of the species.

Recently (2000-2002), R. J. Neves discovered a population in the Dan River (R. J. Neves, VCFWRU, unpublished data). Little is known about the life history, distribution, or even precise taxonomy of this population. Currently it is considered *Pleurobema collina*; however, research is underway to validate its taxonomy. For management purposes, the populations are currently considered different management units of the same species (B. T. Watson, DGIF, pers. comm.). This species is legally protected with the status of Federal and State endangered.

Location

The map of the James spinymussel (Figure 7.58) includes confirmed reaches based on Collections (DGIF 2004b) and potential reaches using size, connectivity and gradient attributes from the DGIF aquatic habitat classification. See Appendix D for more details.

Description of Essential Habitat

This species is found in second and third order streams that are unpolluted, well-oxygenated, and of moderate hardness ($CaCO_3$ > 50mg/l). It is found in runs with moderate current and sand, gravel, and cobble substrate (Clarke and Neves 1984). Streams containing the James spinymussel range in size from 0.3 to 2m deep and 1 to 20m wide (Hove 1990). They seem to prefer bottom sediments of sand and cobble, with or without boulders, pebbles or silt. They are usually buried in the substrate near stagnant riffle-run flows (Hove 1990). The DGIF aquatic habitat classification was also used to identify the diversity of habitat types used by the James spinymussel and to assess patterns of distribution (Table 7.68). This species has been documented in 10 different aquatic habitat types. Extirpated populations may have occurred more frequently in larger rivers with sandy bottoms. This species was once more widely distributed throughout the James River drainage and has been reduced to approximately 5-10% of its historic distribution (B. T. Watson, DGIF, pers. comm.).

Relative Condition of Habitat

Nearly than half of the known habitat reaches in the Ridge and Valley-James EDU lie within or immediately downstream of impaired reaches (DEQ and DCR 2004). The causes of impairment are listed as bacteria or pH from non-point source, non-point source-urban, or unknown sources. The recovery plan for this species reviews past and recent habitat quality concerns (USFWS 1990c).

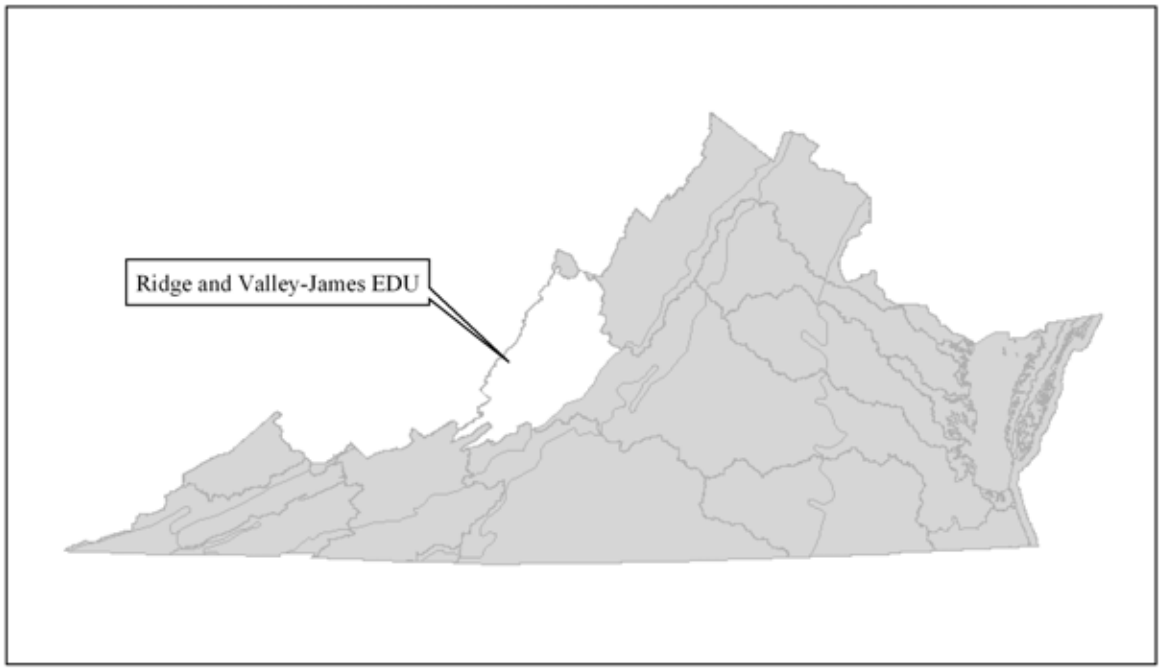

Figure 7.57. Location of the Ridge and Valley-James EDU.

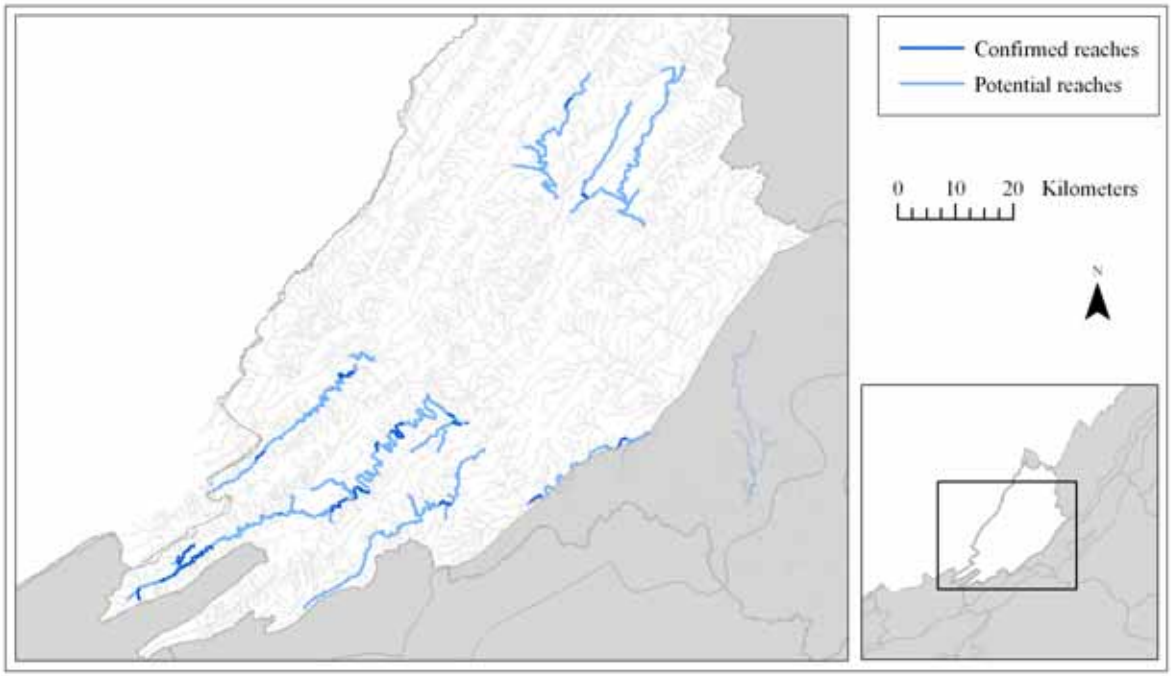

Figure 7.58. Confirmed and potential James spinymussel habitat in the Ridge and Valley-James EDU (DGIF 2004b).

Table 7.68. Aquatic habitat types used by the James spinymussel in the Ridge and Valley-James EDU.

Aquatic Habitat Type	Number of Reaches
Very low gradient small stream connected to another small stream	7
Low gradient small stream connected to another small stream	7
Very low gradient large stream connected to another large stream	5

Aquatic Habitat Type	Number of Reaches
Very low gradient small river connected to another small river	5
Moderate gradient small stream connected to another small stream	2
Low gradient small stream connected to a small river	1
Low gradient large stream connected to another large stream	1
Very low gradient small river connected to a large river	1
Very low gradient large river connected to another large river	1
Low gradient large river connected to another large river	1

Specific Threats and Trends

Neves (1991i) suggested that habitat degradation and reproductive isolation have caused the decline of the James spinymussel. Clarke (1986) also cited competition from the Asian clam *Corbicula fluminea* as a possible threat. Table 7.68 summarizes the data on stresses received from Mussel TAC (2004). These include threats to both the James River and the Dan River populations.

Conservation Actions and Strategies

The recovery plan for the James spinymussel identified two initial conservation actions: investigation of specific threats such as siltation, pesticides, municipal and industrial effluents, and Asian clam interactions; and assessment of projects that pose potentially negative effects on the species or its habitat (USFWS 1990c). Following the implementation and assessment of these actions and the monitoring actions listed below, other secondary actions should be undertaken: control of Asian clam; implementation of appropriate protection strategies as identified; and re-establishment of populations as appropriate.

Mussel TAC (2004) identified conservation actions specific to the threats above (in no particular order):

- Dam removal and/or installation of fish passage for fish host migration and habitat restoration
- Stormwater management
- More efficient use of water
- Education of regional and county planning administrators
- Education of homeowners regarding the use of fertilizers and pesticides (especially molluscicides).
- Work with VDOT to develop possible solutions to salt application and subsequent runoff
- Implementation of appropriate BMPs for agriculture and stormwater management
- Augment population where possible
- Increase hazardous materials response to spills
- Improve enforcement of existing water quality and permitting regulations

Table 7.69. Stresses on the James spinymussel (Mussel TAC 2004).

Stress	Source of Stress	Scope	Severity	Comments
Hydrologic regime alteration	a) dam b) water withdrawal c) municipal development d) beaver activity	a) 2 b) 2 c) 2 d) 1	a) 4 b) 2 c) 3 d) 1	Dam building also floods habitat, causing habitat destruction
Sediment load alteration	Municipal development	4	3	
Insecticides	Municipal development	2	1	Molluscicides possible on lawns
Organic pollutants	Roadways	1	1?[1]	Creosote
Complications due to small populations (inbreeding, stochastic fluctuation, etc.)		4	4	
Toxins	Industrial, other	1	4	Spills from trucks and industrial accidents

Research and Monitoring Needs

The recovery plan for the James spinymussel identified the following research or monitoring needs: determination of essential habitat; threats monitoring; life history and ecology studies to establish the feasibility and methods to re-introduce this species to its historic range; and monitoring of existing and introduced populations (USFWS 1990c). Mussel TAC (2004) listed a few other research needs tied to stress reduction. These include researching and subsequently implementing minimum flow requirements; investigating the amount of sediment reduction needed to see a positive effect on mussel community; researching the impacts of biocide runoff from residents, and investigating the possible effects of creosote contamination from wood bridges and road salts.

7.4.6.2. Aquatic SGCN by Habitat Group: Ridge and Valley-James EDU

There are 11 tiered aquatic species known in this EDU: seven mussels, one snail, one crayfish, and two fish. They are distributed among 4 habitat groups and one unknown or generalist group (Tables 7.70-7.74).

Table 7.70. Aquatic species of greatest conservation need with migratory habits. These species use a range of habitats from large tidal rivers to small streams.

Common Name	Scientific Name	Tier
American eel	*Anguilla rostrata*	IV

Table 7.71. Aquatic species of greatest conservation need in very low and low gradient large streams, small rivers and large rivers (DGIF Classification types 331, 332, 441, and 551).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Roughhead shiner	*Notropis semperasper*	II	82	12

Table 7.72. Aquatic species of greatest conservation need in very low gradient small rivers (DGIF Classification types 441 and 451).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Yellow lance	*Elliptio lanceolata*	III	64	6

Table 7.73. Aquatic species of greatest conservation need in very low to moderate gradient small streams, large streams and small rivers (DGIF Classification type 221, 222, 223, 231, 242, 243, 331, 333, 441, and 451).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
James spinymussel	*Pleurobema collina*	I	93	10
Notched rainbow	*Villosa constricta*	III	96	10
Triangle floater	*Alasmidonta undulata*	IV	89	7
Creeper mussel	*Strophitus undulatus*	IV	100	8

Table 7.74. Aquatic species of greatest conservation need: generalists and those with unknown habitat requirements based on DGIF habitat classification.

Common Name	Scientific Name	Tier	Number of Types Used (DGIF Aquatic Classification)
Virginia springsnail	*Fontigens morrisoni*	I	NA
Atlantic pigtoe	*Fusconaia masoni*	II	5 (11 occurrences)
Green floater	*Lasmigona subviridis*	II	NA
Monongahela crayfish	*Cambarus monongalensis*	IV	NA

7.4.6.2.1. Relative Condition of Habitat

Less than 7% of the riverine habitat in this EDU is impaired (DEQ and DCR 2004). Many of the impairments are bacterial, from non-point sources. Several are general standard (benthics) with no listed source. Just over 15% of the land cover is the Ridge and Valley-James EDU is agricultural (USGS 1992). Less than 1% is developed (USGS 1992). Within the state, agricultural land cover ranges from 2 to 41%, and developed land use ranges from 0.2 to 15% (USGS 1992).

Threats, conservation actions, and research and monitoring needs for the Tier II through Tier IV species are available in Appendices H, I, and J. Mussel TAC (2004) and Fish TAC (2004) provided this information within habitat groups selected at the workshops. The level of detail within these groups does not correspond to that used in the DGIF aquatic habitat classification.

7.4.7. Ridge and Valley-Potomac EDU

The Potomac River drainage covers a large area encompassing parts of Pennsylvania, Maryland, Virginia, and West Virginia. The watershed drains the Ridge and Valley, Blue Ridge, Piedmont, and the Coastal Plain. Several tributaries of the middle Potomac drain the eastern front of the Blue Ridge. The fall line, which occurs at the break between the Piedmont and Coastal Plain, is a natural barrier to most migratory fish. The Ridge and Valley-Potomac EDU (Figure 7.59) is found within the Chesapeake Bay freshwater ecoregion (Abell et al. 2000). As its name implies, this ecoregion encompasses all of the drainages of the Chesapeake Bay. This freshwater ecoregion supports four endemic mussel species and seven endemic fish species, including the roughhead shiner *Notropis semperasper*, found only in the headwaters of the James River. It is also home to several migratory fish including American shad *Alosa sapidissima*, alewife *A. pseudoharengus*, and American eel *Anguilla rostrata*. Abell et al. (2000) list the Chesapeake Bay freshwater ecoregion as "continentally outstanding" in terms of biological distinctiveness.

7.4.7.1. Tier I Species in the Ridge and Valley-Potomac EDU

There are no documented occurrences of any Tier I species in the Ridge and Valley-Potomac EDU.

7.4.7.2. Aquatic SGCN by Habitat Group: Ridge and Valley-Potomac EDU

There are 11 tiered species in this EDU. Six are freshwater mussels, two are freshwater snails, and three are fish. They are distributed among three habitat groups, with one group for generalist species or those for which habitat groups could not be determined (Tables 7.75-7.78). The wood turtle relies on stream habitats for portions of its life; however, it is discussed in detail in Section 7.2.

Table 7.75. Aquatic species of greatest conservation need with migratory habits. These species use a range of habitats from large tidal rivers to small streams.

Common Name	Scientific Name	Tier
American eel	*Anguilla rostrata*	IV

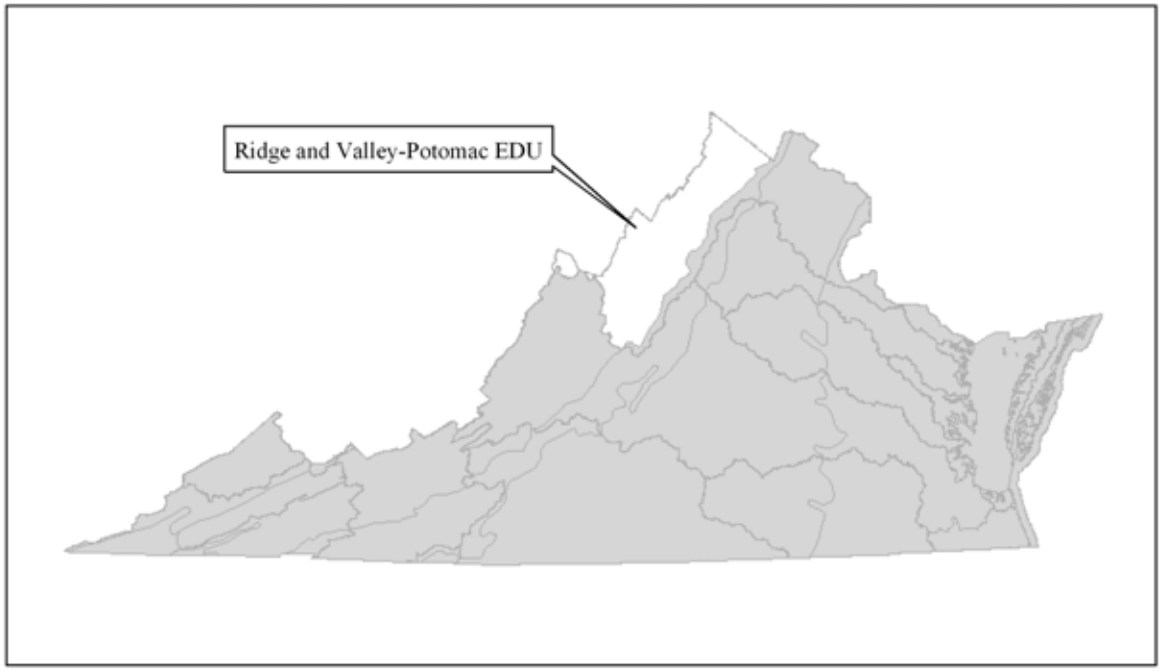

Figure 7.59. Location of the Ridge and Valley-Potomac EDU.

Table 7.76. Aquatic species of greatest conservation need in very low gradient to moderate gradient headwaters and small streams (DGIF Classification types 111, 112, 113, 121, 122, 123, 153, 221, 222, 223, 231, and 232).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Slimy sculpin	*Cottus cognatus*	IV	95	9
Pearl dace	*Margariscus margarita*	IV	89	13

Table 7.77. Aquatic species of greatest conservation need in very low gradient large streams and small rivers (DGIF Classification types 331 and 441).

Common Name	Scientific Name	Tier	Percent Occurrences in Habitat Group	Number of Types Used (DGIF Aquatic Classification)
Brook floater	*Alamidonta varicosa*	II	85	4
Triangle floater mussel	*Alasmidonta undulata*	IV	71	4 (7 occurrences)

Table 7.78. Aquatic species of greatest conservation need: generalists and those with unknown habitat requirements based on DGIF habitat classification.

Common Name	Scientific Name	Tier	Number of Types Used (DGIF Aquatic Classification)
Appalachian springsnail	*Fontigens bottimeri*	II	NA
Green floater	*Lasmigona subviridis*	II	1 (1 occurrence)
Yellow lampmussel	*Lampsilis cariosa*	III	2 (3 occurrences)
Northern lance mussel	*Elliptio fisheriana*	IV	2 (5 occurrences)
Dusky fossaria	*Fossaria dalli*	IV	NA
Creeper mussel	*Strophitus undulatus*	IV	5 (7 occurrences)

7.4.7.2.1. Relative Condition of Habitat

The Ridge and Valley-Potomac EDU has the highest percentage of impaired waters in this ecoregion at 27% (DEQ and DCR 2004). Impairments include fecal coliform, general standard (benthics), and pH. The sources for impairment include non-point source agriculture, urban, and wildlife, atmospheric deposition, and unknown. This EDU also contains the largest percentage of agricultural land cover of any EDU in the state at 41% (USGS 1992). Developed land cover comprises just over 3% (USGS 1992). Within the state, agricultural land cover ranges from 2 to 41%, and developed land use ranges from 0.2 to 15% (USGS 1992).

Threats, conservation actions, and research and monitoring needs for the Tier II through Tier IV species are given in Appendices H, I, and J. Mussel TAC (2004) and Fish TAC (2004) provided this information within habitat groups selected at the workshops. The level of detail within these groups does not correspond to that used in the DGIF aquatic habitat classification.

7.5. Subterranean Species in the Ridge and Valley

7.5.1. Tier I Subterranean Species

7.5.1.1. Natural Bridge cave isopod, *Caecidotea bowmani*

Life History Summary

The Natural Bridge cave isopod is apparently endemic to Rockbridge County, Virginia, where it has only been found beneath leaves in a drain tile (Lewis 1980). This site is privately owned. Nothing is known about the natural history or ecology of this species, except that it is apparently an inhabitant of interstitial water (Holsinger 1991b). The Natural Bridge cave isopod has been designated a species of concern by the Virginia Field Office of USFWS.

Location

The habitat map for the Natural Bridge cave isopod (Figure 7.60) includes a cave Conservation Site (DCR-NH 2004).

Description of Habitat Requirements

This species is known only from the type locality, a small drain tile beside a trail that leads through the privately owned Natural Bridge Park in Rockbridge County (Lewis 1980).

Relative Condition of Habitat

There is a single Conservation Site for Natural Bridge cave isopod in Rockbridge County (DCR-NH 2004). This site does not have any protection from a Conservation Land. The drain tile from which this species is known is obscured by soil and is on private property (Lewis 1980).

Specific Threats and Trends

No specific stresses were reported by Invertebrate TAC. Its single known location is privately owned, so protection of the site is not assured.

Conservation Actions and Strategies

No conservation actions were reported by Invertebrate TAC. Protection of the only known site is important.

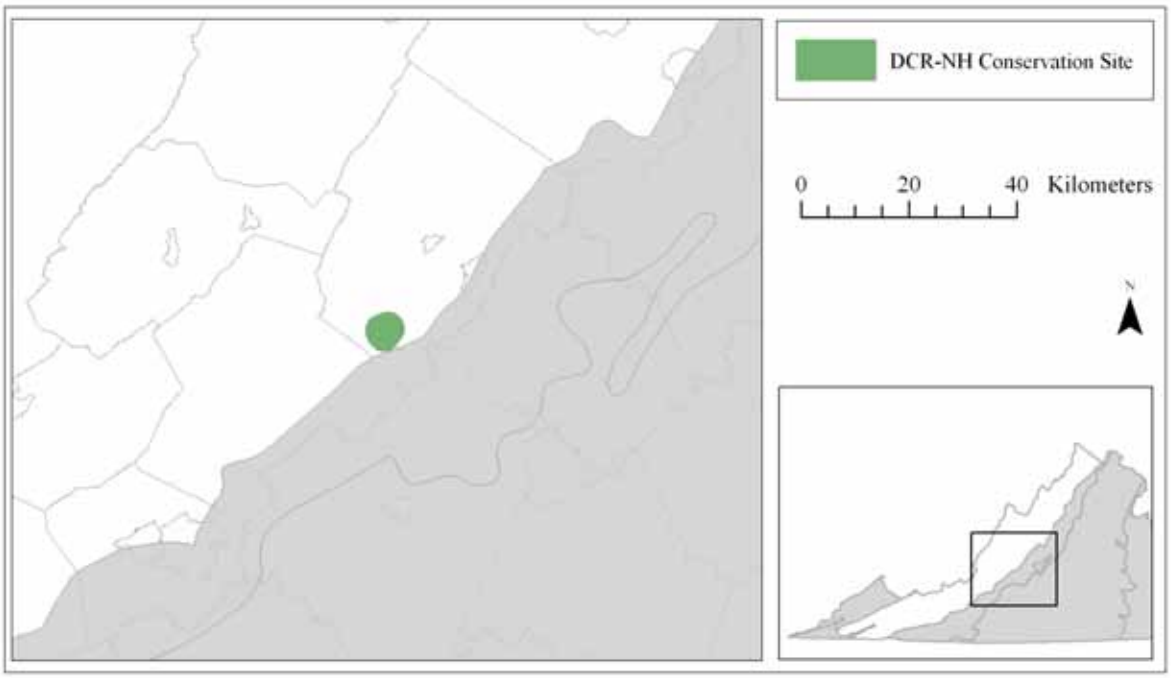

Figure 7.60. Distribution of Natural Bridge cave isopod in the Ridge and Valley.

Research and Monitoring Needs

No specific research or monitoring needs were reported by Invertebrate TAC. Its distribution is poorly known; since its known location is a drain tile, it could presumably be found in other groundwater, and Holsinger (1991b) suggests that it may be found in caves. Also, nothing is known of its life history.

7.5.1.2. Virginia springsnail, *Fontigens morrisoni*

Life History Summary

The life history of the Virginia springsnail is not well known (Stewart and Dillon 2004). It is endemic to the Upper James River basin of Virginia (Hershler et al. 1990; NatureServe 2003).

Location

This species is endemic only to the Upper James River basin of Virginia. It is known from Bath and Highland Counties in two springs and two caves (Hershler et al. 1990; NatureServe 2003). The type locality is a small spring-fed brook in Highland County that is southwest of Mustoe, along Highway 220. The map of the Virginia springsnail (Figure 7.61) includes confirmed locations (DGIF 2004b).

Description of Essential Habitat

The Virginia springsnail is known from caves and springs; however, not enough is known to refine the definition of essential habitat.

Relative Condition of Habitat

There is no information regarding the relative condition of habitat for Virginia springsnail.

Specific Threats and Trends

The Virginia springsnail is limited to only a few locations (Stewart and Dillon 2004). Specific threats are not known, but any significant disturbance could have a catastrophic effect on this species.

Conservation Actions and Strategies

No specific conservation actions could be identified for the Virginia springsnail.

Research and Monitoring Needs

Life history and distributional studies are needed to understand the needs and threats to this species.

7.5.1.3. Rye Cove isopod, *Lirceus culveri*

Life History Summary

This unpigmented, eyeless species is endemic to one cave in Scott County, Virginia. It inhabits the gravel substrate of a stream in McDavids Cave (Holsinger 1991b). Little else is known about its biology. It is potentially threatened by groundwater pollution (Holsinger 1979c, 1991b). It is a State special concern species, and has been designated a species of concern by the Virginia Field Office of USFWS.

Location

The map of habitat for the Rye Cove isopod (Figure 7.62) includes a cave Conservation Site (DCR-NH 2004).

Description of Habitat Requirements

This species is confined to the hydrology of McDavids Cave in Scott County, Virginia (Holsinger 1991b). It inhabits gravel or fused gravel substrate in areas of stream marked by riffles (Estes and Holsinger 1976).

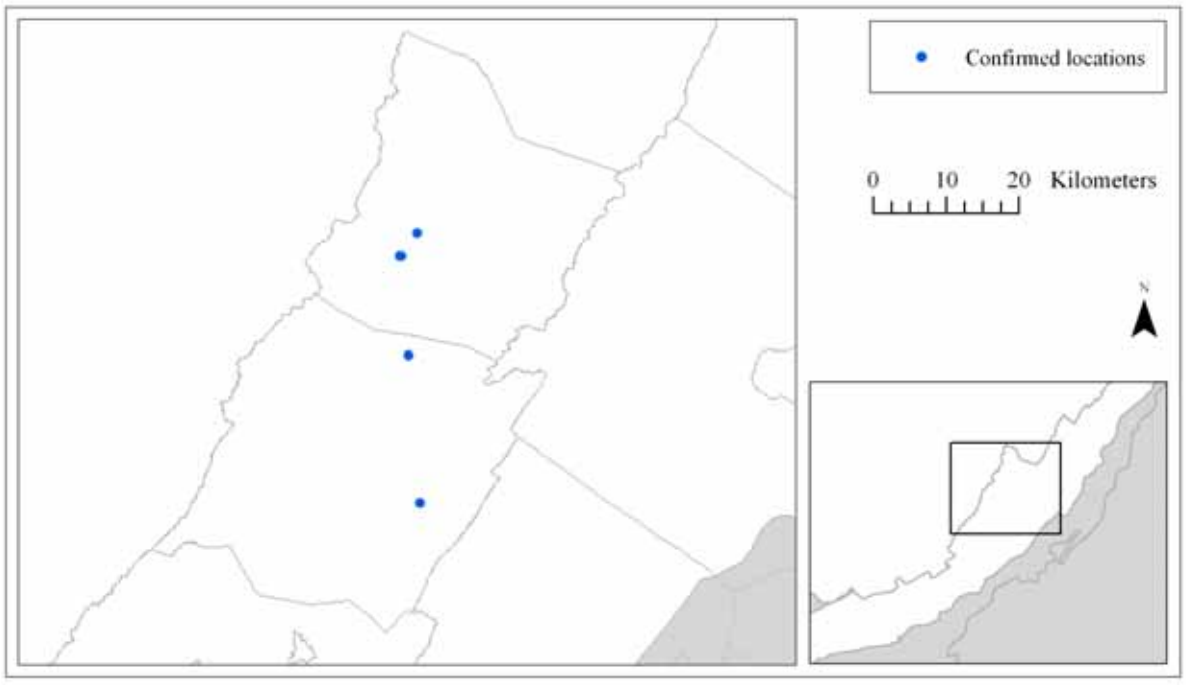

Figure 7.61. Cconfirmed Virginia springsnail habitat in the Ridge and Valley-James EDU (DGIF 2004b).

Relative Condition of Habitat

There is a single Conservation Site for the Rye Cove isopod, covering a portion of Scott County (DCR-NH 2004). This site does not have any protection from a Conservation Land. Nothing in Holsinger (1975) indicates the condition of the cave, and Douglas (1964) does not mention a cave by this name.

Specific Threats and Trends

No specific stresses were reported by Invertebrate TAC. This species is not tolerant of stream perturbance or groundwater pollution (NatureServe 2004).

Conservation Actions and Strategies

No specific conservation actions were reported by Invertebrate TAC. NatureServe (2004) suggests acquisition or closing of McDavids Cave, in conjunction with groundwater protection.

Research and Monitoring Needs

No specific research or monitoring needs were reported by Invertebrate TAC. Further study of its life history is needed, as are additional surveys to determine if this species is truly endemic (Holsinger 1979c).

7.5.1.4. A groundwater planarian, *Procotyla typhlops*

Life History Summary

This species was listed by USFWS (1989b) as a Category 2 taxon under consideration for listing under ESA. Category 2 taxa are those taxa for which information indicates that listing under ESA is "possibly appropriate," but conclusive evidence is still needed (USFWS 1989b). This source lists Virginia as part of *P. typhlops* historic range, but no documented specimens have been collected within the state. This species inhabits springs (NatureServe 2004); little else is known about its natural history or ecology.

Figure 7.62. Distribution of the Rye Cove isopod in the Ridge and Valley.

Location

The type location for this species is in Rockbridge County, where it was collected in the early 1930s (S. M. Roble, DCR-NH, pers. comm.).

Description of Habitat Requirements

This species is known in Rockbridge County in the Ridge and Valley, where it inhabits springs and spring-fed pools (NatureServe 2004).
Relative Condition of Habitat

The records of *Procotyla typhlops* in Virginia are so old that it is impossible to determine the relative condition of its habitat.

Specific Threats and Trends

No specific threats or trends were reported by Invertebrate TAC. Water pollution and alteration of groundwater are potential stresses.

Conservation Actions and Strategies

No specific conservation actions were reported by Invertebrate TAC.

Research and Monitoring Needs

No specific research or monitoring needs were reported by Invertebrate TAC. Little is known about its natural history, and its distribution is not well understood. Any occurrences of this species that are discovered should be protected. Knowledge of the planaria is restricted, and individuals working with the group (or even capable of identifying them) are very rare (C. S. Hobson and S. M. Roble, DCR-NH, pers. comm.). Clearly a primary need is to determine whether it occurs in Virginia.

7.5.1.5. Chandler's planarian, *Sphalloplana chandleri*

Life History Summary

In Virginia, this species is known only from Fallen Rock Cave in Tazewell County (Holsinger and Culver 1988). It presumably inhabits drip pools or stream-fed pools in caves, or flat rocks in small cave streams, although in Indiana it has also been collected in surface springs (S. M. Roble, DCR-NH, pers. comm.). It has been designated a species of concern by the Virginia Field Office of USFWS.

Location

The map for Chandler's planarian (Figure 63) includes a cave Conservation Site (DCR-NH 2004).

Description of Habitat Requirements

This species is only known in Floyd and Harrison Counties, Indiana, and Tazewell County, Virginia (NatureServe 2004). In Virginia, it is known from the Upper Clinch (06010205) watershed, in Fallen Rock Cave, Tazewell County (Holsinger and Culver 1988).

Relative Condition of Habitat

Holsinger (1975) reports that the owner allows entry "only for serious speleological work," so the cave could be considered relatively protected. Based on this (dated) account, this cave appears to be in good (relatively natural) condition.

Specific Threats and Trends

No specific threats or trends were reported by Invertebrate TAC. Water pollution and alteration of groundwater are potential stresses.

Conservation Actions and Strategies

No specific conservation actions were reported by Invertebrate TAC.

Research and Monitoring Needs

No specific research or monitoring needs were reported by Invertebrate TAC. Little is known about its natural history, and its distribution is not well understood. Knowledge of the planaria is restricted, and individuals working with the group (or even capable of identifying them) are very rare (C. S. Hobson, DCR-NH, pers. comm.).

7.5.1.6. Rockbridge County cave planarian, *Sphalloplana virginiana*

Life History Summary

This species is endemic to Rockbridge County, where Showalters Cave is the type locality (Holsinger and Culver 1988). It presumably inhabits drip pools or stream-fed pools in caves, or flat rocks in small cave streams (Holsinger and Culver 1988). This species was listed by USFWS (1989b) as a Category 2 taxon under consideration for listing under ESA. Category 2 taxa are those taxa for which information indicates that listing under ESA is "possibly appropriate," but conclusive evidence is still needed (USFWS 1989b).

Location

The map depicting locations for this species (Figure 7.64) includes a cave Conservation Site (DCR-NH 2004).

Figure 7.63. Distribution of Chandler's planarian in the Ridge and Valley.

Figure 7.64. Distribution of the Rockbridge County cave planarian in the Ridge and Valley.

Description of Habitat Requirements

This species is apparently endemic to Showalters Cave in the Maury River (02080202) watershed, Rockbridge County (Holsinger and Culver 1988). It is found in drip pools or on rocks in small streams (Holsinger and Culver 1988).

Relative Condition of Habitat

Douglas (1964) reports that the owner of this cave "once had it practically sold as a commercial cave, but heavy rains flooded it and washed out the deal." This account, when taken with Holsinger's (1975) discussion of this cave as one that floods during winter and spring, indicate that this cave is unlikely to face heavy interest from cavers during at least part of the year. Beyond these two dated accounts, nothing is known about the condition of this habitat.

Specific Threats and Trends

No specific threats or trends were reported by Invertebrate TAC. Water pollution and alteration of groundwater are potential stresses.

Conservation Actions and Strategies

No specific conservation actions were reported by Invertebrate TAC.

Research and Monitoring Needs

No specific research or monitoring needs were reported by Invertebrate TAC. Little is known about its natural history, and its distribution is not well understood. Knowledge of the planaria is restricted, and individuals working with the group (or even capable of identifying them) are very rare (C. S. Hobson, DCR-NH, pers. comm.).

7.5.1.7. A cave lumbriculid worm, *Stylodrilus beattiei*

Life History Summary

Within Virginia, this species is known only from Steele's Cave in Tazewell County. Holsinger and Culver (1988) report that this worm inhabits gravel substrates of small cave streams. It has been designated a species of concern by the Virginia Field Office of USFWS.

Location

The map of locations for *S. beattiei* includes one cave Conservation Site (Figure 7.65) (DCR-NH 2004).

Description of Habitat Requirements

This species is only known in Greenbrier and Pocahontas Counties, West Virginia, and Tazewell County, Virginia (NatureServe 2004). In Virginia, it is known in the Upper Clinch (06010205) watershed in Steele's Cave, Tazewell County (Holsinger and Culver 1988).

Relative Condition of Habitat

Douglas (1964) reports that Steele's Cave is "on the property of the County Poor Farm," though what this implies in terms of current protection is unclear. Condition of this cave is unknown, though from the 1964 description, it appears that it is easily accessible, which could lead to disturbance by cavers (Douglas 1964).

Specific Threats and Trends

No specific threats or trends were reported by Invertebrate TAC. Water pollution and alteration of groundwater are potential stresses.

Conservation Actions and Strategies

No specific conservation actions were reported by Invertebrate TAC.

Figure 7.65. Distribution of *Stylodrilus beattiei* in the Ridge and Valley.

Research and Monitoring Needs

No specific research or monitoring needs were reported by Invertebrate TAC. Little is known about its natural history, and its distribution is not well understood.

7.5.1.8. Ephemeral cave amphipod, *Stygobromus ephemerus*

Life History Summary

This eyeless species is apparently endemic to two caves in Giles County, Virginia, though nothing is known about its ecology or life history (Holsinger 1979a, 1991a; NatureServe 2004). It inhabits drip pools with mud bottoms It has the status of State special concern, as well as being designated a species of concern by the Virginia Field Office of USFWS.

Location

The map of habitat for the ephemeral cave amphipod (Figure 7.66) includes a cave Conservation Site (DCR-NH 2004).

Description of Habitat Requirements

This species is only known from Giles County in the Middle New watershed (05050002) (Fitzpatrick 1983). It has been recorded in mud-bottomed drip pools and rarely in small cave streams (Holsinger 1991a; Holsinger, ODU, pers. comm.).

Relative Condition of Habitat

There are two Conservation Sites that contain populations of the ephemeral cave amphipod (DCR-NH 2004). These are located just over 1km apart in eastern Giles County. These areas are not protected from any Conservation Land.

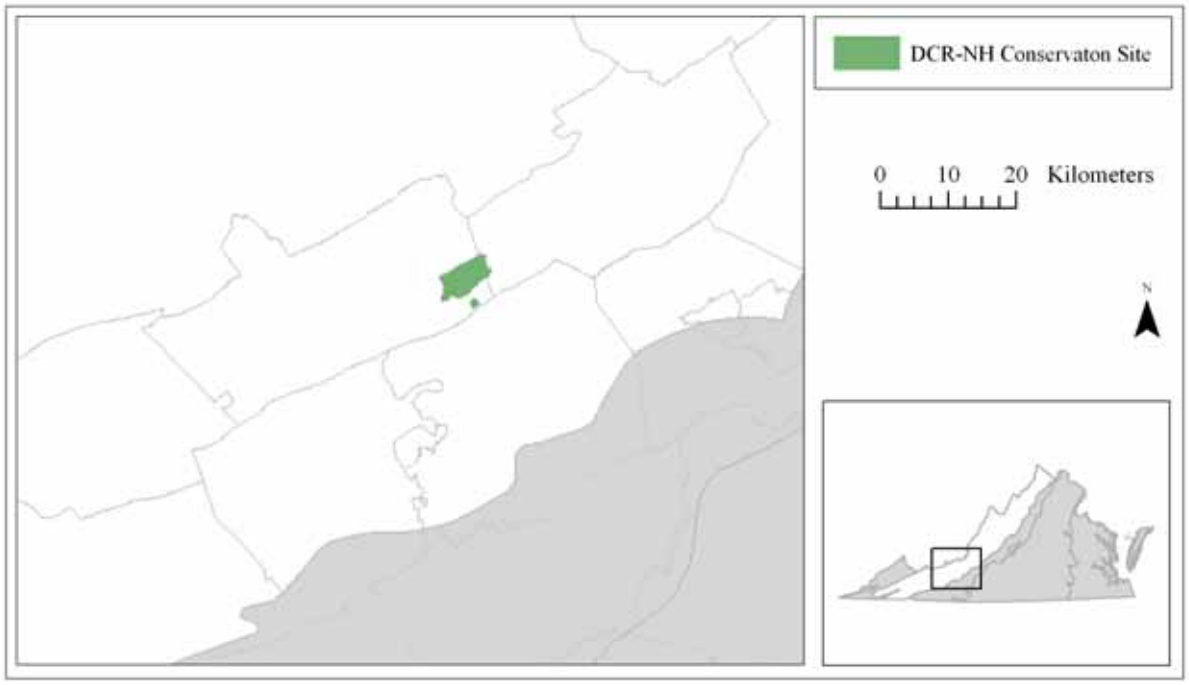

Figure 7.66. Distribution of the ephemeral cave amphipod in the Ridge and Valley.

Holsinger (1975) reports that one of the caves in which this species occurs (Canoe) is gated, and that access to it is restricted. However, Holsinger (1991a) reports that neither cave in which this species occurs is protected, and that one of them (Tawneys) is commonly used by cavers. Douglas (1964) reports that one room within this cave is filled with speleothems (cave formations), and so is geologically as well as biologically sensitive to disturbance. Douglas (1964) reports that similar sensitive formations occur in Canoe Cave.

Specific Threats and Trends

No specific stresses were reported by Invertebrate TAC. Clearly, recreational caving could be a problem for this species. Holsinger (1979a) reports that populations in both locations are "small and fluctuating (p. 159)."

Conservation Actions and Strategies

No specific conservation actions were reported by Invertebrate TAC. Protection of the caves through acquisition, easements, or cooperative agreements would also help to protect ephemeral cave amphipod. Holsinger (1979a) suggests that the groundwater in the area be protected from pollution and alteration.

Research and Monitoring Needs

No specific research or monitoring needs were reported by Invertebrate TAC. Holsinger (1979a) reports that additional surveys in nearby areas have not uncovered additional populations. Little is known about the life history or distribution of this species, so life history research is important.

7.5.1.9. Madison Cave amphipod, *Stygobromus stegerorum*

Life History Summary

The Madison Cave isopod is known from two cave lakes in Augusta County, Virginia, where it is endemic (Holsinger 1991a). This species is one of only two troglobitic species known from these lakes (the other being the Tier II Madison Cave isopod *Antrolana lira*). It is eyeless and is believed to feed on microorganisms and organic matter, though nothing is actually known about its life history (Holsinger 1979b, 1991a). Groundwater pollution and disturbance of the sinkhole recharge system are likely its most serious threats (Holsinger 1991a). This species is protected with the status of State threatened. It has also been designated a species of concern by the Virginia Field Office of USFWS.

Location

The map of habitat for the Madison Cave amphipod (Figure 7.67) includes confirmed locations and a cave Conservation Site (DCR-NH 2004).

Description of Habitat Requirements

This species is only known from Augusta County, in the South Fork Shenandoah (02070005) watershed (Fitzpatrick 1983). It has been found in lakes within two caves (J. R. Holsinger, ODU, pers. comm.; S. M. Roble, DCR-NH, pers. comm.).

Relative Condition of Habitat

There are three Collections locations for the Madison Cave amphipod within a small area of Augusta County (DGIF 2004b). One Conservation Site encompasses all three Collections locations (DCR-NH 2004). Part of the Conservation Site contains Grand Caverns, a privately owned regional park.

Holsinger (1975) reports that this species occurs in one of the most historically significant caves in the U.S., containing signatures of both George Washington and James Madison, for whom the cave is supposed

Figure 7.67. Distribution of the Madison Cave amphipod in the Ridge and Valley.

to have been named. An agreement is in place with the owner of Madisons Cave that allows only limited access to the entrance; however, little prevents dumping in the sinkholes through which the aquifer is recharged (Holsinger 1991a).

Specific Threats and Trends

No specific stresses were reported by Invertebrate TAC. Holsinger (1991a) reports concerns about the integrity of the aquifer that feeds the lakes as the major potential stress.

Conservation Actions and Strategies

No conservation actions were reported by Invertebrate TAC. The boundaries of the watersheds that feed these lakes should be determined to allow for surface protection (Holsinger 1991a). In addition, the second cave (Stegers Fissure) needs to be incorporated into the existing management plan (Holsinger 1991a).

Research and Monitoring Needs

No specific research or monitoring needs were reported by Invertebrate TAC. Since nothing is known of the life history of this species, such studies would be beneficial. In addition, population monitoring in both lakes, along with water quality monitoring, are critical (Holsinger 1991a).

7.5.2. Subterranean Species of Greatest Conservation Need in the Ridge and Valley

7.5.2.1. Species of Greatest Conservation Need by Subterranean Habitat Type

Of the 55 subterranean species occurring in the Ridge and Valley, 54 occur in caves (Table 7.79) and one occurs only in groundwater (Table 7.80).

Table 7.79. Cave species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Needs
Natural Bridge cave isopod	*Caecidotea bowmani*	I	Small cave streams and drip pools
Virginia springsnail	*Fontigens morrisoni*	I	Unknown
Rye Cove isopod	*Lirceus culveri*	I	Cave streams with clean rocky compacted substrate
Indiana myotis	*Myotis sodalis*	I	Limestone caves (hibernation)
Chandler's planarian	*Sphalloplana chandleri*	I	Unknown
Rockbridge County cave planarian	*Sphalloplana virginiana*	I	Unknown
Ephemeral cave amphipod	*Stygobromus ephemerus*	I	Drip pools or streamside pools
Madison Cave amphipod	*Stygobromus stegerorum*	I	Phreatic groundwater
A cave lumbriculid worm	*Stylodrilus beattiei*	I	Unknown
Madison Cave isopod	*Antrolana lira*	II	Phreatic groundwater and connected water
A cave pseudoscorpion	*Apochthonius coecus*	II	Transient organic deposits
A cave pseudoscorpion	*Apochthonius holsingeri*	II	Transient organic deposits
A cave springtail	*Arrhopalites caedus*	II	Unknown
A cave springtail	*Arrhopalites lacuna*	II	Unknown
A cave springtail	*Arrhopalites pavo*	II	Unknown
A cave springtail	*Arrhopalites sacer*	II	Unknown
A cave springtail	*Arrhopalites silvus*	II	Unknown
Henrot's cave isopod	*Caecidotea henroti*	II	Springs, phreatic pools, cave pools
Incurved cave isopod	*Caecidotea incurva*	II	Drip pools, small cave streams
Vandel's Cave isopod	*Caecidotea vandeli*	II	Caves, springs, and seeps
A cave pseudoscorpion	*Chitrella superba*	II	Transient organic deposits
Virginia big-eared bat	*Corynorhinus townsendii virginianus*	II	Summer: warm caves; winter: cold caves, near entrances
A cave pseudoscorpion	*Kleptochthonius anophthalmus*	II	Transient organic deposits
A cave pseudoscorpion	*Kleptochthonius regulus*	II	Transient organic deposits
A cave pseudoscorpion	*Mundochthonius holsingeri*	II	Transient organic deposits
Gray myotis	*Myotis grisescens*	II	Summer: warm caves near water; winter: cold caves
A cave spider	*Nesticus mimus*	II	Unknown
Avernus cave beetle	*Pseudanophthalmus avernus*	II	Cave riparian zone and mudbanks
New River Valley cave beetle	*Pseudanophthalmus egberti*	II	Cave riparian zone and mudbanks
A cave beetle	*Pseudanophthalmus gracilis*	II	Cave riparian zone and mudbanks
Hoffman's cave beetle	*Pseudanophthalmus hoffmani*	II	Cave riparian zone and mudbanks
Burkes Garden cave beetle	*Pseudanophthalmus hortulanus*	II	Cave riparian zone and mudbanks
Hubricht's cave beetle	*Pseudanophthalmus hubrichti*	II	Cave riparian zone and mudbanks
Crossroads Cave beetle	*Pseudanophthalmus intersectus*	II	Cave riparian zone and mudbanks
Mud-dwelling cave beetle	*Pseudanophthalmus limicola*	II	Cave riparian zone and

Common Name	Scientific Name	Tier	Special Habitat Needs
			mudbanks
Nelson's cave beetle	*Pseudanophthalmus nelsoni*	II	Cave riparian zone and mudbanks
Thin-neck cave beetle	*Pseudanophthalmus parvicollis*	II	Cave riparian zone and mudbanks
Petrunkevitch's cave beetle	*Pseudanophthalmus petrunkevithchi*	II	Cave riparian zone and mudbanks
Natural Bridge cave beetle	*Pseudanophthalmus pontis*	II	Cave riparian zone and mudbanks
South Branch Valley cave beetle	*Pseudanophthalmus potomaca potomaca*	II	Cave riparian zone and mudbanks
Overlooked cave beetle	*Pseudanophthalmus praetermissus*	II	Cave riparian zone and mudbanks
Spotted cave beetle	*Pseudanophthalmus punctatus*	II	Cave riparian zone and mudbanks
Straley's Cave beetle	*Pseudanophthalmus quadratus*	II	Cave riparian zone and mudbanks
Saint Paul cave beetle	*Pseudanophthalmus sanctipauli*	II	Cave riparian zone and mudbanks
A cave beetle	*Pseudanophthalmus seclusus*	II	Cave riparian zone and mudbanks
Silken cave beetle	*Pseudanophthalmus sericus*	II	Cave riparian zone and mudbanks
Thomas' cave beetle	*Pseudanophthalmus thomasi*	II	Deep sand deposits in upper stream passages
Vicariant cave beetle	*Pseudanophthalmus vicarius*	II	Cave riparian zone and mudbanks
Maiden Spring cave beetle	*Pseudanophthalmus virginicus*	II	Cave riparian zone and mudbanks
A cave springtail	*Pseudosinella bona*	II	Unknown
A cave springtail	*Pseudosinella extra*	II	Unknown
Ellett Valley Pseudotremia millipede	*Pseudotremia cavernarum*	II	Transient organic deposits
A millipede	*Pseudotremia sublevis*	II	Transient organic deposits
Rockbridge County cave amphipod	*Stygobromus baroodyi*	II	Small cave streams and pools
Burnsville Cove cave amphipod	*Stygobromus conradi*	II	Drip pools
Craig County cave amphipod	*Stygobromus estesi*	II	Drip pools, seeps, and springs
Montgomery County cave amphipod	*Stygobromus fergusoni*	II	Unknown
Alleghany County cave amphipod	*Stygobromus hoffmani*	II	Drip pools
New Castle Murder Hole amphipod	*Stygobromus interitus*	II	Drip pools
Morrison's cave amphipod	*Stygobromus morrisoni*	II	Drip pools/small streams
Bath County cave amphipod	*Stygobromus mundus*	II	Small streams/springs
Luray Caverns amphipod	*Stygobromus pseudospinosus*	II	Drip pools
A cave springtail	*Typhlogastrura valentini*	II	Unknown
A cave spider	*Anthrobia mammouthia*	III	Unknown
Greenbrier Valley cave isopod	*Caecidotea holsingeri*	III	Drip pools and small streams
Southwestern Virginia cave isopod	*Caecidotea recurvata*	III	Drip pools and small streams

Common Name	Scientific Name	Tier	Special Habitat Needs
Tennessee Valley cave isopod	*Caecidotea richardsonae*	III	Drip pools and small streams
Scott County terrestrial cave isopod	*Ligidium elrodii scottensis*	III	Transient organic deposits
Racovitza's terrestrial cave isopod	*Miktoniscus racovitzai*	III	Transient organic deposits
A cave beetle	*Pseudanophthalmus pusio*	III	Cave riparian zone and mudbanks
A cave springtail	*Pseudosinella granda*	III	Unknown
A cave springtail	*Schaefferia hubbardi*	III	Unknown
James Cave amphipod	*Stygobromus abditus*	III	Springs, seeps, drip pools
Bigger's cave amphipod	*Stygobromus biggersi*	III	Drip pools
Shenandoah Valley cave amphipod	*Stygobromus gracilipes*	III	Streams, drip pools, phreatic pools
Price's cave isopod	*Caecidotea pricei*	IV	Springs, seeps, cave streams
Southwestern Virginia cave amphipod	*Stygobromus mackini*	IV	Seeps, springs

Table 7.80. Groundwater species of greatest conservation need in the Ridge and Valley.

Common Name	Scientific Name	Tier	Special Habitat Requirements
A groundwater planarian	*Procotyla typhlops*	I	Unknown

7.5.2.2. Status of Subterranean Habitats

The status of these habitats is very difficult to ascertain, and so is not available at an ecoregional scale. For statewide status and trends of subterranean habitats, see Section 4.2.5.

7.6 Overview of Tier I Species Habitat in the Ridge and Valley

In order to highlight geographic areas that are likely important for one or more Tier I species, the potential and confirmed habitats for Tier I terrestrial (Section 7.3.1), aquatic (Sections 7.4.1-7.4.7), and subterranean (Section 7.5.1) species were overlaid in one map (Figure 7.68). Please note that potential habitat for many Tier I species could not be mapped, and that areas containing habitat for only one or a few Tier I species are important for conservation. However, areas with a higher density of Tier I species habitat may represent extraordinary conservation opportunities.

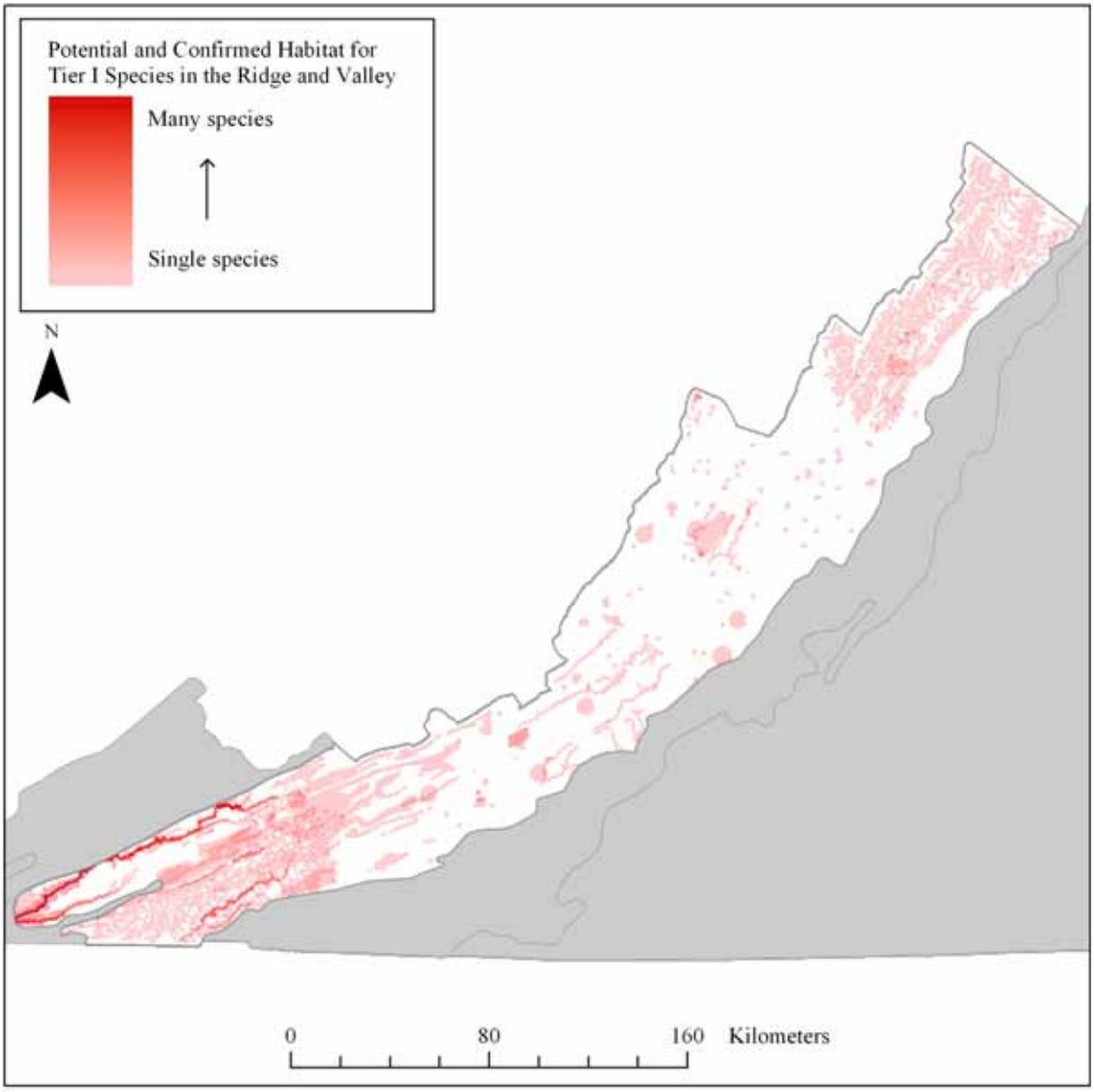

Figure 7.68. Potential and confirmed habitat for Tier I species in the Ridge and Valley. Darker shades represent areas with a higher co-occurrence of these habitats.

Literature Cited

Abell, R. A., D. M. Olson, E. Dinerstein, P. T. Hurley, J. T. Diggs, W. Eichbaum, S. Walters, W. Wettengel, T. Allnutt, C. J. Loucks, and P. Hedao. 2000. Freshwater ecoregions of North America: a conservation assessment. Island Press, Washington, D.C.

Adkisson, C. S. 1991. Bewick's wren. Pages 518-520 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

Ahlstedt, S. A. 1984. Twentieth century changes in the freshwater mussel fauna of the Clinch River (Tennessee and Virginia). Thesis, University of Tennessee, Knoxville, Tennessee.

_____ . 1986. A status survey of the little-wing pearly mussel *Pegias fabula* (Lea, 1838). Endangered Species Field Office, U.S. Fish and Wildlife Service, Asheville, North Carolina.

_____ . 1991a. Little-wing pearlymussel (*Pegias fabula*). Pages 270-271 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991b. Purple bean (*Villosa perpurpurea*). Pages 305-306 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____. 1991c. Twentieth century changes in the freshwater mussel fauna of the Clinch River (Tennessee and Virginia). Walkerana 5:73-122.

Allen, T. J. 1997. The butterflies of West Virginia and their caterpillars. University of Pittsburgh, Pittsburgh, Pennsylvania.

Bailey, R. G. 1995. Descriptions of the ecoregions of the United States. U.S. Forest Service Miscellaneous Publication 1391, Washington, D.C.

Bajema, R. A., T. L. DeVault, P. E. Scott, and S. L. Lima. 2001. Reclaimed coal mine grasslands and their significance for Henslow's sparrows in the American Midwest. Auk 118:422-431.

Batie, R. 1991a. Rubble coil. Pages 310-311 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____. 1991b. Shaggy coil. Pages 311-312 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____. 1991c.Virginia fringed mountain snail. Pages 309-310 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

Bazuin, J. B., Jr. 1991. Upland sandpiper. Pages 504-505 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

Bird TAC (Taxonomic Advisory Committee). 2004. Unpublished proceedings of a workshop on bird threats, conservation actions, and monitoring, Fredericksburg, Virginia, 30 November 2004. Department of Game and Inland Fisheries, Richmond, Virginia.

Bogan, A. E. and P. W. Parmalee. 1983. Tennessee's rare wildlife, volume II: The mollusks. Tennessee Wildlife Resources Agency and Tennessee Department of Conservation. Nashville, Tennessee.

Brindza, L. J. 1991. Henslow's sparrow. Pages 525-526 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

Brown, S., C. Hickey, B. Harrington, and R. Gill, editors. 2001. The U.S. shorebird conservation plan, 2nd edition. Manomet Center for Conservation Sciences, Manomet, Massachusetts.

Bruenderman, S. A. 1989. Life history of the endangered fine-rayed pigtoe, *Fusconaia cuneolus* (Lea, 1840), in the Clinch River, Virginia. Thesis. Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Bryant, R. T. 1979. The life history and comparative ecology of the sharphead darter, *Etheostoma acuticeps*. Tennessee Wildlife Resources Agency Technical Report 79-50. Nashville, Tennessee.

Bulluck, L.P., D.A. Buehler, R. Canterbury and C. Smalling. 2005. Golden-winged Warbler Habitat Associations in the Southern Appalachians. Presented at Golden-winged Warbler Conservation Workshop, August 10-12, 2005, Siren, Wisconsin.

Burkhead, N. M. and R. E. Jenkins. 1991. Fishes. Pages 321-409 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

Cairns, J., J. S. Crossman, K. L. Dickson, and E. E. Herricks. 1971. The recovery of damaged streams. Association of Southeastern Biologists Bulletin 18:79-106.

Canterbury, R. 2005. Response by golden-winged warblers to habitat changes in southern West Virginia. Presented at golden-winged warbler conservation workshop, August 10-12, 2005, Siren, Wisconsin.

Carreker, R. G. 1985. Habitat suitability index models: Snowshoe hare. Biological Report 82(10.101). U.S. Fish and Wildlife Service.

Chazal, A. C., S. M. Roble, C. S. Hobson, and K. L. Derge. 2004. Status of the Appalachian grizzled skipper (*Pyrgus centaureae wyandot*) in Virginia. Banisteria 24:15-22.

Clarke, A. H. 1986. Competitive exclusion of *Canthyria* (Unionidea) by *Corbicula fluminea* (Muller). Malacology Data Net 1:3-10.

_____ and R. J. Neves. 1984. Status survey of the James River spiny mussel, *Canthyria collina*, in the James River, Virginia. Unpublished report, U. S. Fish and Wildlife Service, Newton Corner, MA.

Confer, J. L. 1992. Golden-winged warbler. Number 20 *in* A. Poole, P. Stettenheim, and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, DC.

_____ and J. L. Larkin. 1998. Behavioral interactions between golden-winged and blue-winged warblers. Auk 115:209-214.

_____, _____, and P. E. Allen. 2003. Effects of vegetation, interspecific competition, and brood parasitism on golden-winged warbler (*Vermivora chrysoptera*) nesting success. Auk 120:138-144.

Curson, J., D. Quinn, and D. Beadle. 1994. Warblers of the Americas. Houghton Mifflin, Boston.

DCR (Virginia Department of Conservation and Recreation). 2003. Conservation Lands Database. Richmond, Virginia. http://www.dcr.state.va.us/dnh/ conslandindex.htm.

DCR-NH (Virginia Department of Conservation and Recreation, Division of Natural Heritage). 2004. Virginia Natural Heritage Program's Biotics Data System. Richmond, Virginia. Data provided through cooperative agreement with DCR. For more information about these data please contact the DCR data manager. http://www.dcr.virginia.gov/dnh.

_____ . 2005. Virginia Natural Heritage Program's Biotics Data System. Richmond, Virginia. Data provided through cooperative agreement with DCR. For more information about these data please contact the DCR data manager. http://www.dcr.virginia.gov/dnh.

DeGraaf, R. M and J. H. Rappole. 1995. Neotropical migratory birds: Natural history, distribution, and population change. Comstock, Ithaca.

Dennis, S. 1985. Distributional analysis of the freshwater mussel fauna of the Tennessee River system, with special reference to possible limiting effects of siltation. Dissertation, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

_____. 1987. An unexpected decline in populations of the freshwater mussel, *Dysnomia* (*Epioblasma*) *capsaeformis*, in the Clinch River of Virginia and Tennessee. Virginia Journal of Science 38:281-286.

_____ . 1991a. Green-blossom. Pages 298-299 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991b. Oyster mussel. Pages 295-296 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991c. Tan riffleshell. Pages 296-298 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

DEQ (Virginia Department of Environmental Quality) and DCR (Virginia Department of Conservation and Recreation). 2004. Virginia water quality assessment: 305b/303d integrated report to Congress and the EPA Administrator for the period January 1, 1998 to December 31, 2002. Richmond, Virginia.

DGIF (Virginia Department of Game and Inland Fisheries). 2001. Tennessee dace (*Phoxinus tennesseensis*) draft recovery plan. Nongame and Endangered Wildlife Program, Richmond, Virginia.

_____. 2004a. Virginia Fish and Wildlife Information Service (VAFWIS): Biota of Virginia (BOVA) online database. http://vafwis.org/WIS/ASP/ default.asp.

_____. 2004b. Virginia fish and wildlife information service: Collections database. http://www.vafwis.org/WIS/ASP/default.asp.

Dinkins, G. R., and P. W. Shute. 1996. Life histories of *Noturus baileyi* and *N. flavipinnis* (Pisces: Ictaluridae), two rare madtom catfishes in Citico Creek, Monroe County, Tennessee. Bulletin of the Alabama Museum of Natural History 18:43-69.

Douglas, H. H. 1964. Caves of Virginia. Virginia Cave Survey, Falls Church, Virginia.

Ernst, C. H., J. E. Lovich, and R. W. Barbour. 1994. Turtles of the United States and Canada. Smithsonian Institution, Washington.

Estes, J. A. and J. Holsinger. 1976. A second troglobitic species of the genus *Lirceus* (Isopoda, Asellidae) from southwestern Virginia. Proceedings of the Biological Society of Washington. 89: 481-490.

Etnier, D. A. and W. C. Starnes. 1993. The fishes of Tennessee. The University of Tennessee Press, Knoxville, Tennessee.

Fish TAC (Taxonomic Advisory Committee). 2004. Unpublished proceedings of a workshop on fish threats, conservation actions, and monitoring, Charlottesville, Virginia, 03 December 2004. Department of Game and Inland Fisheries, Richmond, Virginia.

Fitzpatrick, J. F. 1983. How to know the freshwater Crustacea. The Pictured Key Nature Series. Wm. C. Brown Company, Dubuque.

Fraser, J. D. 1991. Loggerhead shrike. Pages 520-522 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

Fuller, S. L. H. 1974. Clams and mussels (Mollusca: Bivalvia). Pages 215-273, *in* C.W. Hart, Jr. and S.L.H. Fuller, editors. Pollution ecology of freshwater invertebrates. Academic, New York, New York.

Gabler, J. 1983. The peregrine falcon in Virginia: Survey of historic eyries and reintroduction effort. Thesis, College of William and Mary, Williamsburg, Virginia.

GeoLytics. 2005. CensusCD estimates (2004), projections (2009), consumer expenditures and profiles. Digital spatial and tabular data. Acquired March 2005. GeoLytics, Inc. East Brunswick, New Jersey.

Gill, F. B. 2004. Overview: Blue-winged warblers (*Vermivora pinus*) versus golden-winged warblers (*V. chrysoptera*). Auk 121:1014-1018.

_____, R. A. Canterbury, and J. L. Confer. 2001. Blue-winged warbler. Number 584 *in* A. Poole, P. Stettenheim, and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, DC.

Groves, C., L. Valutis, D. Vosick, B. Neely, K. Wheaton, J. Touval, and B. Runnels. 2000. Designing a geography of hope: A practitioner's handbook to ecoregional conservation planning, Volume II. The Nature Conservancy.

Harrington, B. and E. Perry. 1995. Important shorebird staging sites meeting: Western hemisphere shorebird reserve network criteria in the United States. Western hemisphere Shorebird Reserve Network.

Herkert, J. R., P. D. Vickery, and D. E. Kroodsma. 2002. Henslow's sparrow. Number 672 *in* A. Poole and F. Gill, editors. The birds of North America. The Birds of North America, Inc., Philadelphia, PA.

Herpetofauna TAC (Taxonomic Advisory Committee). 2004. Unpublished proceedings of a workshop on herpetofaunal threats, conservation actions, and monitoring, Richmond, Virginia, 30 November 2004. Department of Game and Inland Fisheries, Richmond,Virginia.

Hershler, R., J. R. Holsinger, and L. Hubricht. 1990. A revision of the North American freshwater snail genus *Fontigens* (Prosobranchia: Hydrobiidae). Smithsonian Contributions to Zoology. SCZ-509.

Hickman, M. E. 1937. A contribution to the knowledge of the molluscan fauna of East Tennessee. Thesis, University of Tennessee. Knoxville, Tennessee.

Hill, J. M. 1984. Autumn migration of selected raptors and passerines on the Delmarva Peninsula. Thesis, George Mason University, Fairfax, Virginia.

Holsinger, J. R. 1975. Descriptions of Virginia caves. Bulletin 85, Virginia Division of Mineral Resources, Charlottesville, Virginia.

_____. 1979a. Ephemeral cave amphipod. Page 159 *in* D. W. Linzey, editor. Endangered and threatened plants and animals of Virginia. Center for Environmental Studies, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

_____. 1979b. Madison cave amphipod. Pages 152-153 *in* D. W. Linzey, editor. Endangered and threatened plants and animals of Virginia. Center for Environmental Studies, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

_____. 1979c. Rye Cove isopod. Page 131 *in* D. W. Linzey, editor. Endangered and threatened plants and animals of Virginia. Center for Environmental Studies, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

_____. 1991a. Freshwater amphipods. Pages 180-186 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____. 1991b. Freshwater isopods. Pages 186-189 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ and D. C. Culver. 1988. The invertebrate cave fauna of Virginia and a part of eastern Tennessee: zoogeography and ecology. Brimleyana 14:1-162.

Holt, D. 1998. The Virginia hawkwatch: a raptorian report, Fall 1997. Hawk Migration Association of North America.

Houston, C. S., and D. E. Bowen, Jr. 2001. Upland sandpiper. Number 580 *in* A. Poole and F. Gill, editors. The birds of North America. The Birds of North America, Inc., Philadelphia, PA.

Hove, M. C. 1990. Distribution and life history of the endangered James spinymussel, *Pleurobema collina* (Bivalvia: Unionidae). Thesis, Virginia Polytechnic Institute and State University, Blacksburg.

Jenkins, R. E. and N. M. Burkhead. 1975. Recent capture and analysis of the sharphead darter, *Etheostoma acuticeps*, an endangered percid fish of the upper Tennessee River drainage. Copeia 1975:731-740.

_____ and _____. 1994. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland.

Jenkins, R. E. 1975. *Noturus flavipinnnis* Taylor 1969, yellowfin madtom. Status report to the Office of Endangered Species, U.S. Fish and Wildlife Service, Washington, D.C.

Johnsgard, P. A. 1990. Hawks, eagles and falcons of North America. Smithsonian Institution, Washington.

Kearney, R. F. 2003. Partners in Flight landbird conservation plan, physiographic area 10: Mid-Atlantic Piedmont. Version 1.0. American Bird Conservancy.

Kennedy, E. D. and D. W. White. 1997. Bewick's wren. Number 315 *in* A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, DC.

Kitchel, H. E. 1985. Life history of the endangered shiny pigtoe mussel, *Fusconaia edgariana*, in the North Fork Holston River, Virginia. Thesis, Virginia Polytechnic Institute and State University. Blacksburg.

_____. 1991. Rough rabbitsfoot (*Quadrula cylindrical strigillata*). Pages 286-287 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

Klaus, N.A. and D.A. Buehler. 2001. Golden-winged warbler breeding habitat characteristics and nest success in clearcuts in the southern Appalachian Mountains. Wilson Bulletin 114:297-301.

Kondratieff, B. C. and R. F. Kirchner. 1991. Beartown perlodid stonefly. Pages 221-222 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ and _____ . 1993. A new species of *Acroneuria* from Virginia (Plecoptera: Perlidae). Journal of New York Entomological Society 101:550-554.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. wheeler, and K. Wohl. 2002. Waterbird conservation for the Americas: The North American waterbird conservation plan, version 1. Waterbird Conservation for the Americas, Washington, DC.

Layman, S. R. 1991. Life history of the relict, duskytail darter, *Etheostoma* (*Catonotus*) sp., in Little River, Tennessee. Copeia 1991:471-485.

Layzer, J. B. and R. M. Anderson. 1991. Fish hosts of the endangered Cumberland bean pearly mussel (*Villosa trabalis*). NABS Bulletin 8:110.

_____ and _____. 1992. Impacts of the coal industry on rare and endangered aquatic organisms of the upper Cumberland River Basin. Final report to Kentucky Department of Fish and Wildlife Resources, Frankfort, Kentucky, and Tennessee Wild Resources Agency, Nashville, Tennessee.

Lewis, J. J. 1980. A comparison of *Pseudobaicalasellus* and *Caecidotea*, with a description of *Caecidotea bowmani*, n. sp. (Crustacea: Isopoda: Asellidae). Proceedings of the Biological Society of Washington 93:314-326.

Linzey, D.W. 1998. The mammals of Virginia. The McDonald & Woodward Publishing, Blacksburg, Virginia.

Lipford, M. L. 1991. Fanshell. Pages 291-292 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

Luukkonen, D. R. 1987. Status and breeding ecology of the loggerhead shrike in Virginia. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Mammal TAC (Taxonomic Advisory Committee). 2004. Unpublished proceedings of a workshop on mammal threats, conservation actions, and monitoring, Richmond, Virginia, 01 November 2004. Department of Game and Inland Fisheries, Richmond, Virginia.

McNab, W. H. and P. E. Avers. 1994. Ecological subregions of the United States. Technical Report WO-WSA-5, U.S. Forest Service, Washington, DC.

Menzel, J. M. 2003. An examination of the habitat requirements of the endangered Virginia northern flying squirrel (*Glaucomys sabrinus fuscus*) by assessing nesting sites, habitat use and the development of a habitat model. Dissertation, West Virginia University, Morgantown, West Virginia.

Mitchell, J. C. 1991. Amphibians and reptiles. Pages 411-476 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____. 1994. The reptiles of Virginia. Smithsonian Institution Press, Washington and London.

Moore, F. R. and T. R. Simons. 1989. Habitat suitability and stopover ecology of Neotropical landbird migrants. Pages 345-355 *in* J. M Hagan III and D. W. Johnston, editors. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution, Washington.

_____, P. Kerlinger, and T. R. Simons. 1990. Stopover on a Gulf coast barrier island by spring trans-Gulf migrants. Wilson Bulletin 102:487-500.

_____, Gauthreaux, S. A., Jr., Kerlinger, P., and Simons, T. R. 1995. Habitat requirements during migration: important link in conservation. Pages 121-144 *in* T. E. Martin and D. M. Finch, editors. Ecology and management of newtropical migratory birds: A synthesis and review of critical issues. Oxford University, Oxford.

Mussel TAC (Taxonomic Advisory Committee). 2004. Unpublished proceedings of a workshop on mussel threats, conservation actions, and monitoring, Forest, Virginia, 08 November 2004. Department of Game and Inland Fisheries, Richmond, Virginia.

NABCI (North American Bird Conservation Initiative). 2000. North American Bird Conservation Initiative: Bird conservation region descriptions. U.S. Fish and Wildlife Service, Washington, DC.

NatureServe. 2004. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.0. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer.

NESWDTC (Northeast Endangered Species and Wildlife Diversity Technical Committee). 2004. Northeast wildlife species of regional conservation concern: management and research needs. Draft report. Northeast Association of Fish and Wildlife Agencies.

Neves, R. J. 1991a. Appalachian monkeyface. Pages 290-291 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991b. Birdwing pearlymussel. Pages 300-302 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991c. Cracking pearlymussel. Pages 277-278 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991d. Cumberland bean. Page 252 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991e. Cumberland monkeyface. Pages 287-288 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991f. Cumberlandian combshell. Pages 294-295 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991g. Dromedary pearlymussel. Pages 292-294 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991h. Fine-rayed pigtoe. Pages 274-275 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991i. James spinymussel. Pages 281-282 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991j. Mollusks. Pages 251-320 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991k. Rough pigtoe. Pages 284-285 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____ . 1991l. Shiny pigtoe. Pages 272-274 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

Omernik, J. M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers 77:118-125.

Opler, P. A. and G. O. Krizek. 1984. Butterflies east of the Great Plains: An illustrated natural history. Johns Hopkins University, Baltimore and London.

Ortmann, A. E. 1912. Notes upon the families and genera of the najads. Annals of the Carnegie Museum 8: 222-365.

_____. 1914. Studies in najads (cont.). The Nautilus 28:20-22; 28:28-34; 28:41-47; 28:65-69.

_____. 1915. Studies in najads (cont.). The Nautilus 28:106-108; 28:129-131; 28:141-143; 29:63-67.

_____. 1916. The anatomical structure of *Gonidea angulata* (Lea). The Nautilus 30:50-53.

_____. 1919. A monograph of the naeades of Pennsylvania. Part III: Systematic account of the genera and species. Memoirs of the Carnegie Museum 8: xvi-384.

Parmalee, P. W. and A. E. Bogan. 1998. The freshwater mussels of Tennessee. The University of Tennessee Press. Knoxville, Tennessee.

Pierson, E. D. 1998. Tall trees, deep holes, and scarred landscapes: Conservation biology of North American bats. Pages 309-325 *in* T. H. Kunz and P. A. Racey, editors. Bat biology and conservation. Smithsonian Institution, Washington and London.

Reynolds, R. J. 2003. Virginia aerial mountain survey for nesting peregrine falcons. Nongame and Endangered Wildlife Technical Report TR2004.1. Virginia Department of Game and Inland Fisheries, Wildlife Diversity Division, Nongame and Endangered Wildlife Program, Richmond, Virginia. Unpublished Report submitted to U.S. Fish and Wildlife Service.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Inigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, and T. C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Laboratory of Ornithology, Ithaca, New York.

Rosenberg, K. V. 2003. Partners in Flight landbird conservation plan, physiographic area 12: Mid-Atlantic Ridge and Valley. Version 1.0. American Bird Conservancy.

_____. 2004. Partners in Flight continental priorities and objectives defined at the state and bird conservation region levels: Virginia. Unpublished report, Cornell Laboratory of Ornithology, Ithaca.

Rosenberger, A. and P. L. Angermeier. 2003. Ontogenetic shifts in habitat use by the endangered Roanoke logperch (*Percina rex*). Freshwater Biology. 48:1563-1577.

SAMAB (Southern Appalachian Man and the Biosphere Program). 1996. Southern Appalachian Assessment (SAA): A cooperative multi-agency effort to assess the environmental condition of the Southern Appalachian region. Downloaded from http://samab.org/data/ SAA_data.html, April 2004.

Schweitzer, D. F. 1991a. Appalachian grizzled skipper. Pages 240-241 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

_____. 1991b. Regal fritillary. Pages 243-245 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

Scott, J. A. 1986. The butterflies of North America: A natural history and field guide. Stanford University, Stanford, California.

Shapiro, L. H., R. A. Canterbury, D. M. Stover, and R. C. Fleischer. 2004. Reciprocal introgression between golden-winged warblers (*Vermivora chrysoptera*) and blue-winged warblers (*V. pinus*) in North America. Auk 121:1019-1030.

Shepard, T. E. and B. M. Burr. 1984. Systematics, status, and lige history aspects of the ashy darter, *Etheostoma cinereum* (Pisces: Percidae). Proceedings of the Biological Society of Washington 97:693-715.

Sherry, T. W. and R. T. Holmes. 1993. Are populations of Neotropical migrant birds limited in summer or winter? Implications for management. Pages 47-57 *in* D. M. Finch and P. W. Stangel, editors. Status and management of Neotropical migratory birds. Gen. Tech. Rep. RM-229, U.S. Deaprtment of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Shute, P. W. 1984. Ecology of the rare yellowfin madtom, *Noturus flavipinnis* Taylor, in Citico Creek, Tennessee. Thesis, University of Tennessee. Knoxville, Tennessee.

Smogor, R. A. P. L. Angermeier, M. J. Pinder, and S. A. Bruenderman. 2002. Sharphead darter (*Etheostoma acuticeps*) draft recovery plan for Virginia. Nongame and Endangered Wildlife Program, Virginia Department of Game and Inland Fisheries, Richmond, Virginia.

Starnes, W. C. and R. E. Jenkins. 1988. A new cyprinid fish of the genus *Phoxinus* (Pisces: Cypriniformes) from the Tennessee River drainage with comments on relationships and biogeography. Proceedings of the Biological Society of Washington 101:517-529.

Stewart, T. W. and R. T. Dillon. 2004. Species composition and geographic distribution of Virginia's freshwater gastropod fauna: a review using historical records. American Malacological Bulletin 19:79-91.

Swanson, D. A. 1996. Nesting ecology and nesting habitat of Ohio's grassland-nesting birds: A literature review. Ohio Department of Natural Resources, Division of Wildlife, Ohio Fish and Wildlife Report 13.

Thomson, C. E. 1982. *Myotis sodalis*. Number 163 *in* Mammalian species. American Society of Mammalogists.

Tobey, F. J. 1979. Amphibians and reptiles. Pages 375-414 *in* D. W. Linzey, editor. Endangered and threatened plants and animals of Virginia. Center for Environmental Studies, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Tuttle, M. D. 2004. Wind energy & the threat to bats. Bats 22:4-5.

TVA (Tennessee Valley Authority). 1986. Cumberlandian mollusk conservation program. Activity 3: Identification of fish hosts. Office of Natural Resources and Economic Development, Knoxville, Tennessee.

Underwood, M.K. and C.A. Dolloff. 1999. An inventory of stream habitat and Tennessee dace *Phoxinus tennesseensis* in Lynn Camp Creek and Lick Creek, George Washington-Jefferson National Forest, Virginia. Report from the U.S. Department of Agriculture Forest Service, Center for Aquatic Technology Transfer, Blacksburg, Virginia.

USDA (U.S. Department of Agriculture). 2000. Summary Report: 1997 national resources inventory (revised December 2000). Natural Resources Conservation Service, Washington, DC, and Statistical Laboratory, Iowa State University, Ames, Iowa.

USGS (U.S. Geological Survey). 1992. National Land Cover dataset: Virginia. Land Cover based on classication of Landsat Thematic Mapper (TM) at 30m resolution. Digital data version 5/27/1999, downloaded December 2001 from http://seamless.usgs.gov/.

_____ . 2001. National Land Cover dataset: USGS Mapping Zone 60. Land Cover based on Landsat 5 and Landsat 7 at 30m resolution. Digital data downloaded January 2004 from http://seamless.usgs.gov/.

_____ . 2003. National Elevation Dataset. Elevation measured using the North American Vertical Datum of 1998 at 30m resolution. Digital data version April 2004, downloaded from http://seamless.usgs.gov/, April 2004.

USFS (U.S. Forest Service). 2001. FIA (Forest Inventory and Analysis). Digital data, downloaded 04 February 2004. http://www.nrcs2.fs.fed.us/4801/FIADB/fiadb_dump/fiadb_dump.html.

_____. 2002. Continuous Inventory of Stand Condition (CISC). Digital data downloaded from http://www.fs.fed.us/gwjnf/ftp/gis/, October 2002.

USFWS (U.S. Fish and Wildlife Service). 1982. Cumberland monkey face pearly mussel recovery plan. Atlanta, Georgia.

_____. 1983a. Appalachian monkey face pearly mussel recovery plan. Atlanta, Georgia.

_____. 1983b. Birdwing pearly mussel recovery plan. Atlanta, Georgia.

_____. 1983c. Dromedary pearly mussel recovery plan. Atlanta, Georgia.

_____. 1983d. Recovery plan for the Indiana bat. U.S. Fish and Wildlife Service, Rockville, Maryland.

_____. 1983e. Shiny pigtoe pearly mussel recovery plan. Atlanta, Georgia.

_____. 1983f. Spotfin chub recovery plan. Atlanta, Georgia.

_____. 1983g. Virginia fringed mountain snail (*Polygyriscus virginianus*) recovery plan. U.S. Fish and Wildlife Service, Denver Colorado.

_____. 1983h. Yellowfin madtom recovery plan. Atlanta, Georgia.

_____. 1984a. Cumberland bean pearly mussel recovery plan. Atlanta, Georgia.

_____. 1984b. Fine-rayed pigtoe pearly mussel recovery plan. Atlanta, Georgia.

_____. 1984c. Green blossom pearly mussel recovery plan. Atlanta, Georgia.

_____. 1984d. Rough pigtoe pearly mussel recovery plan. Atlanta, Georgia.

_____. 1984e. Tan riffleshell pearly mussel recovery plan. Atlanta, Georgia.

_____. 1985. Pink mucket pearly mussel (*Lampsilis orbiculata*) recovery plan. Atlanta, Georgia.

_____. 1987. Revised peregrine falcon, eastern population recovery plan. U.S. Fish and Wildlife Service, Newton Corner, Massachusetts.

_____. 1989a. Little-wing pearly mussel recovery plan. Atlanta, Georgia.

_____. 1989b. Title 50, Part 17, Subpart B, Section 17.11, Endangered and threatened wildlife and plants; Animal notice of review. Federal Register.

_____. 1990a. Appalachian northern flying squirrels (*Glaucomys sabrinus fuscus, Glaucomys sabrinus coloratus*) recovery plan. Newton Corner, Massachusetts.

_____. 1990b. Cracking pearly mussel (*Hemistena* (=*Lastena*) *lata* recovery plan. Atlanta, Georgia.

_____. 1990c. James spinymussel (*Pleurobema collina*) recovery plan. Newton Corner, Massachusetts.

_____. 1991. Fanshell (*Cyprogenia stegaria* (=*C. irrorata*)) recovery plan. Atlanta, Georgia.

_____. 1992. Roanoke logperch (*Percina rex*) recovery plan. Newton Corner, Massachusetts.

_____. 1993. Duskytail darter recovery plan. Atlanta, Georgia.

_____. 2003. Agency draft recovery plan for Cumberland elktoe, oyster mussel, Cumberrlandian combshell, purple bean, and rough rabbitsfoot. Atlanta, Georgia.

_____. 2004. Critical habitat. A shapefile of stream reaches where Critical Habitat has been designated for the slender chub, spotfin chub and yellowfin madtom, as designated by the Federal Register. U.S. Fish & Wildlife Service, Virginia Field Office, Michael R. Drummond. April 2004.

Wallace, M. S. and F. P. Hain. 2002. Summary of native and established predators of the hemlock woolly adelgid and the balsam woolly adelgid (Homoptera: Adelgidae) in the southeastern United States. Pages 141-149 i*n* B. Onken, R. Reardon, and J. Lashomb, editors. Proceedings: Hemlock woolly adelgid in the eastern United States symposium. Rutgers University and the U.S. Forest Service.

Walters, E. L., E. H. Miller, and P. E. Lowther. 2002. Yellow-bellied sapsucker. Number 662 *in* A. Poole and F. Gill, editors. The birds of North America. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Watson, B. T. and R. J. Neves. 1996. Host fishes for two federally endangered species of mussels. Triannual Unionid Report 10:13.

Watts, B. D. 1999. Partners in Flight: Mid-Atlantic Coastal Plain bird conservation plan. Version 1.0. American Bird Conservancy, The Plains, Virginia.

Wheeler, A.P., A.E.K. Rosenberger, and P.L. Angermeier. 2003. Potential impacts of I-73 on stream habitat and biota, with emphasis on the endangered Roanoke logperch. Final report to Virginians for Appropriate Roads. Rocky Mount, Virginia.

Whitaker, J. O., Jr. and W. J. Hamilton, Jr. 1998. Mammals of the eastern United States. Cornell University, Ithaca.

Wells-Gosling, N. and L. R. Heaney. 1984. *Glaucomys sabrinus*. Number 229 *in* Mammalian species. American Society of Mammalogists.

White, C. M., N. J. Clum, T. J. Cade, and W. G. Hunt. 2002. Peregrine falcon. Number 660 *in* A. Poole and F. Gill, editors. The birds of North America. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Woodward, S. L. and R. L. Hoffman. 1991. The nature of Virginia. Pages 23-48 *in* K. Terwilliger, editor. Virginia's endangered species. McDonald and Woodward Publishing, Blacksburg, Virginia.

Yeager, B. L. 1987. Fish hosts for glochidia of *Epioblasma brevidens, E. capsaeformis,* and *E. triquetra* (Pelecypoda: Unionidae) from the upper Tennessee River drainage. Unpublished report to the Office of Natural Resources and Economic Development, Tennessee Valley Authority, Norris, Tennessee.

_____ and R. J. Neves. 1986. Reproductive cycle and fish hosts of the rabbit's foot mussel, *Quadrula cylindrica strigillata* (Mollusca: Bivalvia: Unionidae) in the upper Tennessee River drainage. The American Midland Naturalist 116:329-340.

_____ and C. F. Saylor. 1995. Fish hosts for four species of freshwater mussels (Pelecypoda: Unionidae) in the upper Tennessee River drainage. The American Midland Naturalist 133:1-6.

Yosef, R. 1996. Loggerhead shrike (*Lanius ludovicianus*). Number 231 *in* A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.