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Conservation Status of The Southern Appalachian Herpetofauna[1]

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ABSTRACT

Seventy one species of amphibians (55 salamanders, 16 anurans) and 46 species of reptiles (15 turtles, 8 lizards, 23 snakes) inhabit a five state area (Kentucky, North Carolina, Tennessee, Virginia, West Virginia) in the southern Appalachian region bordered by the Potomac River, the Blue Ridge Mountains, and the western margin of the Appalachian Plateau. Of these, 47.9% of the amphibian fauna and 52.2% of the reptilian fauna are listed as being of conservation concern by federal, state, and Natural Heritage programs in all or a portion of their ranges in this region. The Shenandoah salamander (*Plethodon shenandoah*) is listed as Endangered and the Cheat Mountain salamander (*Plethodon nettingi*) is listed as Threatened under the U.S. Endangered Species Act. Nine others are classified as federal species at risk. State endangered species number 1-3 (per state), threatened 1-4, and special concern or declining 6-19. Three to 6 species per state are additionally listed as natural heritage S1 and 2-13 as S2. We review the existing and potential threats to species and populations (e.g., timbering, urbanization, collection for the wildlife trade, acid precipitation, introduced species) and provide an assessment of the conservation status of the southern Appalachian herpetofauna based on land ownership.

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INTRODUCTION

The southern Appalachian region of eastern temperate North America harbors a rich diversity of amphibians and reptiles. Of the 117 species currently known for this area, nearly half are salamanders. Emmett R. Dunn (1926) first introduced the high regional diversity of these animals to a wide audience. The era in which he worked on Appalachian salamanders (about 1915-1930) was sandwiched between the older period of sparsely settled rural communities and farms with intense logging of virgin forests and the more recent one of high road density, small farms, urbanization, and logging of second growth forests. These changes in landscape use, especially road building, allowed herpetologists to work in areas previously difficult to reach and collect specimens of and data on all the herpetofaunal groups, not just salamanders. Many new salamander species have been discovered since Dunn's (1926) book was published and several others are currently being described. Thus, most of the information on herpetofaunal species richness, relative abundance, and distribution patterns in the southern Appalachians has accumulated since the 1920s. A review of the conservation status of these two taxonomic groups would provide insights into how changes in land use have affected the herpetofauna.

Relatively recent concern about the decline of biological diversity has resulted in country-wide and state-wide efforts to recognize those species that may need human intervention to prevent further population decline and extinction. Passage of the U.S. Endangered Species Act was followed by establishment of state-level endangered species acts, nongame and endangered wildlife programs, and Natural Heritage programs. Changes in land use over time and human population growth have generated a variety of threats to amphibians and reptiles in the southern Appalachians. In this paper, we review all species of amphibians and reptiles in the southern Appalachian region (defined below) currently listed by federal, state, and natural heritage agencies. We provide a brief overview of existing and potential threats to these species, evaluate the availability of public lands for long-term conservation, and suggest options for continued monitoring and habitat protection.

METHODS

We limited our geographic coverage in this review to the following area: mountainous regions of Kentucky, North Carolina, Tennessee, Virginia, and West Virginia south of the North Fork of the Potomac River, north of the southern borders of North Carolina and Tennessee, west of the eastern margin of the Blue Ridge Mountains in North Carolina and Virginia, and east of the Appalachian Plateau in Kentucky, Tennessee, and West Virginia.

We obtained U.S. federal and appropriate state and Natural Heritage status listings and other information from a variety of published and unpublished sources, including U.S. Fish and Wildlife Service (1994a, b), Lowe et al. (1990), Moseley (1992), and Beacham (1994). State sources were: Kentucky - Warren et al. (1986), Kentucky Nature Preserves Commission (1992); North Carolina - Braswell (1989) and LeGrand and Hall (1995); Tennessee - Tennessee Natural Heritage Program, Biological and Conservation Database; Virginia - Mitchell (1991a), Virginia Department of Game and Inland Fisheries (R. Wadja, pers. comm.), and the Natural Heritage Biological and Conservation Datasystem (S. Roble, pers. comm.); West Virginia - WV Natural Heritage Program and WV Department of Natural Resources (WVDNR).

TABLE 1. Number of amphibian and reptile species of the five states in the southern Appalachian region.

	KY	NC	TN	VA	WV	REGION
Salamanders	25	32	40	36	31	55
Frogs	15	13	15	14	14	16
Turtles	8	6	12	11	13	15
Lizards	7	7	7	6	5	8
Snakes	21	20	21	21	20	23
Totals	76	79	95	88	83	117

In order to be included in this review, a species must be officially recorded on federal, state, or natural heritage lists, as defined herein. Legal categories at the federal level include endangered (FE) and threatened (FT). Federal species at risk (SAR), formerly defined as Category 2 (candidate) species, are those "Taxa for which information now in the possession of the Service indicates that proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data on biological vulnerability and threat are not currently available to support proposed rules" (U.S. Fish and Wildlife Service, 1994b). Legal categories at the state level include endangered (SE) and threatened (ST). State-level categories somewhat equivalent to federal SAR are special concern (SC) in KY, NC, VA, and WV. Other categories are "Deemed in need of management" (D) in Tennessee, and "Scientific Interest" (SI, unique scientific value, e.g., endemic, uncertain taxonomic status) in West Virginia. State Natural Heritage Program (NHP) listings in this report include S1 (extremely rare, 1-5 known populations) and S2 (very rare, 6-20 known populations) rankings. SH represents historical records not recently confirmed. We arbitrarily chose not to include NHP rankings of S3 (rare to uncommon, 20-100 occurrences) and SU (status uncertain) because these categories apply to more common and inadequately surveyed species, respectively, than those of concern to us in this paper. Species included with state ranks but without NHP rankings are listed as SU or S3 or higher. The number of species of concern varies among states because a listed species in one state may be more widely distributed and locally abundant in one or more neighboring states covered by this paper.

RESULTS

The herpetofauna of the southern Appalachian region consists of 117 species, including 71 amphibians (55 salamanders, 16 anurans) and 46 reptiles (15 turtles, 8 lizards, and 23 snakes). These species are variously distributed among the five states within the region, ranging in number from 76 in Kentucky to 96 in Tennessee (Table 1). Within these five taxonomic groups, 50.9% of the salamanders, 37.5% of the anurans, 66.7% of the turtles, 87.5% of the lizards, and 30.4% of the snakes are of conservation concern at the federal or state level, or are listed as extremely rare or very rare by state Natural Heritage programs. A complete list of species, their listed status by program,

agency, and state, and a summary of threats follows. Common and scientific names follow Crother (in press).

SPECIES ACCOUNTS

Salamanders

Streamside salamander (*Ambystoma barbouri*) (WV - S1/S2) This ambystomatid was first described by Kraus and Petranka (1989) and is restricted to central Kentucky, southwestern Ohio, western West Virginia, and southeastern Indiana. It is known only from two localities in Wayne County, WV (Longbine et al., 1991). Few verified records and lack of data on the status of known populations in the state justify the NHP ranking in WV.

Mole salamander (*Ambystoma talpoideum*) (NC - SC, S2) Mole salamanders occur primarily in the Coastal Plain and Mississippi River lowlands (Conant and Collins, 1998). However, five occurrences in the Appalachian region of North Carolina have been recorded. Threats in these areas include loss of breeding habitat and the floodplain component of the terrestrial habitat. Murdock (1994) noted that this salamander inhabits floodplain pools, a habitat type lost at a higher percentage than other mountain wetlands.

Small-mouthed salamander (*Ambystoma texanum*) (WV - SI, S2). This species is found throughout the midwestern United States from southern Ontario to the Gulf of Mexico (Conant and Collins, 1998). It is known from three localities along the Ohio River (Mason and Wood counties) in West Virginia (Longbine et al., 1991). Few verified records and lack of data on the status of known populations in the state justify the NHP ranking.

Eastern Tiger salamander (*Ambystoma tigrinum*) (NC - ST, S2; VA - SE, S1) The eastern tiger salamander (*A. t. tigrinum*) is widespread in the midwestern portion of its range but rare in Atlantic Coast states (Conant and Collins, 1998). One of the five localities in Virginia occurs in the Blue Ridge Mountains (Pague and Buhlmann, 1991; Mitchell and Buhlmann, in press). Primary threats include habitat loss (both aquatic and terrestrial), acid precipitation causing declines in pH and increases in aluminum concentrations (Downey et al., in press), genetic pollution from introduced tiger salamanders (waterdogs) from the Midwest sold as fishing bait (Mitchell, pers. obs.), and stocking of breeding ponds with fish.

Green salamander (*Aneides aeneus*) (SAR in North Carolina: NC - SE, S1; TN - D, S1; WV - SC). The NC population of this species underwent an, as yet, unexplained decline in the late 1970s that appears to have caused some local extinctions (A.L. Braswell, unpublished). Recovery has occurred at some sites. In Tennessee, *A. aeneus* occurs primarily in the Cumberland Mountains, Cumberland Plateau, and the eastern Highland Rim. Isolated populations have been reported outside the region covered in this report (Redmond, 1985). The conservation status of this species in TN results from potential threats to its specialized habitat and lack of demographic information. This species is known to occur throughout most of WV (Green and Pauley, 1987; Pauley, 1991b, 1993b). It is listed by the NHP because of over-collecting in some areas and loss of habitat. This species was formerly listed as SC in KY but was delisted by the Kentucky Nature Preserves Commission (1992).

Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*) (SAR in Kentucky, North Carolina, Tennessee, Virginia, West Virginia: NC - SC; TN - D; VA -

SC, S2/S3). This large aquatic salamander occurs in rivers and their tributaries in much of the southern Appalachian region (Conant and Collins, 1998) where it is threatened by a variety of factors, including aquatic pollution. Hellbenders in Tennessee have been reported from many of the streams and rivers of the eastern two thirds of the state, including many localities within the Cumberland Plateau, Ridge and Valley, and Blue Ridge Mountains (Redmond, 1985). Urban growth with its associated siltation and eutrophication of streams probably represents the most important threat to this species in North Carolina (Van Devender, 1989). Pague (1991c) reported that portions of the Holston and Powell rivers in Virginia lack hellbenders and suggested that pollution in these streams has affected their distribution. Little is known about the distribution and biology of the hellbender in WV. Many streams where it is known or suspected to occur are affected by acid mine drainage and other pollutants.

This species is no longer listed as SC in Kentucky (Kentucky Nature Preserves Commission, 1992). Although there are populations that appear to be doing well in the state, those in the Ohio and Kentucky Rivers have been reduced considerably, apparently due to the effects of pollution Kentucky (Kentucky Nature Preserves Commission, 1992).

Seepage salamander (*Desmognathus aeneus*) (TN - S1). This small salamander is restricted to the Unicoi Mountains in southeastern Tennessee (Jones, 1982). The floodplain pool habitat used by this species is declining in abundance (Murdock, 1994). Its conservation status in TN is based on its limited distribution in the state.

Black-bellied salamander (*Desmognathus quadramaculatus* (TN - D, S?; WV - S2/S3). In TN, this species occurs along permanent, rocky, wooded streams throughout the Blue Ridge Mountains and the Bays Mountain Area in the Ridge and Valley (Redmond, 1985). Conservation status in TN is prompted by concerns that populations could be in jeopardy due to the use of this species as fish bait (P. Wyatt, pers. comm.). Blackbellied salamanders reach the most northern point of their range near the confluence of the New and Gauley rivers in WV. Pauley (1993b) surveyed 103 streams in the New River Gorge and found this species in 51. Many streams within its range in WV are polluted with mine drainage or sewage. Overcollection for fish bait is a serious threat (Turner and Pauley, 1992).

Pygmy salamander (*Desmognathus wrighti*) (VA - SC, S2). This small, terrestrial salamander occurs in Virginia only in the vicinity of Whitetop Mountain and Mount Rogers (Tobey, 1985; Conant and Collins, 1998) where it inhabits high elevation coniferous forests. Its conservation status in Virginia is based primarily on its limited occurrence in the state and secondarily on potential habitat loss in this region (Pague, 1991a). The Virginia Department of Game and Inland Fisheries recently passed a regulation prohibiting the collection of all salamanders in the vicinity of Mt. Rogers except by special permit.

Three-lined salamander (*Eurycea guttolineata*) (KY - ST, S2). Three-lined salamanders inhabit streamside zones of small rivers, streams, and creeks. Pollution of aquatic systems, creation of impoundments, and habitat loss constitute the primary threats.

Junaluska salamander (*Eurycea junaluska*) (SAR in North Carolina: NC - SC, S2; TN - S1). This salamander is restricted to streamside habitats in western NC and southeastern TN. Almost no demographic information exists on populations of this species. This salamander is known only from the Cheoak River and its larger tributaries

in Graham County, NC, and is considered rare (Ryan, 1997, 1998). Primary threats appear to be deforestation, road construction, urban development, and other activities that may lower water quality in stream habitats used for breeding and larval development (Sever, 1989). This species is currently being considered for protection under the federal Endangered Species Act.

Long-tailed salamander (*Eurycea longicauda longicauda*) (NC - SC, S2). This species inhabits streamside zones of small rivers, streams, and creeks. Threats include pollution of aquatic systems and creation of impoundments. Murdock (1994) noted that floodplain habitats inhabited by this salamander are decreasing at a higher rate than other habitat types.

Cave salamander (*Eurycea lucifuga*) (WV - SC). This species was originally thought to be restricted to limestone caves in the southeastern portion of the state. However, Pauley (1993b) found this species in abandoned coal mines in the New River Gorge. It is listed due to overcollecting, heavy use of caves by spelunkers, and water pollution from agricultural activities.

Tennessee cave salamander (*Gyrinophilus palleucus*) (SAR in Tennessee; TN - ST, S2). This troglodyte is restricted to the subterranean waters of the Ridge and Valley, Eastern Highland Rim, and Cumberland Plateau of eastern TN, northwestern Georgia, and northern Alabama (Redmond, 1985). A few isolated populations have also been reported from the Eastern Highland Rim and Central Basin of TN (Redmond, 1985; Miller, 1995; Miller and Walther, 1994). Lack of demographic information, restricted habitat (McCrady, 1954) and limited distribution prompted its conservation status at both the federal and state levels.

West Virginia spring salamander (*Gyrinophilus subterraneus*) (SAR in West Virginia; WV: S1). This species was described by Besharse and Holsinger (1977). It is known to occur in only one location in Greenbrier County. The limited distribution and lack of information on the only known population justify the federal and NHP rankings.

Four-toed salamander (*Hemidactylium scutatum*) (NC - SC; TN - D, S2). This small salamander ranges throughout much of the eastern two thirds of North America (Conant and Collins, 1998). It is primarily associated with sphagnum bogs, hardwood swamps, or other still waters (Neill, 1963). Primary threats in NC are loss of terrestrial habitat, which includes hardwood forests for adults and well-established bogs, floodplain pools, and seepages for breeding and larval development (Braswell, 1989; Murdock, 1994). The conservation status of this species in TN is based on its specialized and localized habitat, which is often disturbed by logging and agricultural practices.

Shovel-nosed salamander (*Desmognathus marmoratus*) (VA - SC, S2). In Virginia, this aquatic species is only known to occur in several streams near Whitetop Mountain in Grayson and Washington counties (Gourley and Pague, 1991). Its conservation status is based on its limited occurrence in the state and possible habitat degradation from landscape alteration and timbering operations causing siltation and changes in oxygen capacity.

Common Mudpuppy (*Necturus maculosus maculosus*) (NC - SC, S1; VA - S2) Mudpuppies in North Carolina are limited to small parts of the upper French Broad River basin in Davidson and Mill rivers. In Virginia, this species occurs in several locations in four southwestern counties (Mitchell, 1991a). Limited number of occur-

rences and potential for population decline from pollution are the basis for the special concern and NHP rankings.

Tellico salamander (*Plethodon aureolus*) (NC - S2). This salamander is limited in distribution to the Little Tennessee and Hiwassee rivers in Cherokee and Graham counties in NC and adjacent counties in TN (Conant and Collins, 1991). The small range and threats from deforestation are the bases for this listing.

Peaks of Otter salamander (*Plethodon hubrichti*) (SAR in Virginia; VA - SC, S2) This terrestrial salamander is endemic to a small area in the northern Blue Ridge mountains (Highton, 1986; Pague and Mitchell, 1991) where it may be locally common in some areas (Kramer et al., 1993). Potential threats include logging activities, habitat fragmentation, and defoliation and changes in forest habitats from the introduced gypsy moth (*Lymantria dispar*) (Mitchell et al., 1996; Sattler and Reichenbach, 1998). Conservation plans have been developed in cooperation with three federal agencies (George Washington and Jefferson National Forests, U.S. Fish and Wildlife Service, and Blue Ridge Parkway, 1997).

Crevice salamander (*Plethodon longicrus*) (NC - SC). This salamander was described by Adler and Dennis (1962), but was synonymized within *Plethodon yonahlossee* by Highton (1972) and Guttman et al. (1978). It is not listed in Crother (in press). It occurs in parts of Buncombe, Henderson, and Rutherford counties, NC, and is primarily associated with cool rock crevices. Its small distribution and specialized habitat requirements are the primary cause for its listing, along with the taxonomic uncertainty.

Cheat Mountain salamander (*Plethodon nettingi*) (FT; WV - S2). This salamander is known to occur in 60 disjunct populations in five counties in eastern West Virginia (Pauley, unpublished). All populations have been adversely affected by habitat perturbations, such as roads, hiking trails, ski slopes, timbering operations, and coal activities (Pauley, 1994). It is found at elevations ranging from 805 to 1482 meters ASL (Pauley, 1993a). The recovery plan (Pauley, 1991a) describes the objectives to delist this species.

Cow Knob salamander (*Plethodon punctatus*) (SAR in Virginia and West Virginia; VA - SC, S2; WV - SC, S1) Cow Knob salamanders (sometimes called white-spotted salamanders, Conant and Collins, 1998) are restricted to Shenandoah Mountain along the Virginia - West Virginia state line and one locality on Great North Mountain in Virginia (Highton, 1988b; Green and Pauley, 1987; Pague et al., 1991). Buhlmann et al. (1988) found this species to be largely restricted to mature hardwood forests and absent from recently logged sites. Pauley (1995) found *P. punctatus* in 17 of 40 sites surveyed on Shenandoah and Great North Mountain in WV. Populations are apparently small and scattered within this region. They may be threatened by logging operations and changes in forest habitat due to defoliation by gypsy moths. Much of the known range of this salamander is protected within a special biological area on the George Washington National Forest. Potential threats include changes in forest structure from defoliation by the gypsy moth, and loss of hemlocks from the hemlock woolly adelgid (*Adelges tsugae*).

Ravine salamander (*Plethodon richmondi*) (TN - S1). Ravine salamanders are associated with wooded hillsides, primarily within the central Appalachians (Conant and Collins, 1998). The conservation status is based on its limited distribution in the Blue Ridge Mountains, Ridge and Valley, and Cumberland Mountains.

Shenandoah salamander (*Plethodon shenandoah*) (FE; VA - SE, S1) This species is endemic to the northern Blue Ridge Mountains where it is known to occur on only three mountain talus slopes in Shenandoah National Park (Highton, 1988a; Wynn, 1991). It is vulnerable to competition with the common, sympatric congener *Plethodon cinereus* (red-backed salamander), habitat loss due to natural succession, drought, soil acidification, and hybridization with *P. cinereus* in some areas (e.g., Jaeger, 1970, 1971, 1980; Wynn, 1991; Griffis and Jaeger, 1998). Gypsy moth defoliation may cause habitat alteration in some areas (Wynn, 1991). The federal draft recovery plan (Jacobs, 1994) outlines a variety of objectives to minimize human impacts in the national park while still allowing natural competition to occur.

Southern zigzag salamander (*Plethodon ventralis*) (NC - SC, S1; VA - S1) Recent taxonomic revision of the *Plethodon dorsalis* complex (Highton, 1997) revealed that populations in eastern Kentucky and Tennessee and adjacent states were a new species, *P. ventralis*. This form is known from two localities in Buncombe and possibly Henderson counties, NC. Threats include deforestation of the limited areas from which this species is known. Only two localities have been recorded in Virginia (Highton, 1979). Nothing has been published on its population status or life history in this portion of its range that would allow a clear assessment of its conservation status.

Wehrle's salamander (*Plethodon wehrlei*) (NC - ST, S1; KY - SE, S1). This salamander is known from only one Blue Ridge Province locality and one upper Piedmont locality in North Carolina (Beane and Somers, 1994). The primary threat is deforestation. Only the yellow-spotted morph occurs in Kentucky, and at only one locality (Cupp and Towles, 1983). It is very secretive in its streamside, shale, rock cliff habitat. It is considered rare because of its apparently limited habitat affinity and localized distribution.

Weller's salamander (*Plethodon welleri*) (NC - SC, S2; TN - S1; VA - SC, S2) This terrestrial salamander occurs in high elevation red spruce and Fraser fir forests in northeastern Tennessee, northwestern North Carolina, and in the vicinity of Whitetop Mountain and Mount Rogers in southwestern Virginia (Conant and Collins, 1998). The population in the Whitetop area has apparently been stable since it was first studied by Organ in the late 1950s (Organ, 1960; unpublished). This species may be threatened by changes in these high elevation forests (tree mortality from environmental perturbations) and fragmentation of habitat (Pague, 1991b). In North Carolina, this species is threatened by deforestation and development. Declines in high elevation forests have apparently been caused by pollution. Its conservation status in TN is based on inadequate knowledge on stability of known populations and its restricted habitat within three counties in the Blue Ridge Mountains.

Frogs

Eastern cricket frog (*Acris crepitans crepitans*) (WV - SI, S2) Northern cricket frogs (*A. c. crepitans*) occur throughout much of the eastern half of the United States (Conant and Collins, 1998). West Virginia is on the periphery of the range of two subspecies: *Acris c. crepitans* (northern cricket frog) and *A. c. blanchardi* (Blanchard's cricket frog). Northern cricket frogs occur in the eastern panhandle and Blanchard's cricket frogs occur along the Ohio River. The latter has not been observed in the state for over 20 years. Few verified records and lack of data on the status of known populations in the state justify the NHP ranking.

Barking treefrog (*Hyla gratiosa*). (TN - D). Barking tree frogs are associated with coastal plain habitats within the southcentral states (Caldwell, 1982). Several populations have been reported from central and western TN (Redmond, 1985; Miller and Campbell, 1995), and two have been reported from the Cumberland Plateau (Redmond and Scott, 1996). The conservation status of this anuran is based on temporally separated and geographically disjunct distribution records, the absence of published demographic information and loss of habitat.

Mountain chorus frog (*Pseudacris brachyphona*) (NC - SC, SH). The single NC record (Schwartz, 1955) has not been revalidated. Deforestation, urbanization, loss of floodplain pools, other factors have caused the decline of appropriate habitat for this species (Murdock, 1994). It may no longer occur in NC.

Upland chorus frog (*Pseudacris feriarum feriarum*) (WV - SI, S?). This species occurs throughout eastern and midwestern North America (Conant and Collins, 1998). It is listed in West Virginia because the subspecies *P. f. feriarum* occurs only in the extreme eastern edge of the state.

Northern leopard frog (*Rana pipiens*) (KY - SC, S1; WV - SI). This anuran occurs throughout much of northern North America (Conant and Collins, 1998). In West Virginia, it probably only occurs along the Ohio River (Green and Pauley, 1987). Few verified records and lack of data on the status of known populations in the state justify its NHP ranking.

Eastern spadefoot (*Scaphiopus holbrookii*) (WV - SC, S2) The eastern spadefoot (*S. holbrookii*) occupies the eastern margin of West Virginia, as well as isolated localities in Hardy and Kanawha counties (Green and Pauley, 1987). It is listed because of loss of habitat and loss of known populations. Several known populations in the western portion of WV have been destroyed by urbanization.

Turtles

Eastern spiny softshell (*Apalone spinifera spinifera*) (NC - SC, S1; VA - S2) In North Carolina, the eastern spiny softshell (*A. s. spinifera*) has been recorded from only six localities in the middle and lower segments of the French Broad River (Palmer and Braswell, 1995). They also occur in several of the major rivers and their tributaries in southwestern Virginia (Mitchell, 1994). They may be threatened directly or indirectly by degradation of aquatic systems, largely through pollution. Fewer than ten sites have been recorded for this aquatic turtle in Virginia (Mitchell, 1994).

Spotted turtle (*Clemmys guttata*) (WV - SI, S1) Spotted turtles are closely tied to wetland ecosystems that offer shallow marsh-like habitats. They have been recorded in West Virginia only from Jefferson County in the eastern panhandle (Green and Pauley, 1987). The potential for habitat loss and the few occurrences known suggest that this species should be included in a higher category.

Wood turtle (*Clemmys insculpta*) (VA - ST, S2; WV - SI) In Virginia, wood turtles occur in the northern tier of counties extending from the metropolitan Washington, D.C. area in Fairfax County to the rural counties of Rockingham and Shenandoah in the Ridge and Valley Physiographic Province (Mitchell, 1994). Populations in the eastern portion of its range in Virginia have been experiencing severe declines and many populations east of the Blue Ridge are now extirpated (Ernst and McBreen, 1991). Habitat loss from residential and commercial development, degradation of streams, and the collection of adults for the pet trade constitute the most severe threats to this species. All known localities of this species in West Virginia occur in

northeastern counties (Green and Pauley, 1987). Populations in this state have been subjected to heavy collecting for the pet trade. Rapid urbanization in the eastern panhandle is threatening habitats and known populations.

Bog turtle (*Clemmys muhlenbergii*) (FT by similarity of appearance in North Carolina, Tennessee, and Virginia; NC - ST, S2; TN - ST, S1; VA - SE, S1). The bog turtle may be the most threatened freshwater turtle in mid-Atlantic and northeastern states (Bury, 1979; Klemens, 1993). It receives some level of protection in all states in which it occurs. Northern populations were listed as FT in 1997 and southern populations were included as FT by similarity of appearance to protect this species from commercial trade (U.S. Fish and Wildlife Service, 1997). The most important threats are habitat loss, isolation of populations, habitat alteration, and illegal collection for the pet trade. Southern populations have been declining due to these factors (Tryon and Herman, 1990; Mitchell et al., 1991; Murdock, 1994). Bog turtles occur in four counties in Virginia (Mitchell, 1994), 17 counties in North Carolina (Palmer and Braswell, 1995), and one county in Tennessee (Tryon and Herman, 1990). Many populations occur in isolated wetlands on private property and appear to be small with fewer than 30 adult individuals (Carter, 1997).

Northern map turtle (*Graptemys geographica*) (VA - S2) The distribution of this turtle is limited to rivers of southwestern Virginia that lie within the Tennessee River drainage. There are fewer than 12 known localities (Mitchell, 1994), although map turtles are probably more widespread than current records indicate. Map turtles may be threatened directly or indirectly by water pollution and in the near future by introduced zebra mussels (*Dreissena polymorpha*) that are likely to reduce native molluscan prey (Williams et al., 1993).

False map turtle (*Graptemys pseudogeographica pseudogeographica*) (KY - S2; WV - SI). This freshwater turtle occurs in the Mississippi drainage (Conant and Collins, 1998). It is known to occur in only one county in West Virginia (Richmond, 1953). The lack of data on the status of this one population justifies the NHP rankings.

River cooter (*Pseudemys concinna*) (VA - S1) The subspecies of concern is *P. c. hieroglyphica*, which is known from only one locality on the North Fork of the Holston River in Scott County (Mitchell, 1994). Its listing by the NHP is based on this single occurrence. Its population status is unknown. The conservation status of this turtle requires reevaluation in light of the synonymy of *hieroglyphica* within *P. concinna* (Seidel, 1994; Crother, in press).

Northern red-bellied cooter (*Pseudemys rubriventris*) (WV - SI, S2) Although common in Virginia (Mitchell, 1994), this large, basking turtle has been observed at only three sites in northeastern West Virginia in the Potomac River drainage on the western periphery of its range (Green and Pauley, 1987). Few verified records and lack of data on population status justify the NHP ranking in WV.

Stripe-necked musk turtle (*Sternotherus minor peltifer*) (NC - SC, S1; VA - S2) This subspecies occurs in both states. It is almost entirely aquatic. It is known in NC from two localities near the TN state line (Palmer and Braswell, 1995). It has been recorded from only five localities in Virginia (Mitchell, 1994). Aquatic musk turtles may be susceptible directly and indirectly to water pollution and the zebra mussel through declines in prey populations.

Slider (*Trachemys scripta*) (VA - S1; WV - SI) The Cumberland slider (*T. s. troostii*) occurs naturally in southwestern Virginia at two locations (Mitchell, 1994)

and the red-eared slider (*T. s. elegans*) occurs naturally in West Virginia at five locations (Green and Pauley, 1987). The yellow bellied slider (*T. s. scripta*) reaches its northernmost distributional limits in southeastern Virginia. Intergradation with the introduced red-eared slider occurs in several locations results in offspring with a mix of *scripta* and *elegans* genes (Mitchell, 1994). The scarcity of verified records justifies the NHP ranking for southwestern Virginia populations. It is listed in West Virginia based on the disjunct and possibly relict populations and lack of data on the status of known populations.

Lizards

Green anole (*Anolis carolinensis*) (TN - D). The green anole is an arboreal species widespread in the southern United States (Conant and Collins, 1998). Northernmost populations occur in the counties forming the southern margin of TN (Eagar and Hatcher, 1980). Because northern peripheral populations may be susceptible to severe winter mortality, the stability and persistence of these populations may be tenuous.

Six-lined racerunner (*Cnemidophorus sexlineatus sexlineatus*) (TN - D). This species inhabits relatively dry, sparsely vegetated open habitats, such as prairies, old fields, cedar glades, and rail and road rights-of-way (Mount, 1975; Dundee and Rossman, 1989). Racerunners have an extensive range throughout most of the lower eastern third of the United States (Conant and Collins, 1998). The conservation status of this lizard in TN is based on the few available published records and scant information on population dynamics.

Northern coal skink (*Eumeces anthracinus anthracinus*) (KY - ST, S1; TN - S1; VA - S2; WV - SC, S2). This secretive lizard is known from southeastern to southcentral Kentucky (Barbour and Ernst, 1971; Stephens and Sievert, 1982; Cambell et al., 1990). The distribution of the coal skink in TN is spotty (Conant and Collins, 1998). Fewer than 10 locations have been recorded for this state (Redmond et al., 1990). Populations have been reported in Monroe and Polk counties in the Blue Ridge Mountains and in Benton County in western TN. Its conservation status in TN is based on its limited distribution and apparent rarity. Nine scattered occurrences have been recorded for this species in Virginia in a variety of habitats (Mitchell, 1994; Hayslett, 1994; Roble, 1994). Listings of this skink are based on the disjunct nature of its distribution. Little has been published on the population status of this species in the southern Appalachians.

Southeastern five-lined skink (*Eumeces inexpectatus*) (KY - SC). Few records are available for this species in the Appalachian region in southeastern Kentucky (Barbour, 1971; Barbour and Ernst, 1971; Conant and Collins, 1998). Its listing is based on the limited distribution information.

Broad-headed skink (*Eumeces laticeps*) (WV - S2). This ranking is based on the five disjunct records in the central and western portions of the state and one record in the eastern panhandle (Green and Pauley, 1987).

Slender glass lizard (*Ophisaurus attenuatus*) (KY - ST, S2; TN - D). Glass lizards burrow in a variety of habitats, including prairies, pastures, old fields, and open woods. The range of this species is extensive, including most of the southeastern United States (Conant and Collins, 1998). This species has been found in only three counties in eastern Kentucky (Stephens, 1985; Campbell et al., 1990). The conservation status in these two states reflects the scant demographic information and limited distribution.

Ground skink (*Scincella lateralis*) (WV - SI). This species occurs in five counties in southwestern WV and in Hardy county in the northeast (Green and Pauley, 1987). It is listed as SI because of its occurrence on the northern edge of its range.

Snakes

Cornsnake (*Elaphe guttata*) (KY - SC; WV - SI). This secretive snake is known to occur in two disjunct localities in Kentucky (Barbour, 1971; Campbell et al., 1989). It has been reported from only one locality in the eastern panhandle of WV (Green and Pauley, 1987). Threats include habitat loss and collecting for the pet trade. The limited occurrence of this species was the justification for the listings in these states.

Common kingsnake (*Lampropeltis getula*) (VA - S2; WV - SI) The subspecies occurring in southwestern Virginia is the black kingsnake (*L. g. nigra*). Only six occurrences are known (Mitchell, 1994). The eastern kingsnake (*L. g. getula*) is locally common in the Blue Ridge and Ridge and Valley north of the New River (Mitchell, 1994). West Virginia is on the western periphery of the range of *L. g. getula* (Green and Pauley, 1987) and is listed as SI by WVDNR.

Smooth green snake (*Liochlorophis vernalis*) (NC - SC, SH) This species occurs on mountaintop balds in the Appalachian region (Mitchell, 1994; Palmer and Braswell, 1995). Loss of such habitats through fire suppression, ecological succession, and encroachment by hardwood trees has caused many of the former grassy habitats to become unsuitable. The four records of this snake in North Carolina are considered historical (SH) because no additional specimens have been collected or individuals observed since 1962 (Palmer and Braswell, 1995).

Northern pine snake (*Pituophis melanoleucus melanoleucus*) (SAR in North Carolina, Tennessee, Virginia, West Virginia; KY - ST, S2; NC - SC; TN - ST) The northern pine snake is apparently rare in the Appalachian region. It has a disjunct distribution in Kentucky (Barbour, 1971; Campbell et al., 1990; Conant and Collins, 1998). Only one specimen has been found in West Virginia (Green and Pauley, 1987). Its rarity, lack of information on its population status, and listing as a threatened species at the northern edge of its range in New Jersey (Zappalorti and Burger, 1985) contributed to the listing by the U.S. Fish and Wildlife Service as a SAR species. Reasons for listing this snake as threatened in Kentucky and Tennessee and Special Concern in North Carolina result from the few recorded locations and lack of population data.

Southeastern crowned snake (*Tantilla coronata*) (VA - S2) This small snake occurs in pine-dominated habitats in the southern Piedmont and former long-leaf pine forests in southeastern Virginia (Mitchell, 1994). It also occurs in the foothills of the Blue Ridge Mountains in Amherst County. The few available observations on its life history and population status make it one of the least known species in this state.

Eastern ribbonsnake (*Thamnophis sauritus sauritus*) (KY - SC; WV - SC) Ribbon snakes are of special concern in Kentucky and West Virginia because they are not common anywhere in these states (Barbour, 1971; Green and Pauley, 1987; Conant and Collins, 1998). The listing in WV is based on loss of wetlands and lack of data on status of populations. This species is listed as SC in Kentucky because of the scarcity of records and the difficulty in locating this snake at its reported locality.

Smooth earthsnake (*Virginia valeriae*) (VA - SC, S1; WV - SI) The montane subspecies of this small snake (*V. v. pulchra* [mountain earthsnake]) occurs only in Highland County, Virginia on the unglaciated Appalachian Plateau (Mitchell, 1994). Threats in Virginia are largely unknown, but timber harvesting, clearing of the

TABLE 2. Summary of the conservation status of the amphibians and reptiles of the southern Appalachians. Each species is included only in the highest category to which it has been assigned by federal, state, or Natural Heritage programs. FE and FT are federal endangered and threatened, SE and ST are state endangered and threatened, SC is special concern, and S1 and S2 are Natural Heritage Program rankings. Total is the sum of each row.

	FE	FT	SE	ST	SC[1]	S1	S2	Total
Salamanders	1	1	3	2	16	4	1	28
Anurans					6			6
Turtles			1	1	6	1	1	10
Lizards				2	4		1	7
Snakes				1	5		1	7

[1] Includes Deemed in Need of Management and Scientific Interest

landscape for agricultural purposes, and fragmentation may harm populations (Mitchell, 1991b). This subspecies has been recorded in four counties in West Virginia (Green and Pauley, 1987). It is a Special Interest species in this state because of its limited distribution in montane areas and lack of data on the status of known populations.

DISCUSSION

A summary of the status listings of the amphibians and reptiles of concern in the southern Appalachian region (Table 2) demonstrates that 10.3% of the total number of species (12 of 117) currently receives legal protection. Two salamanders and one turtle are listed at the federal level, four species are listed as state endangered, and six as state threatened. The remaining 46 species of concern (39.3%) are considered vulnerable to population decline and need to be monitored at least periodically to determine if their status requires re-evaluation. Nine of these are federal species at risk. In total, 47.9% of the amphibian fauna and 52.2% of the reptilian fauna in the southern Appalachian region are of conservation concern by federal and state agencies or Natural Heritage programs in all or a portion of their ranges.

Legal protection of the twelve endangered and threatened species varies in its effectiveness. Federal protection is complete in that it covers the species' habitat (except for bog turtle), as well as the issue of take (removal of individuals for some purpose; e.g., personal use, commercial trade). State protection is comparatively incomplete, as none of the endangered species acts in the five state region includes protection of critical habitat. More commonly, state listings afford protection only from collecting. Such listings may hinder investigations which could prove beneficial to properly managing truly endangered species (Gans, 1992). Enforcement of state endangered species acts is also variable. Two of the federally-listed species (*P. nettingi* and *P. shenandoah*) are afforded additional protection because they occur on National Forest Service and National Park Service lands, respectively.

Public land ownership should convey some additional habitat protection because federal and state environmental laws are more directly applied here than on privately-owned land. Of the total land area in the southern Appalachian region within the five

TABLE 3. Summary of public and non-government organization land ownership in the southern Appalachian region. Total land area is 20,914,912 hectares; % of total is based on this number.

	Hectares	% of Total
National forests	2,154,415	10.3
National parks	387,625	1.9
State forests	55,891	0.3
State parks	105,261	0.5
Wildlife management areas	214,925	1.0
TVA and others	27,643	0.13
Natural heritage	2,706	0.01
Total	2,948,466	14.1

TABLE 4. Federal, state, and Natural Heritage lands in the southern Appalachians by state. Numbers are percent of total land area (see Table 3) in the Appalachian region within each state.

	KY	NC	TN	VA	WV
Federal	9.3	24.7	12.0	16.3	6.2
State	2.6	0.3	1.1	1.1	2.9
Natural Heritage	0.04	---	---	0.02	---
Total	11.94	25.0	13.1	17.42	9.1

state area on which we focus here (20,914,912 ha), some 14.1% is in public ownership. Most of these lands are in national forests (10.3%) and the remainder are divided among national parks, state-owned lands, and other federal and state entities (Table 3). An analysis of public land ownership by state (Table 4) reveals that West Virginia has the least (9.1%) and North Carolina the most (25%).

Is the amount of public land in the southern Appalachians enough to protect the species of conservation concern in this region for the long term? We cannot now answer this question because detailed inventory and monitoring efforts (Short and Hestbeck, 1995), GAP analyses (Scott et al., 1993), and studies on population size, viability, and space requirements have only just begun. Populations of most species occur on both private and public lands. The few that occur largely or entirely on federal or state property (e.g., *Plethodon nettingi*, *P. punctatus*, *P. shenandoah*) probably have a better chance of long-term survival than the other species of concern.

Private land ownership should not, however, be viewed negatively with respect to long-term viability of amphibians and reptiles. Many landowners are sympathetic to endangered species issues and consciously manage their land with native species in mind. Programs such as the Forest Stewardship Program and the Natural Areas Registry Program enable land owners to provide conservation easements and other means of protection from adverse landuse changes. The Nature Conservancy (TNC),

a private conservation organization, is well known for its efforts to accumulate land for the benefit of rare species. Some 62 preserves are now being managed by TNC in the five state portion of the southern Appalachians (KY - 2; NC - 16; TN - 6; VA - 15; WV - 23).

A variable, but probably substantial, amount of land owned by private corporations is unused for commercial purposes and supports native habitats for many species. Such lands provide habitat for aquatic and terrestrial amphibians and reptiles. The Wildlife Habitat Council (WHC), a private organization based in Silver Spring, Maryland, has been working with corporations since 1990 to develop habitat restoration projects and management plans for native wildlife. WHC certifies the plans and programs developed by company employees, often in conjunction with local partners, such as schools, and lists them in their International Registry of Certified Corporate Wildlife Habitats. Native species usually benefit from active habitat management and restoration. Although most corporations focus on the more traditional game species, such as deer and turkey, many are including such groups as songbirds, butterflies, and turtles (Wildlife Habitat Enhancement Council, 1993). WHC has recently stressed the benefits of biodiversity inventory and protection and requires each corporation to obtain species lists on all their managed lands. Some corporations develop conservation plans on their own initiative, usually in conjunction with a federal or state agency (LaClaire, 1997).

Privately-owned lands represent an unknown but substantial percentage of the southern Appalachian landscape supporting habitats for amphibian and reptile populations. Although private lands with natural habitats are likely to be fragmented and of varying quality, they do contribute to the total area available for conservation efforts. Long-term conservation and protection of the region's herpetofauna would benefit from partnerships with public, private, and corporate land owners.

The threats facing these species on both public and private lands include habitat loss and degradation, habitat fragmentation, pollution, commercial collecting, and introduced species (Dodd, 1997). Habitat loss in the southern Appalachians occurs from agricultural, timber, and mining operations, urbanization, stream impoundments, and construction and maintenance of roads and power lines. Habitat degradation results from acid precipitation and other forms of pollution. Removal of individuals from natural populations for the pet trade, commercial education supply houses, and other commercial needs contribute to the decline of some of the region's amphibians and reptiles. Introduced species, such as the gypsy moth, zebra mussel, and hemlock woolly adelgid, contribute to habitat alteration. Introduced domestic and feral cats have a direct impact on native populations (Mitchell and Beck, 1993). Such threats have been identified for all of the species of conservation concern, but few, if any, have been quantified in ways that allow us to determine the magnitude of the threat. None of these threats has been controlled or managed adequately to prevent them from causing population decline.

Despite various threats to the long-term viability of amphibian and reptile populations, this component of the biota of the southern Appalachians remains healthy when compared to other groups. Unlike freshwater mussels (e.g., Wolcott and Neves, 1994; Williams et al., 1993), no species has become extinct or has suffered severe range contractions. Aquatic species have not been subjected to the pressures of other introduced amphibians and reptiles, as seen with freshwater fish communities (Etnier and Starnes, 1993; Jenkins and Burkhead, 1994).

This is not to say, however, that we should not be vigilant. Amphibians and reptiles are threatened with extinction worldwide and many species are declining. The increasing body of scientific and popular literature is documenting species declines, extinctions, and causes of these problems (e.g., Blaustein and Wake, 1990; Blaustein, 1994; Corn, 1994; Phillips, 1990; 1994; Drost and Fellers, 1996; Lips, 1998, 1999). Most species of amphibians in eastern North America have not experienced the severe declines and problems reported from western North America (Pechmann et al., 1991; Pechmann and Wilbur, 1994). However, many aquatic amphibians and reptiles have declined in the southeast, largely due to habitat loss and alteration (Dodd, 1997; Buhlmann and Gibbons, 1997). The underlying problem in assessing whether declines are occurring or not is the lack of long-term population data over large geographic areas.

The Declining Amphibian Populations Task Force (DAPTF) established by the IUCN is a growing network of scientists whose aim is to conduct long-term monitoring of amphibian populations. DAPTF has recommended the use of standardized monitoring techniques based on those in Heyer et al. (1994) so that results can be compared across space and time. We stress that such monitoring and inventory programs should be conducted throughout the southern Appalachians. Such projects will produce the baseline and trend data needed to determine if populations in this region are declining, fluctuating, or remaining stable over the long term. Accurate future assessments of the conservation status of the amphibian and reptilian fauna of the southern Appalachians depends on cooperation with a variety of programs, such as the Environmental Protection Agency's Mid-Atlantic Highlands Assessment project, state wildlife agencies, Natural Heritage programs, museums, and private organizations and the network of volunteers and professionals who participate in the amphibian monitoring network.

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