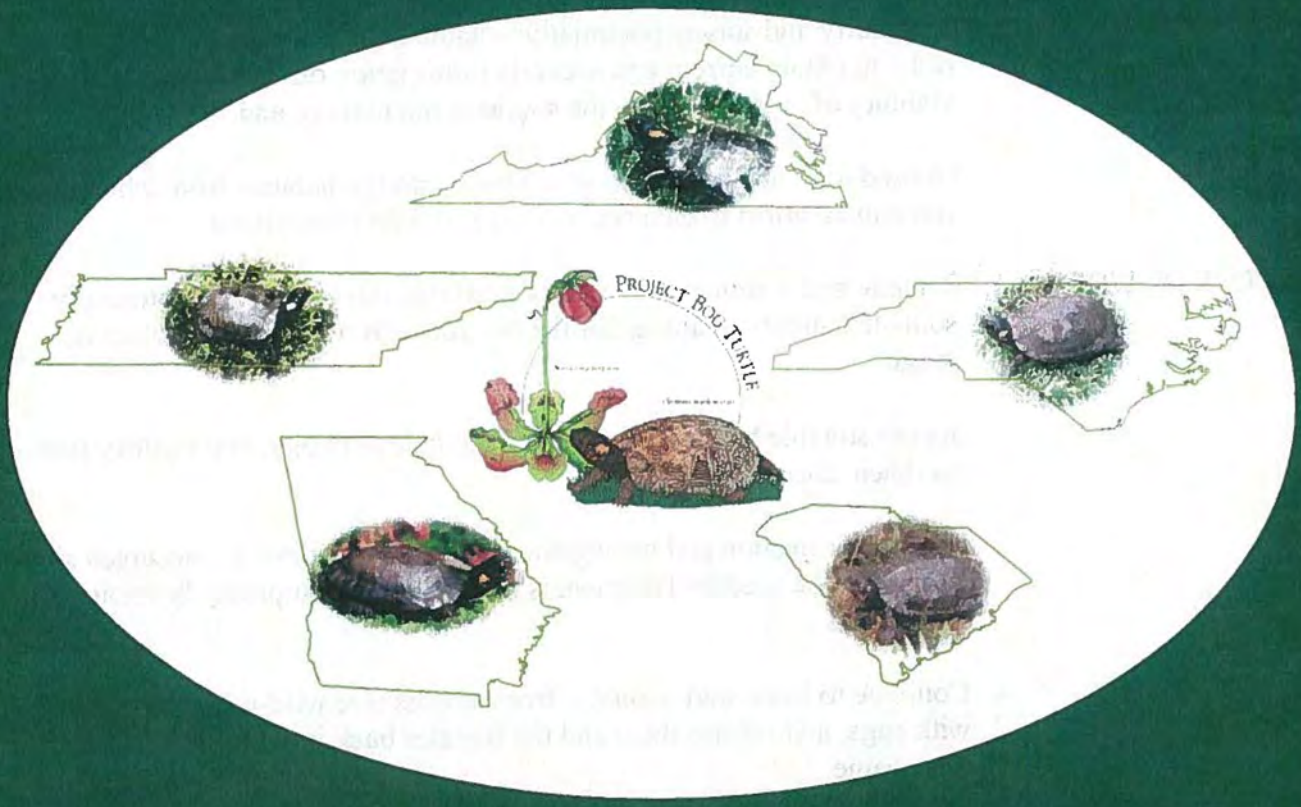
Status of the Bog Turtle *Clemmys muhlenbergii* Schoepff, in the Southern United States

Final Report to the U.S. Fish and Wildlife Service on the 1996-2002 Status Survey Conducted Under Grant Agreement #1448-0004-96-9126



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October 30, 2003

TITLE: Status Survey of the Bog Turtle (*Clemmys muhlenbergii* Schoepff 1801) in the Southern Part of its Range, Including Georgia, North Carolina, South Carolina, Tennessee, and Virginia.

AGREEMENT #: 1448-0004-96-9126

PRINCIPAL INVESTIGATOR:

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PURPOSE:

1. To identify and survey potentially suitable habitat for the bog turtle in order to obtain current and accurate information on the status and viability of, and threats to, the southern population; and

2. To head-start and release neonates back into the habitats from which they came in an effort to enhance and expand wild populations.

SCOPE OF WORK:

1. Compile and summarize presently available information on potentially suitable habitat remaining for the bog turtle in the southern part of its range.

2. Survey suitable habitat, using all available technology, and identify new occupied sites.

3. Develop protection and management recommendations for occupied sites that might be used by landowners or managers to improve the habitat for bog turtles.

4. Continue to head-start neonates from at least five wild-captured turtles with eggs, and release them and the females back into the sites from which they came.

CONTENTS

List of Tables

List of Figures & Photographs

About the Cover

The cover, designed by Dennis and Amy Herman, represents the cooperation and partnerships that developed over the last seven years between Project Bog Turtle and the various researchers and state biologists in the five states in which bog turtles occur in the Southeast. The bog turtles in the photographs, clockwise from the top, were found in:

VA:	Floyd Co.	Dennis W. Herman photo
NC:	Buncombe Co.	Dennis W. Herman photo
SC:	Pickens Co.	Dennis W. Herman photo
GA:	Towns Co.	Kenneth M. Fahey photo
TN:	Johnson Co.	Bern W. Tryon photo

FOREWORD

Twenty-six years have passed since I found my first bog turtle. The feeling that swept over me that morning cannot be described. I had just encountered North America's smallest turtle species and that chance meeting set in motion a future that I had not expected. What started out as a chance to return to the Blue Ridge Mountains of North Carolina I had enjoyed as a youth turned into a lifetime project filled with respect, not only for the bog turtle and its environment, but to the intricate and delicate connectivity of the natural world.

My work with the bog turtle has introduced me to many people I now call friends, and I have, in some small way, tried to introduce them to the joys and frustrations of bog turtle field work and conservation biology. We have shared many experiences searching for *Clemmys muhlenbergii* throughout the Southeast, with its accompanying highs and lows. The highs being finding new sites and meeting wonderful landowners, and the lows witnessing the loss or degradation of once large and viable wetlands. Having witnessed unchecked destruction of bog turtle habitat in the Southeast, especially in North Carolina, over the years, I was compelled to do what I could to save the remaining populations.

I recall standing along a stretch of the Blue Ridge Parkway in November 1993 with my friends, Bern Tryon, Nora Murdock, and Allen Boynton. Along with us were Carol Copeyon (U.S. Fish and Wildlife Service biologist, NE Office) and two of her consultants, Michael Klemens (American Museum of Natural History) and Joe Mitchell (University of Richmond). We had just spent a 2½ day tour of bog turtle sites in western North Carolina and stopped at this parkway site to reflect on the isolated nature of the turtle populations that we had visited. Our discussion turned to the overall status of the bog turtle in the Southeast, in an effort to decide whether *C. muhlenbergii* warranted endangered or threatened status. It was during this discussion that Nora (U.S. Fish and Wildlife Service biologist) and Allen (N.C. Wildlife Resources Commission biologist) dropped their bombshell. **Less than 50% of the available area in North Carolina had been searched for new turtle colonies** and this was more or less true throughout the turtle's southern range. Needless to say, three shocked people stood before us with deep concerns that this information would somehow hinder their proposal to protect the bog turtle under the U.S. Endangered Species Act. After the initial shock wore off the discussion turned to funding and a status survey of the bog turtle in the southern states. Everyone departed from this educational experience, and it seemed that very little resulted from it for several years.

Project Bog Turtle was founded in November 1995 as a conservation initiative of the North Carolina Herpetological Society two years after the above meeting took place. It was decided that the project's mission would be the protection and conservation of the bog turtle and its habitat in the Southeast. Two separate projects in North Carolina (Blue Ridge Mountains and Piedmont surveys) were combined so resources and funding could best be used for fieldwork. Tax-exempt donations fueled the volunteer efforts of the project's workers. To further strengthen the fund raising efforts, Project Bog Turtle expanded the surveys into the other southern states and the various biologists and state agencies in those states began to share information and provide support. Donations were few and the expense of the fieldwork decreased the number of days searching potential sites for bog turtles. Financial help came in a big way. Nora Murdock was one of the project's biggest allies. She located

funding for a grant agreement between the Fish and Wildlife Service and Project Bog Turtle to conduct a status survey for the bog turtle in the Southeast. Nora asked me to be the principal investigator on this multiyear project and I accepted. Now the fun began.

ACKNOWLEDGEMENTS

A survey of this magnitude would not have been possible without the support and guidance of many people from various institutions and agencies. I thank the following for supporting Project Bog Turtle from its infancy to the present: Chris McGrath and Randall Wilson (Nongame Wildlife Program, N.C. Wildlife Resources Commission); Merrill Lynch (N.C. Nature Conservancy); Nora Murdock (currently U.S. National Park Service); Bob Currie (U.S. Fish & Wildlife Service; Alvin L. Braswell, William M. Palmer, and Jesse Perry (N.C. Museum of Natural Sciences); Bob Cherry, Tom Davis, and Bambi Teague (National Park Service, Blue Ridge Parkway); Michael Pinder (VA Department of Game and Inland Fisheries); Joe Mitchell (University of Richmond); Steve Bennett and Mary Bunch (S.C. Department of Natural Resources); and John Jensen (GA Department of Natural Resources).

I was fortunate to meet and befriend many landowners and caretakers that granted me permission to conduct fieldwork on their respective properties. The following individuals extended their gracious hospitality and friendship for which I am grateful: Mr. T. Absher, Mrs. V. Akers, Mr. J. Amburn, Mr. W. Bentley, Biltmore Farms, Inc., Mr. C. Blevins, Mr. H. Bowlin and Mr. D. Bowlin, Mr. A.J. Boyd, Mr. J. Brittain, Mrs. N. Church, Mr. B. Cochran, Mr. C. Cock, Mr. C. Cock, Jr., Crescent Properties, Mr. R.S. Davis, Dehart Memorial Park, Mrs. I. DeJournette, Mrs. H. Dulaney, Mr. L. Edwards, Mr. Ernst, Mr. J.R. Everhart, Mr. B. Faw, Mr. D. Fletcher, Mrs. E. Franklin, Mr. E. Friday, Mr. I. Gambill, Mr. R. Gentry, Mr. A. Goad, Mr. C. Goad, Mrs. Gregson, Mr. F. Gropen, Mr. Harmon, Mr. And Mrs. D. Hartness, Mr. G. Hayes, Mr. D. Hoppers, Mr. E. Johnso, Mr. R. Johnson, Mr. B. Joines, Mr. M. Holden, Mr. R. Mitchell, National Park Service Blue Ridge Parkway, Mahala family, Mr. R. McQueen, Mrs. E. Nichols, N.C. Department of Transportation, N.C. Wildlife Resources Commission, N.C. State Parks, Mrs. L. Quesenberry, Mrs. O. Quesenberry, Rainbow Springs Club, Mrs. Richards, Mr. J. Robertson, Mr. T. Schuyler, Mr. Shelor, Mr. J.D. Smith, Mrs. C.K. Spangler, Mr. N. St. John, Mrs. Sumner, Mr. Suther, R.M. Thompson, TNC North Carolina Chapter, Tennessee Chapter TNC, U.S. Forest Service, Mr. E. Wagner, Mr. J.W. Walters, Mr. R. West, Mr.Westlund, and Mr. Winesett.

As principal investigator, I had the rare opportunity to work with and coordinate the efforts of many outstanding people. I am indebted, not only to the people mentioned previously, but, also, to the following for a wide variety of favors, including field assistance, supplying specimen and site localities, and other pertinent data: Stan L. Alford, Evan Allen, Tristan Allen, Charles Anderson, Doni Angell, Tess Ann, Michael Ayers, Larissa Bailey, Alexis Baker, Ginny Bass, Jeffrey C. Beane, Jean Berry, Joel Beverly, Jim Billings, Jessie Birckhead, Dr. Gary Blank, Beth Bockhoven, Tara Bowers, Charles Bowles, Deena Breener, Dr. Kenneth Bridle, John Brubaker, Jason Bulluck, Justin Bussone, David Campbell, Dr. Theresa Carroll, Shawn Carter, Sandra Cavalieri, John Cecil, Eric Chapell, Bob Cherry, Melissa Christie, Brent Cochran, Susan Wright Cochran, David Cooper, Jeff Corser, Kevin Coyle, Billy Crowell, Dave Davenport, Bob Davis, Tom Davis, Dan Dombrowski, Dr.

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Most of the photographs included herein were taken by the principal investigator. I thank the following people for generously allowing me to use their photographs to fill-in gaps in the pictorial record of the survey: Kenneth M. Fahey, Merrill Lynch, Melissa McGaw, Ann B. Somers, Emily Stanley, Tom J. Thorp, Bern W. Tryon, Wayne Van Devender, and Joe S. Zawadowski. All photographs are copyrighted and cannot be used without the permission of the photographer.

Financial support for this project was provided by a grant from the U.S. Fish & Wildlife Service (Agreement #: 1448-0004-96-9126), and personal resources by many of the participants. An incredible amount of volunteer hours were spent by the many people mentioned above that assisted in field work, and business leave was granted and approved by the Knoxville Zoological Gardens, N.C. Museum of Natural Sciences, and Three Lakes Nature Center and Aquarium.

Endangered and scientific collecting permits were provided by the Georgia Department of Natural Resources, North Carolina Wildlife Resources Commission, S.C. Department of Natural Resources, Tennessee Wildlife Resources Agency, and Virginia Department of Game and Inland Fisheries. Voucher specimens and photographs were deposited in the North Carolina State Museum of Natural Sciences.

Most of all, my warmest thanks go to my wife, Amy, for many years of continued support. Her patience and encouragement kept me sane and gave me the strength it took to see that this project met its goals through these past seven years. She was instrumental in designing the report cover, and assisting on the layout and production of this report, as well as creating and setting up the Project Bog Turtle website.

INTRODUCTION

An ongoing concern over the future of the bog turtle, *Clemmys muhlenbergii* (Schoepff), led to the species inclusion to the U.S. Department of Interior's Endangered Species Act in 1997 (USFWS 1997). The threatened status designated, with the full power of the ESA, is granted only to the turtle's northern population. The southern population's status is "threatened due to similarity of appearance" because the proponents of the turtle's federal protection felt that southern bog turtle populations had not undergone the drastic habitat loss and decline in turtle numbers over the previous 20 year span that had been documented for the northeast. Some of the reasons listed in the 1997 ESA listing were valid, with the overall status of the turtle's southern range being the biggest unknown. There are still gaps in our knowledge of the bog turtle, especially its movements and dispersal patterns. Studies over the past eight years have shed light on these unknowns and have added greatly to our understanding of the secretive and elusive bog turtle's natural history in the Southeast.

Project Bog Turtle, a grass roots conservation initiative of the N.C. Herpetological Society, was founded in November 1995 and combined the principal investigator's (Herman) mountain surveys and studies with the society's N.C. Piedmont surveys (Kemp 1997). The project expanded into the other southern states and began to work closely with state wildlife agencies and biologists in those areas in 1997. Drawing on the society's tax-exempt status, Project Bog Turtle began to solicit donations to support its goals. These goals include: protection of habitat through leases, purchases, or easements; restoration of altered habitats and management of turtle sites; continued surveys to locate new populations; continued monitoring and study of population dynamics in selected sites; landowner involvement, cooperation, and education; and consultation with, and dissemination of information to, federal and state agencies. Project Bog Turtle maintains the largest bog turtle database in the Southeast with information on nearly 250 occurrence records and sites in Georgia, North Carolina, South Carolina, Tennessee, and Virginia. In addition to surveys, Project Bog Turtle biologists and associates have been actively involved with restoration and management projects, conservation lease agreements with private landowners, a permanent identification transponder implantation project (Project PIT-tag), radio telemetry studies, a medical screening program for wild and captive bog turtles, consultation and wetland surveys for DOT mitigation projects, and assisting with a microsatellite DNA study.

Several major studies in recent years on the relationship of the *Clemmys* turtle group has resulted in nomenclature changes to the bog turtle's scientific name. Ernst (2001) presented an overview of the North American turtle genus *Clemmys* Ritgen and suggested that relationships within the group are confusing and controversial. Holman and Fritz (2001) proposed the placement of the wood turtle (*Clemmys insculpta*) and bog turtle (*C. muhlenbergii*) in the genus *Glyptemys* Agassiz based on earlier studies by McDowell (1964) and new molecular data studies of Burke et al. (1996), Bickham et al. (1996), and Lenke et al. (1999). In a similar, and separate, study Feldman and Parham (2002) moved the wood turtle and the bog turtle into the genus *Calemys* Agassiz based on the studies and conclusions that led Holman and Fritz (2001) to make a nomenclature change. After 40 years of stability using the genus *Clemmys* confusion now reigns. Some turtle biologists commented about the nomenclature change, among them Harding (2002) who suggested that the bog turtle should be recognized as *Glyptemys muhlenbergii* based on the fact Holman and Fritz (2001) were the first to publish their name change. Harding's suggestion was supported by Parham and Feldman (2002) who

remarked that the bog turtle's appropriate, valid name should be *Glyptemys muhlenbergii* based on priority. Additional studies on the hemoglobin variation of the North American turtle family Emydidae by Siedel (2002) supported the above name changes for both the wood turtle and bog turtle.

I have opted to continue to use *Clemmys muhlenbergii* as the scientific name for the bog turtle for this report to avoid any confusion. The following report presents an updated overview of the status and natural history of the bog turtle in the Southeast, along with the results of the surveys conducted by Project Bog Turtle and associates from 1996 through 2002 in Georgia, North Carolina, South Carolina, Tennessee, and Virginia.

"Nobody made a greater mistake than
He who did nothing because he could do only a little".

Edmund Burke

SECTION ONE: DESCRIPTION

Bog turtles are characterized by their small size, dark coloration, and large yellow to orange patches on each side of the head. Carapace lengths of bog turtles average 75-95 mm (3-3¾ in), with a maximum recorded carapace length of 114 mm (4½ in) (Conant and Collins 1998).

The brightly colored blotch located behind the eye on each side of the head is the chief identifying character of the bog turtle. Blotch color can vary from yellow, yellow-orange, orange, to orange-red from population to population. Turtles with yellow or orange blotches may be found within the same population and in some localities the blotches may be only yellow or orange (Somers et al. 2000).

The upper shell (carapace) is usually very dark, from mahogany-brown to black. This dark coloration may be contrasted with lighter whitish to yellowish rays of color in the individual scutes. The lower shell (plastron) is usually black with varying amounts of creamy white patches. The soft body parts, ie. neck, limbs, and tail, are generally dark brown or black, with or without streaks of red or orange (Herman 1997). The top of the head is speckled with black in a vermiform pattern. The lower jaw is often suffused with red or orange spots. The upper jaw is notched. There is usually a mid-dorsal keel or ridge along the top of the carapace. Pronounced growth rings may be present on the carapace giving the turtle a sculpted appearance, especially in juveniles and sub-adults. Older turtles usually possess smooth, worn shells, usually without any evidence of mid-dorsal keels, due to years of burrowing in mucky soils.

Females of most chelonians have a greater sexual size dimorphism (SSD) than males (Gibbons and Lovich 1990), but bog turtles and other *Clemmys* are an exception. Male bog turtles have a greater SSD than females and variations are observed region to region (Lovich et al. 1998). In the Southeast (PBT database) males average 89 to 102 mm (3½ to 4 in) in carapace length, while females are slightly smaller with an average of 76 to 89 mm (3 to 3½ in). Females have greater carapace width to length ratios and shell heights than males. Other aspects of sexual dimorphism are very evident in bog turtles. Males usually have larger, more robust heads, and often display flared rear marginals and a streamlined appearance from above; females appear more circular. The plastron is concave in males and flat in females. The long, thick tail of the male has the cloacal opening extending beyond the plastron edge, which is in strict contrast to the females' short tails and cloacal opening inside the plastron edge.

SECTION TWO: HISTORY, STATUS, AND DISTRIBUTION

The bog turtle, *Clemmys muhlenbergii* (Schoepff), is an uncommon and secretive member of the turtle family Emydidae that is restricted to open herbaceous wetland ecosystems along riparian corridors. This species occurs in 12 northeastern, mid-Atlantic, and southeastern states, but a 400 km gap between central Maryland and southwestern Virginia separates the bog turtle's range into "northern" and "southern" populations (Figure 2.1). The "northern" population occurs in Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Delaware, and Maryland while the "southern" population is found in Virginia, North Carolina, Tennessee, South Carolina, and Georgia (Iverson 1992; Ernst et al. 1994). *C. muhlenbergii* was initially discovered in "Pennsylvaniae" in the late 18th Century by Gotthilf Heinrich Ernst Mühlenberg (Schoepff 1801). The type locality was restricted to Lancaster County by Stejneger and Barbour (1917).

The bog turtle's range in the Southeast is very spotty and discontinuous with occurrences scattered along the Blue Ridge intermontane plateau and adjacent Piedmont from southwestern Virginia to northeastern Georgia (Herman 1981). The majority of occurrence records (81%) is located in the Blue Ridge Mountain province. These elusive turtles occupy small relict bogs and fens from 216 m (710 ft) elevation (Forsyth Co., NC) in the upper Piedmont up to 1373 m (4500 ft) (Ashe Co., NC) in the mountains (Herman and Pharr 1986). Sixty-five percent of the occurrence records (158 of 244) are located between 610-914 m (2000-3000 ft) elevation (Table 2.1).

Bog turtle occurrence records have been reported from both the Ohio-Mississippi River and Atlantic Ocean drainages (Figure 2.2). Of note is the fact that bog turtles are known almost exclusively from streams that have their origins on the Blue Ridge Escarpment. The only exceptions are two records that originate in the South Mountains in North Carolina, and both of these streams (First Broad River and South Muddy Creek) are part of the Broad River and Catawba River basins, respectively, that do have origins on the escarpment.

The turtle records in Georgia are found along tributaries of the Nottley River and Oconee River in the greater Hiawassee-Tennessee River system. North Carolina turtles are known from tributaries in both the Atlantic Ocean and Mississippi River drainages. The Atlantic drainage includes records in the Broad River, Catawba River, Dan-Roanoke River, Savannah River, and Yadkin-Pee Dee River systems. The North Carolina records in the Mississippi River drainage occur in the French Broad River, Hiawassee River, Little Tennessee River, and Watauga River basins in the greater Tennessee River system, and the New River basin in the Ohio River system. The Saluda River system contains all of the known turtle records in South Carolina. Tennessee turtles are found in one tributary of the South Holston River basin that is part of the Tennessee River system. The majority of bog turtle records in Virginia are found along tributaries of the New River, while a few records have been reported from the Yadkin-Pee Dee River system and the Dan River and Smith River basins in the Roanoke River system.

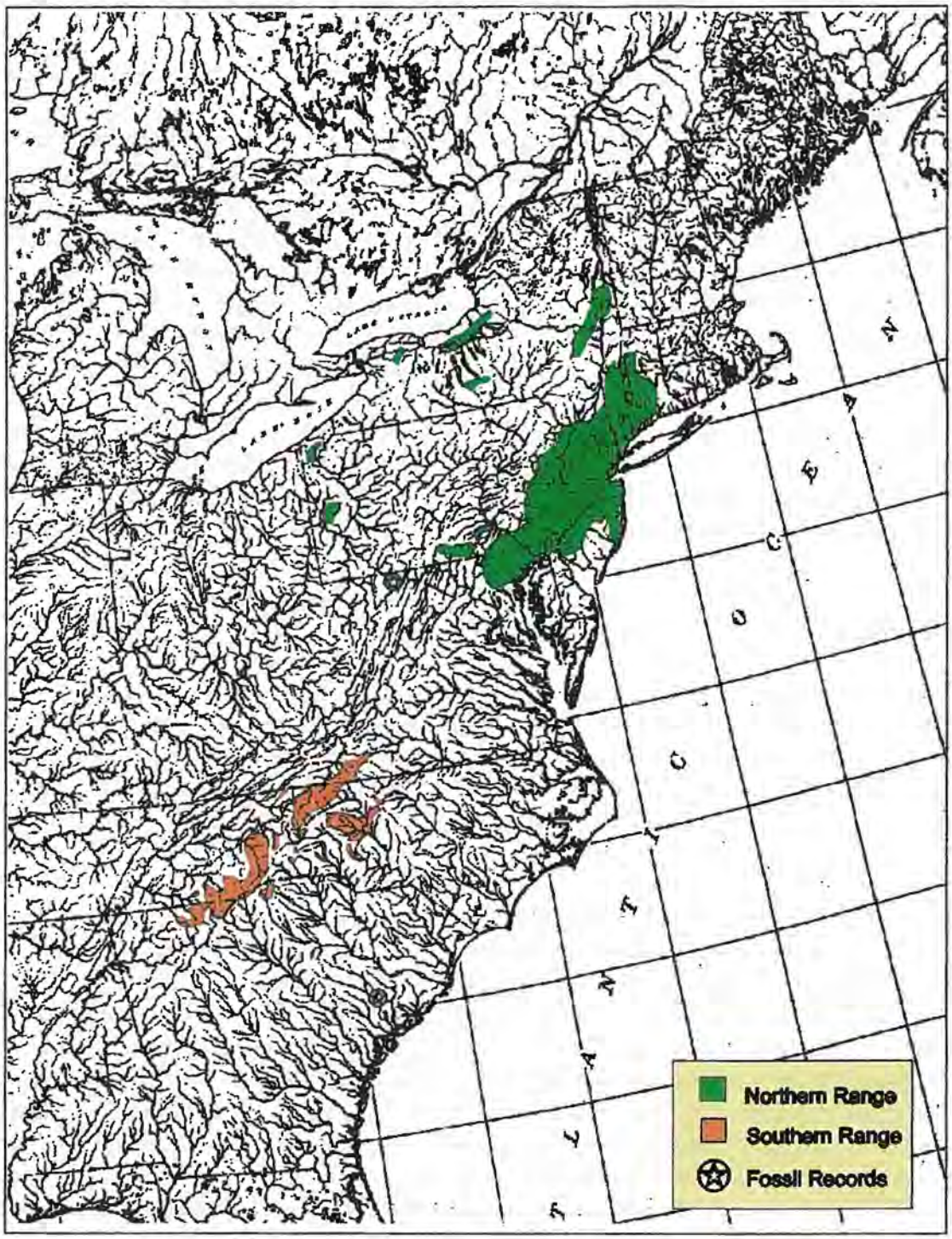

Figure 2.1. Range of *Clemmys muhlenbergii* in the United States. Note the 400 km gap between the southern and northern populations. Maryland fossil record from Holman (1977), and the South Carolina fossil from Bentley and Knight (1998).

ELEVATION (feet)	GEORGIA s (or)	NORTH CAROLINA s (or)	SOUTH CAROLINA s (or)	TENNESSEE s (or)	VIRGINIA s (or)	ELEVATION Totals s (or)
700-799		6 (9)				6 (9)
800-899		0 (1)				0 (1)
900-999		0 (0)	1 (2)			1 (2)
1000-1099		4 (5)	1 (2)			5 (7)
1100-1199		1 (1)				1 (1)
1200-1299		2 (3)				2 (3)
1300-1399		7 (9)				7 (9)
1400-1499		6 (6)			1 (1)	7 (7)
1500-1599		1 (2)			0 (1)	1 (3)
1600-1699		1 (1)			0 (0)	1 (1)
1700-1799	1 (1)	1 (1)			0 (0)	2 (2)
1800-1899		0 (0)			1 (1)	1 (1)
1900-1999		1 (1)			0 (0)	1 (1)
2000-2099	2 (2)	4 (7)			1 (1)	7 (10)
2100-2199	1 (1)	6 (7)			0 (0)	7 (8)
2200-2299		3 (4)			0 (0)	3 (4)
2300-2399	1 (1)	1 (2)			7 (7)	9 (10)
2400-2499		1 (2)			12 (12)	13 (14)
2500-2599	1 (1)	3 (4)			20 (23)	24 (28)
2600-2699		9 (11)			7 (9)	16 (20)
2700-2799		5 (9)		3 (3)	5 (10)	13 (22)
2800-2899	1 (1)	5 (10)			11 (16)	17 (27)
2900-2999		11 (12)			3 (4)	14 (16)
3000-3099		4 (6)			2 (3)	6 (9)
3100-3199		1 (1)			0 (0)	1 (1)
3200-3299		4 (5)			0 (0)	4 (5)
3300-3399		2 (2)			0 (2)	2 (4)
3400-3499		6 (7)				6 (7)
3500-3599	1 (1)	2 (5)				3 (6)
3600-3699		0 (1)				0 (1)
3700-3799		1 (2)				1 (2)
3800-3899		1 (1)				1 (1)
3900-3999		0 (0)				0 (0)
4000-4099		0 (0)				0 (0)
4100-4199		0 (0)				0 (0)
4200-4299		1 (2)				1 (2)
4300-4399		0 (0)				0 (0)
4400-4499		0 (0)				0 (0)
4500+		1 (1)				1 (1)
Total	**8 (8)**	**101 (140)**	**2 (4)***	**3 (3)**	**70 (89)***	**184 (244)***

Table 2.1 Elevations of Individual Bog Turtle Sites and Occurrence Records in the Southeast. (**s** = individual site & **or** = occurrence record) *Does not include 2 South Carolina and 1 Virginia literature records.

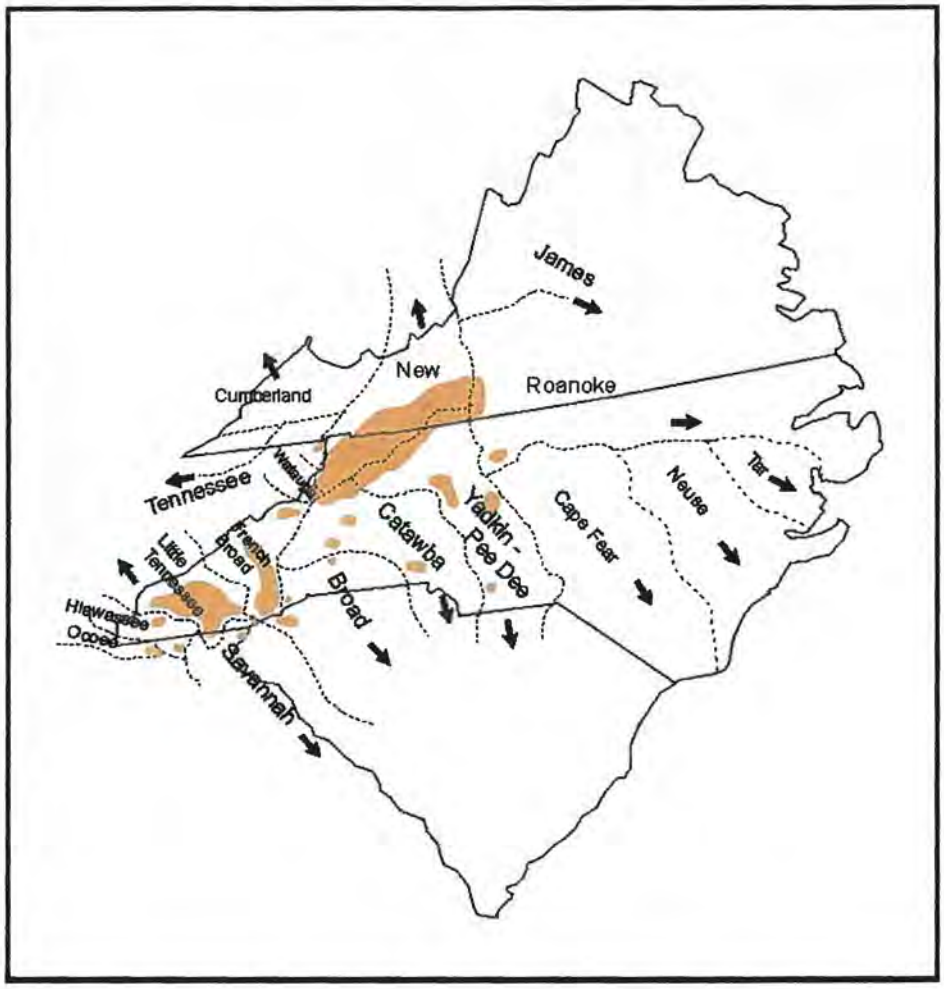

Figure 2.2. Bog turtle's southern population and associated river basins. The majority of the populations occur in the New River basin.

2.1 Georgia

Bog turtles had been known from counties north of the Georgia state line since 1968. Surveys in potential habitat for *C. muhlenbergii* from 1976-1978 were unsuccessful until the species was discovered in Union County in 1979 (Hale and Harris 1980), one hundred years after its discovery in neighboring North Carolina. Herman and Putnam (1983) reported the first Rabun County specimens when turtles were captured in two wetlands in 1980. Fahey (1999) reported bog turtles from a site in Towns County in 1992. Additional Union County sites were discovered in 1992, 1994, and 1996, respectively, and a new Rabun County record was discovered in 1996 (Fahey 1999). The 1992 turtle site discovered in Union County represents the southern and western-most record for the species range-wide (Fahey 1999). A reported record from Stephens County has not been verified, although the wetland appeared to be suitable habitat and similar to those found in neighboring South Carolina turtle sites during a visit by this investigator.

Figure 2.3. Bog turtle's range in Georgia.

Georgia bog turtle sites occur in the southern Blue Ridge Mountains and one unvouchered record lies off the escarpment in the upper Piedmont (Fahey 1998). Documented turtle sites range from 543-1079 m (1780-3540 ft) elevation.

The largest male and female bog turtles measured by Fahey (1998) and Herman (Project Bog Turtle database) had maximum carapace lengths of 106.6 mm (4.2 in) and 97.4 mm (3.8 in), respectively. The maximum body masses for the heaviest male and female turtles were 144 g (5.1 oz) and 148 g (5.3 oz), respectively. Two Union county populations are considered to be viable while the single Towns County population may be potentially viable with habitat management. There are 12 ha (30 ac) of core habitat estimated in Georgia. The total bog turtle population density is estimated between 450-600 turtles based on an approximate average of 37-50 turtles per hectare (15-20 per ac) of excellent core habitat (Herman and Tryon 1997). At least 90% of occupied bog turtle habitat occurs on privately owned land. Most of the habitat under private ownership is nonprotected, but 8.1 ha (20 ac) of the largest Union County site is under a conservation lease agreement with Project Bog Turtle and protected through 2005. Considered Georgia's rarest turtle species (Wilson 1991), the bog turtle was afforded "threatened" status in October 1992 (Lenz 1992-1993).

2.2 North Carolina

The first bog turtles ever reported from the Southeast happened to be discovered in North Carolina in 1879 (Yarrow 1882) when three specimens were sent to the U.S. National Museum from

Iredell County by A.L. Barringer (Brown 1992). E.R. Dunn (1917) discovered specimens in Avery and Transylvania counties in 1916. C.S. Brimley (1922) reported a bog turtle taken in Clay County around 1907, and Breder and Breder (1923) captured two specimens in Ashe Co. in 1922 during a fish, reptile, and amphibian survey of the region. An unpublished record from Buncombe Co. collected in 1933 by I.E. Gray is in the U.S. National Museum (NCSM files; USNM 91696). Brimley (1943) did not include Buncombe Co. in his bog turtle account when he summarized its North Carolina distribution, but he did include the previously mentioned counties. Bog turtles were collected along a swampy creek in Forsyth County in 1964 (NCSM 3174-75; NCSM files). From 1968 to the present bog turtle records were reported with more frequency and over a greater area. K.T. Nemuras (1974; NCSM files) captured the first bog turtles known from Macon, Alleghany, and Watauga counties during his surveys from 1968-1973. R.T. Zappalorti reported turtles from several Henderson County colonies in 1975 and 1976 (Zappalorti and Johnson 1981). A Wilkes County specimen was captured crossing a road in 1977 and sent to the N.C. Museum of Natural History (NCSM 19835; NCSM files), although the first officially reported Wilkes County turtle was found by Herman and Weakley (1986) in the Brushy Mountains. D. W. Herman (1986b) reported on the first bog turtles from Alexander and Yancey counties that he found in 1985. A male bog turtle was collected crossing a road in Cherokee County in 1988 by the late Joseph Bauman (Herman and Beane 1997). A.S. Williams captured a six year old female turtle crossing a road in Gaston County in May 1991 and a large population was discovered a short distance from the Williams' record in April 1992 (Herman et. al. 1992). Two empty shells were found in a Surry County wetland in April 1993 (Beane 1993; Beane et. al. 1993) and a female bog turtle was captured crossing a road in McDowell County in May 1993 by R.E. Weaver, Jr. (Herman et. al. 1993). A very large adult female was captured by Elizabeth Hunter in Mitchell County as it crossed a road in June 1996 (Herman et al. 1996). An adult female, with three eggs, was found dead in a large Graham County wetland during a mitigation/restoration site monitoring study in 1996 (Herman and Beane 1997). The most recent county record was discovered in Burke County when an adult male turtle was found dead in a large wetland complex in October 2002 (Herman et al. 2003).

Bruce (1977) and Palmer and Braswell (1995) stated that bog turtles have been recorded in the northern and southern mountains (Blue Ridge Province) and in the western and west central Piedmont in North Carolina. Occurrence records range from 216 m (710 ft) in the Piedmont to 1373 m (4500 ft) elevation in the Blue Ridge Province (Herman and Pharr 1986).

The maximum carapace lengths for male and female turtles as reported by Palmer and Braswell (1995) were 107 mm (4.21 in) and 102 mm (4.0 in), respectively. The largest male and female bog turtles measured during our survey were 109.0 mm (4.3 in) and 105.9 mm (4.17 in), respectively. Maximum body masses for the heaviest male and female were 165 g (5.9 oz) and 188 g (6.7 oz), respectively.

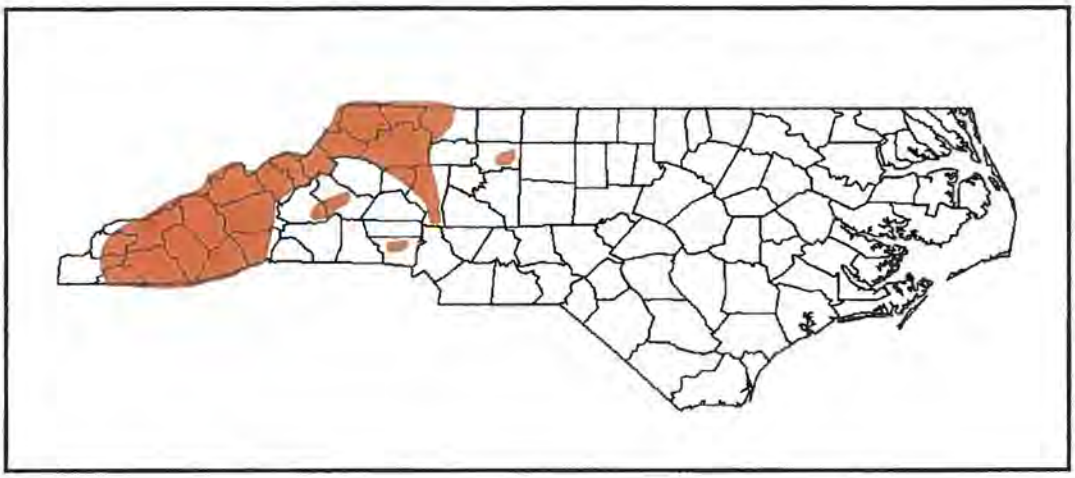

Figure 2.4. Bog turtle's range in North Carolina.

North Carolina contains the majority (57%) of the bog turtle records in the Southeast. There are 140 occurrence records from 21 counties currently known from North Carolina. Less than 1000 total specimens have been found or reported to date. Tryon (1990) estimated the total North Carolina population density between 1500-2000 turtles. Only 30 populations or metapopulations are considered viable or potentially viable covering an estimated 40.5 ha (100 ac) or less of core habitat with an estimated population density of 1400-2000 turtles based on our present knowledge. Only 22% of the occupied bog turtle habitat is federally owned (U.S. Forest Service and U.S. National Park Service Blue Ridge Parkway), 58% is under private ownership, and the remaining 20% is state owned (N.C. Wildlife Commission and N.C. Department of Transportation) or owned by the N.C. Nature Conservancy. Project Bog Turtle currently holds conservation lease agreements on seven privately owned sites, totaling nearly 16.2 ha (40 ac). The bog turtle was upgraded from "species of special concern" to "threatened" in 1990.

2.3 South Carolina

South Carolina's first bog turtles were discovered in two Greenville County wetlands in 1980, but only one of the sites was reported by Herman and Putnam (1983). A large male turtle was captured crossing a road in Pickens County during early morning in June 1991 (Batson 1991). Fontenot and Platt (1995) failed to find turtles during their status survey in 1992-1993, but reported that an individual reportedly found three turtles, independently of their survey, in several Pickens County wetlands that they searched. An additional Pickens County specimen was found dead on a road in July 2001 and reported to this investigator by Steven Poterala (pers. comm.). This specimen was deposited in the Clemson University vertebrate collection (Steve Bennett, pers. comm.). Fontenot and Platt (1995) listed six occurrence records from two counties after their 1992-1993 survey. The bog turtle is currently known from seven occurrence records in two counties, with the addition of the latest Pickens County turtle (Project Bog Turtle database).

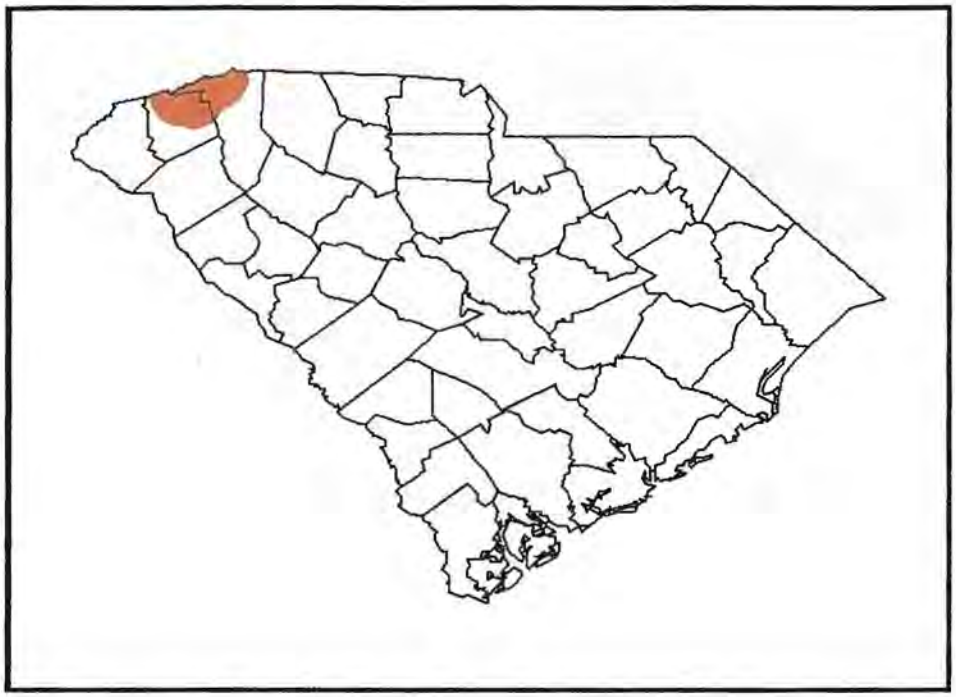

Figure 2.5. Bog turtle's range in South Carolina.

Bog turtle occurrence records are currently known from the base of the escarpment in the Blue Ridge Province and adjacent Piedmont. The occurrence records range from 290-331 m (950-1085 ft) elevation.

Fontenot and Platt (1995) reported that maximum carapace lengths of male and female turtles measured during their study were 104.7 mm (4.12 in) and 100.9 mm (3.97 in), respectively and maximum body masses of the heaviest male and female were 140 g (5.0 oz) and 147 g (5.25 oz), respectively.

Only one population may be viable with less that 4.5 ha (10 ac) of core habitat estimated. The state's entire population density is estimated at 165-225 turtles. Surveys to date indicate that this estimate is inaccurate. Most of the occupied bog turtle habitat in South Carolina is suboptimal or marginal at best (Tryon 1990; Herman and Tryon 1997). All of the currently known sites are privately owned and, therefore, unprotected. South Carolina lists the bog turtle as a "threatened" species.

2.4 Tennessee

Tennessee's first bog turtle was discovered in Johnson County in May 1986 (Herman and Warner 1986). Two days after this initial discovery three turtles were found in another Johnson County wetland nearly 4023 m (2.5 mi) north by Tryon (1988). An exhaustive search in a large Carter County wetland in June 1986 by D.W. Herman and B.W. Tryon failed to find bog turtles,

although the habitat was ideal (Tryon 1988). This site was selected for an experimental release study using head-started turtles from a captive propagation program at the Knoxville Zoological Gardens, with the first turtles released in 1991 (Tryon 1999). A third Johnson County site was located in 2002 while tracking a male turtle during a radio-telemetry study (B.W. Tryon, Tennessee Bog Turtle Project).

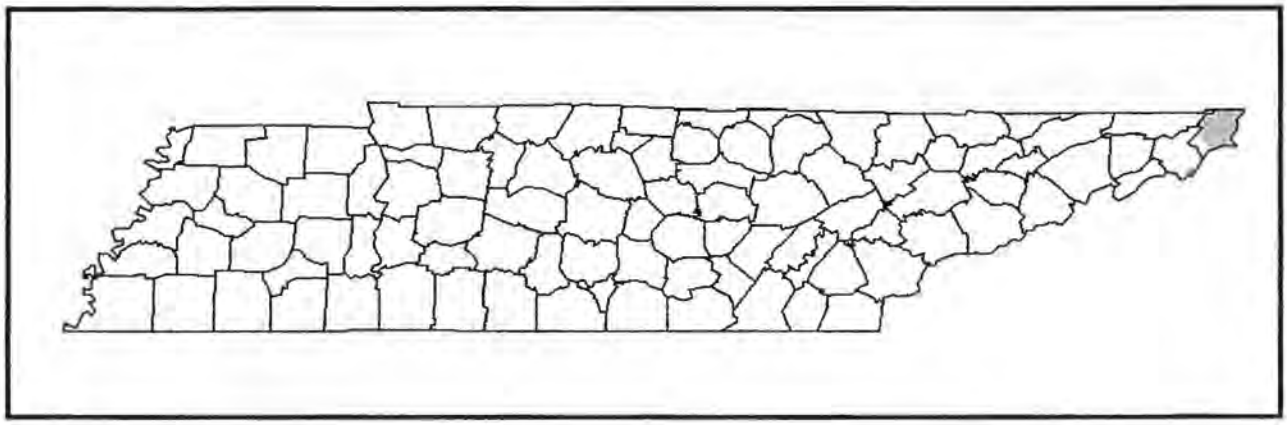

Figure 2.6. Bog turtle's range in Tennessee.

The bog turtle is currently known from only three occurrence records in one county, and the established population at the Carter County release site. Additional sites may be located in counties along the Tennessee and North Carolina border (Tryon 1988). All of the occurrence records are located in the Blue Ridge Province of eastern Tennessee. Occurrence records range from 847-1082 m (2780-3550 ft) elevation, including the release site in Carter County.

The three Tennessee sites are included in a greater metapopulation and are considered viable. The available area known to be used by turtles exceeds 28.3 ha (70 ac) with at least 6.1 ha (15 ac) of total core habitat. The population density of Tennessee turtles is estimated to exceed 100 turtles.

The Tennessee Nature Conservancy owns one of the Johnson County sites and a large portion of a second site, while the newest site is under private ownership. Tennessee upgraded the bog turtle from "in need of management" to "threatened" status in 1991.

2.5 Virginia

Virginia's first bog turtle record was reported by Hutchison (1963) after a turtle was found crossing the Blue Ridge Parkway in Floyd County in 1957. There is an unreported record from 1961, also found on the Parkway, in Carroll County (Virginia Natural Heritage Program database #010). Bog turtles were initially found in Grayson County in 1973 by K.T. Nemuras (1974) and in

Patrick County crossing the Parkway during the late 1970s and early 1980s by district ranger Randall Kendrick (Mitchell and Buhlmann 1991). Additional records from these four counties were discovered during subsequent surveys in 1971-1973 (Nemuras 1974b), 1982-1986 (J.L. Warner, pers. comm.), 1987 (D.W. Herman, PBT database), 1990 (B.W. Tryon, pers. comm.), 1987-1990 (Mitchell and Buhlmann 1991), 1992 (K.A. Buhlmann 1992), 1996-1997 (S. Carter 1997, pers. comm.), 1996-2000 (T. Davis, pers. comm.), and 2002 (S. Roble 2002), and during our survey from 1998-2002 (this report). Mitchell (1989) commented on the erroneous historical record from Fairfax County and Tobey (1985) listed an unvouchered record from Montgomery County.

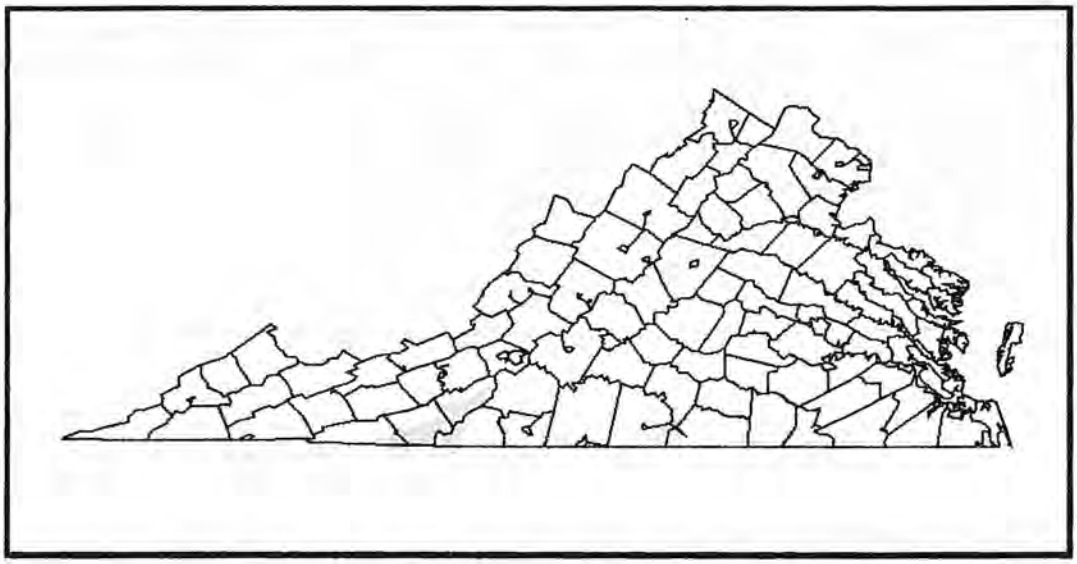

Figure 2.7. Bog turtle's range in Virginia.

Bog turtle records are scattered along the Blue Ridge Intermontane Plateau (Mitchell 1994) and just below the escarpment in the Blue Ridge Province and upper Piedmont (Herman, this report). Occurrence records range from 427 m (1400 ft) elevation in Patrick County to 1024 m (3360 ft) elevation in Floyd County.

Mitchell (1994) reported the maximum known carapace length for Virginia *C. muhlenbergii* at 102 mm (4.0 in) and the maximum body mass at 132 g (4.7 oz). The largest male and female bog turtles measured during our survey had maximum carapace lengths of 105.2 mm (4.14 in) and 102.9 mm (4.05 in), respectively. The maximum body masses of the heaviest male and female were 173 g (6.12 oz) and 186 g (6.64 oz), respectively.

Currently there are at least 90 occurrence records known from 4 counties in Virginia (PBT database). At least 15-20 populations or metapopulations may be viable in Virginia, and only one metapopulation has been studied somewhat extensively (Carter 1997). An estimated 32.4 ha (80 ac) of core habitat support a total estimated population density of 1100-1500 turtles based on current survey results. At least 75% of the occupied bog turtle habitat is privately owned, while the remainder is federally owned (U.S. National Park Service Blue Ridge Parkway). The bog turtle was afforded "endangered" status in Virginia in August 1987 (Hoffman 1987).

Dennis W. Herman

Fig. 2.8. Male bog turtle: Union County, Georgia.

Kenneth M. Fahev

Fig. 2.9. Male bog turtle: Towns County, Georgia.

R.W. Van Devender

Fig. 2.10. Female bog turtle: Watauga County, North Carolina.

Dennis W. Herman

Fig. 2.11. Female bog turtle: Buncombe County, North Carolina.

Dennis W. Herman

Fig. 2.12. Male bog turtle: Pickens County, South Carolina.

Dennis W. Herman

Fig. 2.13. Juvenile bog turtle: Greenville County, South Carolina.

Bern W. Tryon

Fig. 2.14. Male bog turtle: Johnson County, Tennessee.

Dennis W. Herman

Fig. 2.15. Male bog turtle: Floyd County, Virginia.

SECTION THREE: BOG TURTLE HABITAT DYNAMICS

Herman and Tryon (1997) referred to the bog turtle's habitat preference as spring-fed, palustrine wetlands that are organically rich but nutrient poor. Southern populations seem to occupy natural communities with a diverse flora or communities slightly altered by land use, natural succession, hydrology shifts, or climatic reasons, ie. drought. Viable populations are dependent upon unfragmented riparian systems that permit the natural creation of bogs, fens, marshes, and wet meadows that offset natural succession (Herman and Tryon 1997). Very few southern bog turtle populations are considered pristine wetland ecosystems because of habitat fragmentation and habitat continuity loss along riparian corridors due to natural succession, and/or the disappearance of the agents that created or maintained suitable habitats.

The U.S. Natural Resources Conservation Service (NRCS) is continually updating soil maps, particularly in mountain counties where they are outdated or nonexistent. Soil types in the Southeast that are associated with bog turtle wetlands consist of alluvial silt loams that are poorly drained. These soil types include, but are not limited to: Hatboro, Nikwasi, Toxaway, and Wehadkee soils in the mountains and Cecil, Chewacla, Codorus, Colfax, Nikwasi, and Wehadkee in the Piedmont (Herman and Tryon 1997).

Close inspection of the mucky soils in many bog turtle habitats reveal the presence of mica, quartz sand, and iron oxide. Some sites have so much bog iron that the turtles usually display a rusty appearance to the shell or evidence of pitting caused by layers of iron oxide (Herman 1989). The iron is associated with small masses of gelatinous material and the water surface usually appears to have a rainbow-hued oil slick. Crerar et al. (1979) analyzed bog iron in the New Jersey Pine Barrens wetlands and found that locales of bog iron precipitation all shared in common one factor, the presence of Fe-oxidizing bacteria, which are capable of providing the necessary catalyst for bog iron formation. Known Fe-oxidizing bacteria which had been positively identified in southern New Jersey included *Thiobacillus ferroxidans*, *Leptothrix ochracea*, *Crenothus polyspora*, *Siderocapsa geminata*, and *Melallogenium* sp. These iron-fixing bacteria, and others, may be identified in southern wetlands during future research.

The following natural communities that support bog turtles have been classified by Schafale and Weakley (1990) as: Southern Appalachian Fen, Southern Appalachian Bog (northern and southern subtypes), Swamp Forest-Bog Complex (southern and typic subtypes), and Hillside Seepage Bog. There has been some confusion over exactly what to call bog turtle habitats. Are they really bogs or fens? In the Southeast, bog turtle wetlands are technically fens because they are spring-fed. Fens are very similar to bogs, but they are generally wetter, and they receive nutrients from the surrounding ground water. Today, many scientists generally restrict the term "bog" to rain-fed (ombiotrophic) and very poorly-fed (oligotrophic) peatlands and call the mineral nourished, spring-fed (minerotrophic) and less oligotrophic peatlands "fens" (Johnson 1985). Peat mosses (*Sphagnum* sp.) are usually quite commonplace in many of the more pristine wetlands that bog turtles inhabit. Fens are probably the most common type of *Sphagnum*-dominated wetland in North America and are characterized by a wide range in pH, from just above 4 to 7 (McQueen 1990). McQueen (1990) stated that three broad classes of fens are recognized: poor, medium, and rich fens. McQueen further remarked that "poor fens" have a flora similar to bogs and a pH range about 4 to

5, "medium fens" have a higher nutrient level than the poor fen with the pH ranging from 5 to 6.5, and "rich fens" are dominated by sedges (*Carex* sp.) rather than peat moss, receive a large influx of minerals from the surrounding ground water, and have a pH ranging from 6 to 8. Schafale and Weakley (1990) referred to Southern Appalachian Bogs in the Southeast as "poor fens", but they are called bogs to conform to common usage and to suggest their strongly acid, *Sphagnum*-dominated vegetation.

In the southern part of the turtle's range many of the altered natural communities are referred to as "meadow bogs", which are identical to the "wet meadow" as described by Kiviat (1978). Meadow bogs (= wet meadows) are either used for grazing or are in the vicinity of pastures, and turtle densities are likely to be higher there than in more pristine communities that have a shrub canopy (Herman 1999; Somers et al. 2000).

It has already been mentioned that many southern bog turtle habitats are dominated with, or support peat moss (*Sphagnum* sp.) development. In fact, many of the mountain wetlands have flora and fauna more closely allied to northern or "boreal" peatlands. In most cases these northern disjuncts make up some of the rarest floristic components in southern wetlands. Some plant species may be found in a majority of bog turtle habitats (Herman and George 1986), but many are found spottily because of elevation, hydrology, nutrient levels, or habitat alteration. A great diversity of invertebrates, amphibians, reptiles, birds, and mammals can be found in these habitats. The meadow vole (*Microtus pennsylvanicus*) is, not only a common habitat resident, but one that provides beneficial services to bog turtles as a food source (newborn and weanling voles) and creator of tunnels that bog turtles use to move through the dense vegetation (personal observations). Additional common and rare animal species have been reported in southern bog turtle sites, including the federally endangered St. Francis' satyr butterfly, *Neonympha mitchellii francisci*, (Roble et al. 2001). A list including both common and rare plant and animal species associated with southern bog turtle sites may be found in Appendix A.

Kiviat (1978) discussed, in great detail, habitat development, formation, and maintenance. Gaddy (1981) suggested that paludification may have created and maintained the Nantahala River bogs in Macon County, North Carolina, as well as others in southwestern North Carolina. Paludification is the creation of a peatland by drowning or submerging upland, and local paludification may result from altered drainage from beaver damming or tree fall (Johnson 1985). Strong evidence exists that paludification is a prime mechanism for peatland development. The developmental pathways vary with geographical location, water quality, climate, and climate change, topography, and now man's influence as well (Johnson 1985). Schafale and Weakley (1990) mentioned that flooding by beaver, grazing, fire, and clearing by Indians may have been agents that created and maintained mountain bogs and fens. The main factors in the creation and management of turtle habitats were probably beaver activity and herbivore retardation of tall plant growth prior to European colonization. The shallow wetlands created by beaver are dynamic and may rapidly undergo vegetational changes on a time order of a decade (Kiviat 1978). Nearly extirpated from the southern mountains by trappers and hunters, the beaver has re-occupied many valleys in its former range. What effects they will have on existing turtle sites remains to be seen. Short-term flooding of bog turtle sites by beaver has been observed in several southern turtle sites. In fact, beaver activity today may have deleterious effects to established turtle populations because

the natural mosaic is missing and dispersal is limited (Herman 1994).

There appears to be a special relationship between bog turtles and large herbivorous grazers and browsers, and bison and elk were responsible for keeping wet meadows open in pre Colonial times (Lee and Norden 1994). Cattle, horses, goats, sheep, whitetail deer, and other native mammals have replaced the bison and elk that once roamed the eastern United States. A bone fragment that was tentatively identified as bison bone was found in a core sample from a pristine North Carolina wetland during a search for rare plants in 1999 (Patrick D. McMillan, pers. comm.). Additional sampling in southern peatlands may reveal further evidence of bison existence. Herman (1999) concluded that 96% of southern turtle sites, with turtle densities greater than 20 individuals, were located in currently grazed or recently grazed sites. Somers et al. (2000) discussed the benefits of grazing on bog turtle habitat based on Herman's (1999) observations and made recommendations for the seasonal use of cattle, goats, and horses in maintaining bog turtle habitat. Additional studies were conducted in New Jersey on the effects of grazing in bog turtle sites and the beneficial results observed (Ehrenfeld 2001; Tesauro 2001).

Herman (1989) and Schafale and Weakley (1990) suggested that fire may have been an agent that kept mountain wetlands open and free from invasive trees and shrubs, although no evidence was available to support the authors' opinions. Evidence, however, that fire is beneficial, and in fact necessary, to maintain the rich plant diversity in coastal peatlands and savannas has been known for decades. Many of the mountain wetlands in the southeastern United States have many similarities to coastal bogs and pocosins, and to prairie fens and sedge meadows in the upper Midwest region (Lee and Norden 1994). Kost and De Steven (2000) described plant community responses to prescribed burning in Wisconsin sedge meadows and found that prescribed fire can be used to maintain and enhance sedge meadows' plant diversity. Small bands of charcoal were discovered in soil core samples from a pristine wetland in Alleghany County, North Carolina during a rare plant survey in 1999 (P.D. McMillan, pers. comm.). This site contained a large section of pitch pine (*Pinus rigida*), a serotinous species that depends on fire for successful germination and growth. Additional mountain wetlands may yield evidence of periodic burning through the discovery of charcoal bands in core samples. Beaver activity and the effects of grazers, browsers, or fire are important in preventing canopy closure which is probably the most critical limiting habitat factor for the bog turtle (Nemuras and Weaver 1974).

Many southern peatlands are thought to be remnants of the last Pleistocene Epoch glaciation (Wisconsinan). Ages of mountain bogs have been estimated to be up to 10,000 years old and correspond to the end of the Wisconsin glaciation. The Flat Laurel Gap Bog, a high elevation (ca. 1524 m [5000 ft]) peatland, in Haywood County, North Carolina had a thermoluminescence analysis date of 7400± 100 Y.B.P. by Shafer (1988). Plants of the heath family (Eriaceae) have dominated the vegetation in the Flat Laurel Gap Bog for at least the last 3000 years (Shafer 1986).

Klemens (1993) designed the Standardized Bog Turtle Site-Quality Analysis based on northern bog turtle populations. He described the metapopulation concept, wherein, individual bog turtle sites occur along streams, are usually separated by less than 1.6 km (1.0 mi) from each other, and turtles can move freely between sites along stream corridors without impediments to travel. Fragmentation of the metapopulation can occur when streams are impounded and individual sites

are divided by highway construction. Many of the southern bog turtle populations known today are very isolated from each other due to high mountain ridges, and natural succession has taken its toll on many individual sites. There are, however, some very good metapopulations that still exist in the turtle's southern range. Many of these occur in Virginia and northwestern North Carolina where the topography is flatter, but a few exist further to the southwest along the Blue Ridge Mountains and upper Piedmont.

The typical southern metapopulation (Figure 3.1) consists of individual turtle sites and potential wetland patches on the slopes and terraces of headwater streams. Turtles may move between these habitat patches along the stream corridor or they may move overland and cross ridges into adjacent valleys. Because the turtles are able to move without many impediments the metapopulation will usually include more than one valley and drainage. The atypical southern metapopulation (Figure 3.2) is similar to the typical metapopulation. The main difference in the two is that turtle movement occurs on and off the Blue Ridge Escarpment between sites in the Blue Ridge intermontane plateau and the escarpment base. Turtles, and gene flow, enter both the Ohio-Mississippi River and Atlantic drainages when these escarpment movements occur.

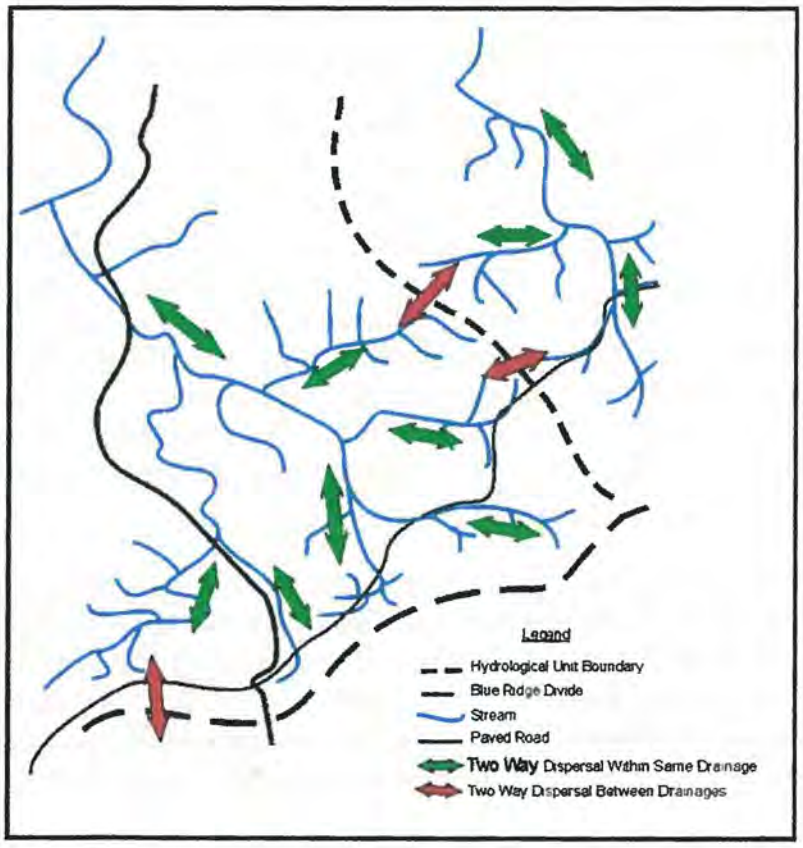

Figure 3.1. A typical southern bog turtle metapopulation. (Based on an actual metapopulation and dispersal patterns in Floyd Co., VA).

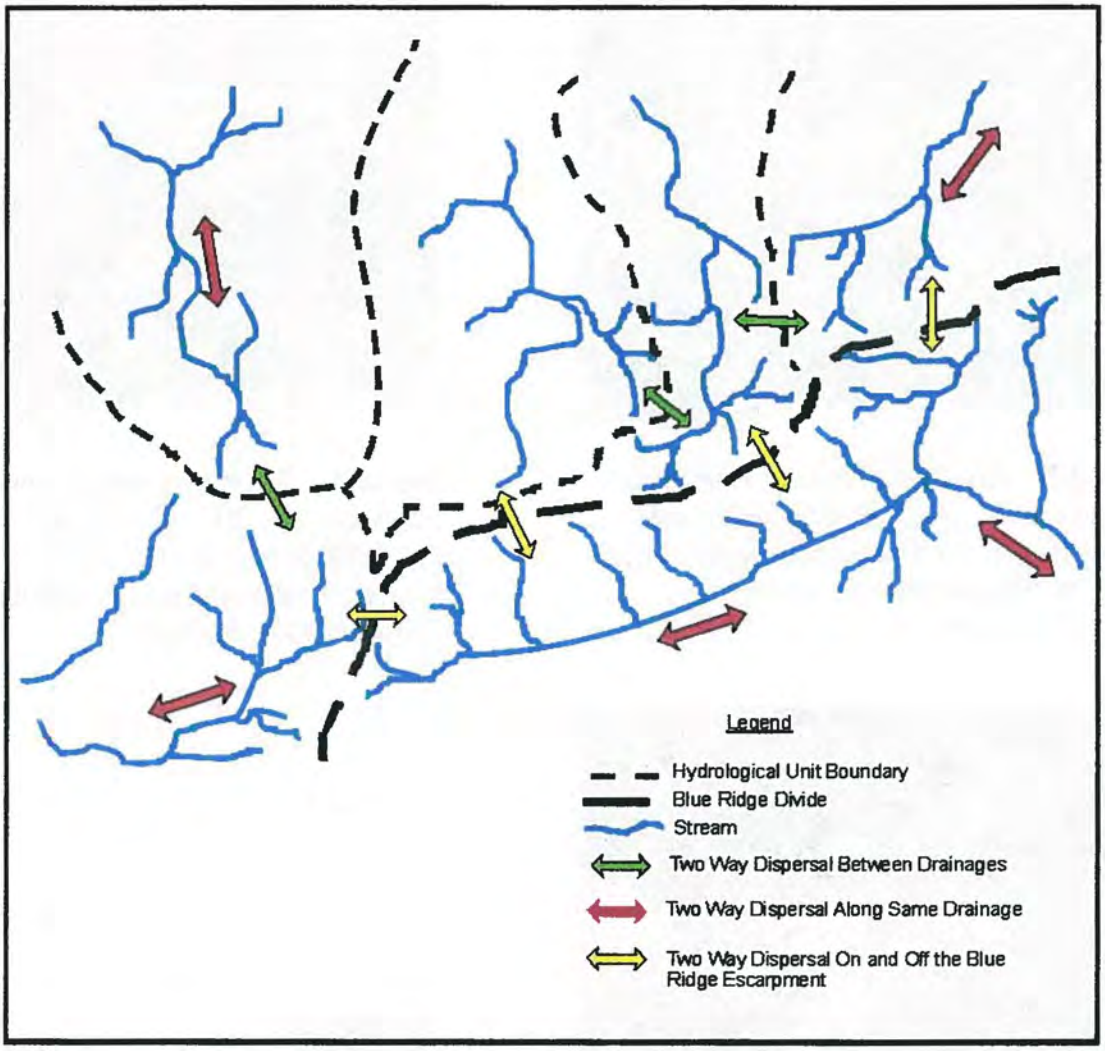

Figure 3.2. An atypical southern bog turtle metapopulation. Note the dispersal within the same drainage, between different hydrological units, and off and on the Blue Ridge Escarpment. (Based on an actual metapopulation in Floyd and Patrick counties, VA).

Dennis W. Herman

Fig. 3.3. Southern Appalachian Bog: Watauga Co., NC. Sedge and peat moss dominate this habitat type, which also harbors many rare plant and animal species.

Dennis W. Herman

Fig. 3.4. Southern Appalachian Bog: Johnson Co., TN. This site is just a remnant of the 10,000 acres of wetlands that were drained in the 1960s by the Soil Conservation Service.

Merrill Lynch

Fig. 3.5. Southern Appalachian Fen: Ashe Co., NC. Many rare plant species are found in these nutrient rich wetlands.

Kenneth M. Fahey

Fig. 3.6. Meadow Bog: Union Co., GA. Bog turtle populations inhabit more of this habitat type than any other in the Southeast.

Dennis W. Herman

Fig. 3.7. Meadow Bog: Alleghany Co., NC. The open sedge community of this habitat is preferred by bog turtles.

Dennis W. Herman

Fig. 3.8. Meadow Bog: Patrick Co., VA. Old ditches and livestock grazing are commonplace in many of these sites.

Common and Rare Plants Found in Southern Bog Turtle Habitats

Dennis W. Herman

Fig. 3.9. Mountain sweet pitcher plant, *Sarracenia jonesii*: Henderson Co., NC. A federally endangered species found only in North and South Carolina.

Dennis W. Herman

Fig. 3.10. Swamp pink, *Helonias bullata*, from Ashe Co., NC. This beautiful federally threatened species occurs rarely in the Southeast.

Dennis W. Herman

Fig. 3.11. Peat moss, *Sphagnum recurvum*, in Henderson Co., NC. Rare forms of peat moss are found in wetlands that have pH levels from slightly acidic to nearly neutral.

Dennis W. Herman

Fig. 3.12. Wicky or sheep kill, *Kalmia carolina*, in Alleghany Co., NC. This uncommon relative of the mountain laurel can be found in coastal pocosins and mountain bogs.

Dennis W. Herman

Fig. 3.13. Crested shield fern, *Dryopteris cristata,* in Alleghany Co., NC. This fern is a good indicator species for bog turtle habitat.

Dennis W. Herman

Fig. 3.14. Canada burnet, *Sanguisorba canadensis*, in Ashe Co., NC. This plant thrives in nutrient rich wetlands.

Dennis W. Herman

Fig. 3.15. Cranberry, *Vaccinium macrocarpon*, in Johnson Co., TN. There are less than 30 acres remaining of the 10,000 acres of cranberry bogs that once flourished in this Tennessee valley.

Dennis W. Herman

Fig. 3.16. Robin-run-away, *Dalibarda repens*, in Alleghany Co., NC. This rare plant is known from only 3 counties in North Carolina.

Dennis W. Herman

Fig. 3.17. Tawny cottongrass, *Eriophorum virginicum*, in Johnson Co., TN. This northern disjunct is found in several southern mountain bogs.

Dennis W. Herman

Fig. 3.18. Poison sumac, *Toxicodendron vernix*, in Johnson Co., TN. This shrub is often found in coastal pocosins, as well as mountain bogs.

SECTION FOUR: MATERIALS AND METHODS

4.1 Study Area

Intensive preparation is a must before a survey of this magnitude can commence. Project Bog Turtle associates and advisors met periodically to prioritize areas to begin the survey. Various maps were used to locate potential areas to investigate, including U.S. Geological Survey 7.5' topographic maps, U.S. Natural Resources Conservation Service (formerly U.S. Soil Conservation Service) soil survey maps, state county maps, and aerial surveys. Museum records, literature records, state natural heritage inventories, reports, and databases, and personal contacts with landowners, district wildlife enforcement officers and park rangers, state district wildlife/fisheries biologists, and local county agents were all helpful in locating bog turtle sites. The extensive database maintained by Project Bog Turtle proved very useful in providing which stream basins and hydrological units needed additional work and in which to concentrate search efforts. Rare plant surveys were useful in identifying potential sites based on indicator species. And, most importantly, potential sites were located by simply driving secondary roads in the mountains and foothills looking for indicator plant species that would point us in the right direction.

Potential bog turtle sites were search for in 49 counties in Georgia, North Carolina, South Carolina, Tennessee, and Virginia (Figure 4.1). These counties include:

Georgia:	Rabun, Towns, and Union
North Carolina:	Alexander, Alleghany, Ashe, Avery, Buncombe, Burke, Cabarrus, Caldwell, Catawba, Cherokee, Clay, Davidson, Davie, Forsyth, Gaston, Graham, Haywood, Henderson, Iredell, Jackson, Lincoln, Macon, Madison, McDowell, Mitchell, Polk, Rutherford, Stokes, Surry, Swain, Transylvania, Watauga, Wilkes, Yadkin, and, Yancey
South Carolina:	Greenville, Oconee, and Pickens
Tennessee:	Carter and Johnson
Virginia:	Carroll, Floyd, Franklin, Grayson, Montgomery, Patrick, Roanoke, and Washington

4.2 Habitat Assessment Methods

Project Bog Turtle used two methods to assess wetland habitats searched during the survey. One of the methods was the Standardized Bog Turtle Site-Quality Analysis (Klemens 1993), which is referred to as the Population Analysis Site (PAS). This method was used to compare bog turtle sites with others range wide, but because it was designed mostly for bog turtle populations in the Northeast, it did not work well with the southern populations, and needed modification. We (PBT) used our own method to assess potential bog turtle sites. This method was dependent on evaluating existing habitat components, such as hydrology, soil moisture, presence or absence of grazing, duration of grazing, amount of canopy cover, amount of open sunny, sedge or bulrush dominated areas, site size, former impacts (ditching/draining attempts), and proximal threats. See Somers et al. (2000) for a detailed description of this assessment method.

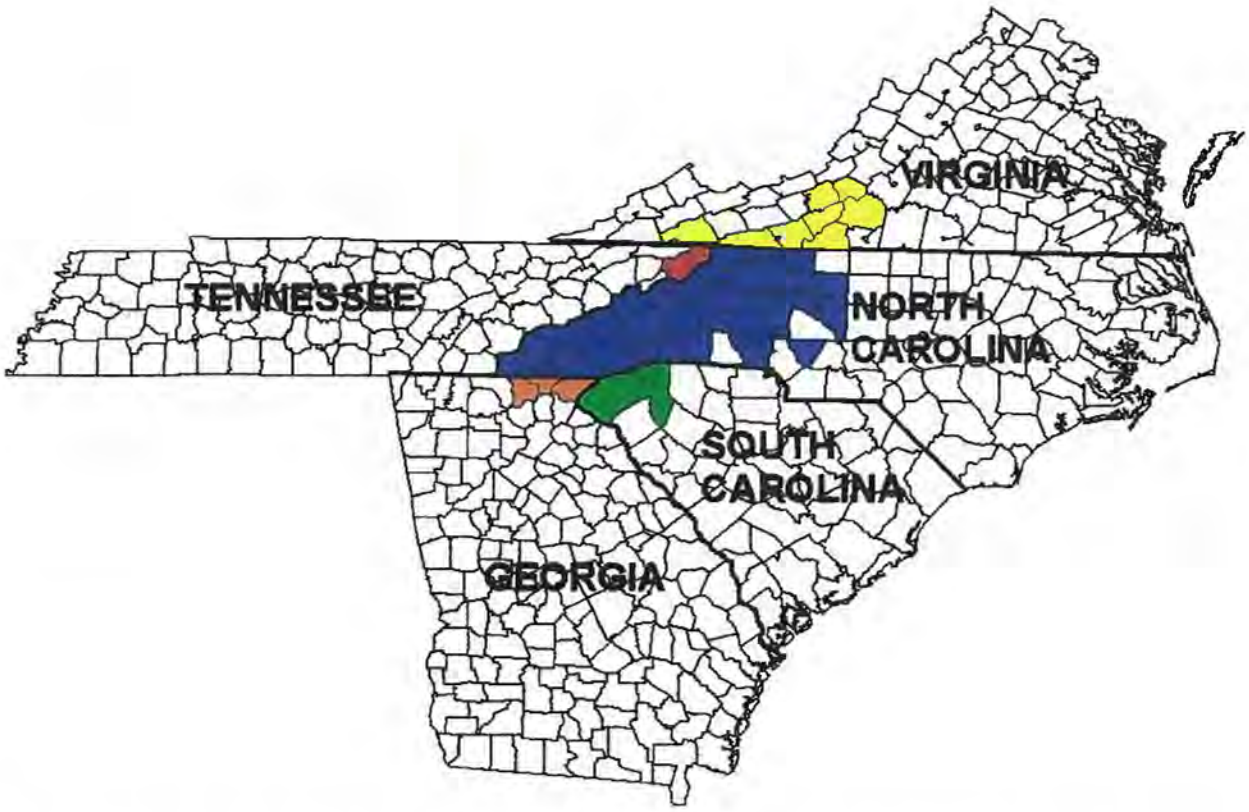

Figure 4.1. Southeastern counties searched during the status survey, 1996 – 2002.

4.3 Bog Turtle Search Methods

When potential habitat was found the real work began trying to find bog turtles. Random visual searches were conducted by walking through a wetland and carefully looking for active or inactive turtles. Active turtles were observed walking or running along a mucky rivulet or through rodent tunnels and trails, digging into the mud, foraging for food, and while eating, mating, or fighting. Inactive turtles were found as they basked in shallow, muddy water, or on top of sedge tussocks or mossy mounds, and as they rested in or under vegetation or other cover. Long wooden sticks (broom handles or hiking sticks) were used to move sedges, rushes, and other vegetation aside and to probe into muddy pockets and holes at the base of tussocks of vegetation or shrubs in search of hidden turtles (Beane 2001). Probing into holes and under vegetation by hand was another technique used to locate turtles (Lynch 1998). Physical signs of bog turtles were determined by observing turtle footprints in the mud or oval tunnels and trails in dense ground cover, nests with eggs, hatched egg shells, dead turtle remains, such as shells, bones, and other parts, and road killed specimens (Ernst et al. 1994; Herman 1994).

Wire traps were used, in conjunction with the above search methods, in several sites to determine population density and to aid in locating turtles in potential sites in the searcher's absence. These traps were a modified version of those developed and used by Fahey (1992, 1998) and

constructed of 6.35 mm (¼ in) hardware cloth or 2.54 cm X 2.54 cm (1 in X 1 in) welded wire. The traps had openings at both ends that measured approximately 89-102 mm (3.5- 4 in) square, were 305-610 mm (12-24 in) long, and free falling trapdoors attached to the inside of each open end. Other versions were slightly larger, 127-152 mm (5-6 in) square, and had folding extensions or "wings" that could be unfolded to form a funnel-like trap to guide turtles into the trap. The traps were placed in muddy runs, especially those where tracks had been observed, or nestled into rodent tunnels under cascading sedges. Trapping of sites mostly followed the "20-20 Rule" developed by Somers (2000) and is based on her long-term study at a Surry County, North Carolina site. At least 20 traps/ha (2.47 ac) of habitat were used to saturate the prime areas of a site for 20 days. Traps were covered to shade any captured turtles and checked a minimum of every 24 hours. Somers' study found that a minimum of 9,000 trap hours were required per site if the site was less than one hectare in size to capture one turtle in a known population of ten turtles at her study site. Only one trapped turtle is needed to confirm a bog turtle site. Traps were removed after one capture unless a population assessment involving long-term data collection is required. A full description of the guidelines for trapping surveys and the "20-20 Rule" can be found in Somers et al. (2000).

4.4 Bog Turtle Collection Data

Turtles captured during the survey were assigned identification numbers and were marked by filing notches in the marginal scutes. The notching code system used was similar to that of Cagle (1939), Ernst et al. (1974), and Mitchell and Buhlmann (1991), or a modification of those systems. Each turtle was weighed and measurements of the carapace, plastron, nuchal (cervical) scute, and shell height were taken and recorded in a field notebook. The turtles were closely examined and the shell condition, shell anomalies, or injuries (fresh or healed) were noted and recorded, along with a drawing indicating their location on the carapace or plastron. Age of each turtle was determined or estimated by counting the growth annuli on the right abdominal scute and other plastral or carapacial scutes, if necessary. Turtles with smooth shells with few or no growth annuli were recorded as 20+ years old based on observations of shell wear during long-term mark-recapture studies conducted in several sites. The locality, date, and time of capture were recorded, along with any observed behaviors or activity. Other data recorded included landowner information, hydrologic units, elevation, and other pertinent data. Older adult turtles recaptured during repeat visits to several sites were only weighed if the recapture was a short time period from the turtle's last capture. Recaptured juveniles were weighed and measured to determine any significant growth. The turtles were released at their point of capture after all of the data were recorded. Dead turtles or egg shells were deposited in the North Carolina Museum of Natural Sciences as vouchers.

Dennis W. Herman

Fig. 4.2. Carapace length was one of measurements taken using calipers.

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Fig. 4.3. Sticks were often used to probe around sedge clumps or in muddy holes to locate bog turtles. However, visual search remained the primary method.

SECTION FIVE: RESULTS

This status survey not only included searches for new bog turtle sites, but repeat visits to known populations in an effort to determine population densities using mark-and-recapture techniques, as well. The majority of this survey was conducted in North Carolina and Virginia and the results reflect this, but the results also include additional data from the field work conducted by Dr. Kenneth M. Fahey (Georgia) and Bern W. Tryon (Tennessee). The results reported, herein, are as complete as possible and include the following: the number of sites searched, number of counties in the Southeast searched, the number of sites in which turtles were found, number of individual turtles, number of recaptured turtles (previously marked), total turtle captures (new and recaptures), new turtle sites found or were reported to this investigator from other sources, number of search days, number of search hours (manhours), turtles per unit effort (turtles/search hour), trapping data, and mileage logged.

Approximately 231 individual sites were searched in 42 counties in Georgia, North Carolina, South Carolina, Tennessee, and Virginia. Bog turtles were captured in 79 individual sites (34% of sites searched) in 21 counties (50% of counties searched). New bog turtle occurrence records totaled 65, of which 50 were individual sites. Project Bog Turtle was responsible for 37 records while an additional 28 were reported to us from various sources. A total of 1054 bog turtle captures were recorded during the survey; 506 individual turtles (48%) and 548 previously marked turtles (52%) were captured. Sixty-three (63) additional turtles were reported to Project Bog Turtle from Georgia, North Carolina, South Carolina, Tennessee, and Virginia.

Fieldwork consumed 704 search days using a total of 7146 search hours. Trapping data results include 322,248 trap hours (number of traps X number of days X 24 hours). Approximately 172,355 miles were driven during the survey looking for new sites or travelling to previously known sites to conduct population studies.

Capture/unit effort ratios were 3.7 turtle captures/day and .26 turtle captures/search hour. These totals include only North Carolina and Virginia survey data. The results for the individual southern states surveyed from 1996 through 2002 are as follows.

5.1 Georgia

The results in Georgia were taken from Fahey (1998) and include 1996 data only. Subsequent years' data were not forwarded to the principal investigator for inclusion into this report. Six individual sites were searched in 2 counties (Rabun and Union). Six individual bog turtles were captured in five of the sites in the two counties above. Twenty-six (26) days were spent searching the six sites or checking turtle traps using 80 search hours. This results in a capture/unit effort of .23 turtle captures/day and .075 turtle captures/search hour. Trapping data include 3 turtles trapped during 9360 trap hours (26 days) with trapping ratios of 3120 trap hours/turtle captured and .12 turtles trapped/day. A total of 2477 miles were logged in 1996.

Two new sites were discovered in 1996; one in Rabun County and one in Union County. The new Rabun County record was located on a tributary of the Savannah River drainage; the first

record for this drainage in Georgia (Fahey 1999), although several bog turtle records are known from this drainage in neighboring North Carolina (Project Bog Turtle database). The bog turtle is currently known from 8 sites in 3 counties in Georgia with the addition of these new records.

5.2 North Carolina

The majority of the survey was conducted in North Carolina with some very good results. Approximately 158 individual sites were searched in 31 counties (Alleghany, Ashe, Avery, Buncombe, Burke, Cabarrus, Catawba, Cherokee, Clay, Davie, Forsyth, Gaston, Graham, Haywood, Henderson, Iredell, Jackson, Lincoln, Macon, McDowell, Mitchell, Polk, Rutherford, Stokes, Surry, Swain, Transylvania, Watauga, Wilkes, Yadkin, and Yancey). A total of 376 individual turtles (127.203.46 = 127 males, 203 females, 46 unsexed) were captured in 13 counties (Alleghany, Ashe, Avery, Buncombe, Burke, Forsyth, Gaston, Henderson, Macon, Surry, Watauga, Wilkes, and Yancey) from 45 individual sites. There were 485 previously marked turtles captured (187.293.5) during the survey for a total of 861 turtle captures (314.496.51). Field searches were conducted over 241 days with a total of 3329 search hours logged. The captures/unit effort ratios were 3.6 turtle captures/day and .26 turtles/search hour. Trapping data include a total of 237,384 trap hours (264 days) with 21 turtles trapped with ratios of 11,304 hours/turtle capture and .000088 turtle captures/trap hour. A total of 81,883 miles were traveled searching for new sites and visiting previously known sites for population studies.

Thirty-six (36) new bog turtle sites or occurrence records were found in 10 counties (Alleghany, Ashe, Buncombe, Burke, Graham, Henderson, Macon, Mitchell, Watauga, and Wilkes). Three new county records were found or reported during the survey: Burke (Herman et al. 2003), Graham (Herman and Beane 1997), and Mitchell (Herman et al. 1996). An additional 14 turtles were reported to Project Bog Turtle from 14 sites in North Carolina. Six of these turtles were found on the road. Bog turtle tracks were observed at a new Macon County site in 1999. The bog turtle is currently recorded from 140 sites or occurrence records in 21 counties in North Carolina with the addition of these new records.

5.3 South Carolina

Project Bog Turtle did not conduct surveys in South Carolina from 1996 through 2002. One new bog turtle record was reported to the principal investigator after a bog turtle was found crushed on a road in Pickens County in 2001 by Steven Poterala (pers. comm.). The dead turtle was retrieved for the Clemson University research collection and the area was searched in an attempt to identify a wetland that the turtle may have originated from shortly after the turtle's discovery (Steve Bennett, pers. comm.). The bog turtle is currently known from 4 sites in two counties in South Carolina with the addition of this new record.

5.4 Tennessee

Bern W. Tryon (Knoxville Zoological Gardens) kindly furnished the following data for this report from his long-term Tennessee bog turtle project. Project Bog Turtle associates assisted Mr. Tryon on several occasions with his work in Tennessee in 1997, 1999, and 2002. The following

data include Tryon's radio telemetry study, mark-and-recapture study, and trapping efforts in three study and one experimental release site study area from 1996 through 2002.

At least 400 search days were used looking for new sites, tracking turtles, checking traps, or conducting mark-and-recapture studies in 4 sites in two counties (Carter and Johnson) for a total of 2971 search hours by Mr. Tryon and his associates. This total does not include an additional 351 office hours spent pouring over maps, drawing maps, filling out data sheets, and writing reports during the project for 2001 and 2002. Trapping data include a total of 75,504 trap hours (283 days) recorded for 2001 and 2002 with 56 turtle captures in the experimental study site in Carter County. Trapping ratios were 1348.3 hours/turtle capture and .00074 turtle captures/trap hour.

One new site was discovered in Johnson County; the first new Tennessee bog turtle record since 1986. This site was discovered after a turtle, fitted with a transmitter, from one of the original study sites was tracked into the site. The bog turtle is currently known to occur naturally from 3 sites in Johnson County. Additional records include the observation of a radio-tracked turtle that moved overland from its home base site in Johnson County, crossing a 1128 m (3700 ft) elevation ridge into Sullivan County during 2002, and the Carter County site used for an experimental release study that began in 1991 by Tryon (pers. comm.).

5.5 Virginia

Project Bog Turtle conducted surveys during 1998-2000, and made limited visits in 2001-2002 in Virginia. Approximately 63 sites were field searched in 7 counties (Carroll, Grayson, Floyd, Franklin, Montgomery, Patrick, and Roanoke). A total of 130 individual turtles (54.63.13 = 54 males, 63 females, 13 unsexed) were captured in 4 counties (Carroll, Grayson, Floyd, and Patrick) from 25 individual sites. We recorded 63 recaptures (19.27.17) during the survey for a total of 193 turtle captures (73.90.30). Field searches were conducted over 42 search days during 758 search hours. The captures/unit search effort ratios were 4.6 turtle captures/day and .25 turtle captures/search hour. We did not conduct any trapping for turtles during the survey in Virginia. A total of 24,706 miles were traveled searching for new sites and visiting previously known sites for population studies.

Twenty-five (25) new sites or occurrence records were found or reported in 4 counties (Carroll, Grayson, Floyd, and Patrick). An additional 29 turtles (3.18.18) were reported to Project Bog Turtle during the survey incorporating 12 new occurrence records or sites. Two turtles were discovered on roads; one dead and one alive. Several of the new sites reported were the result of surveys preceded by or that over-lapped our survey efforts by Blue Ridge Parkway personnel, Virginia Game and Inland Fisheries staff, and Virginia Natural Heritage Program staff. No new county records were discovered in Virginia, but one of the new Patrick County sites was located east of the Blue Ridge Escarpment at an elevation of 427 m (1400 ft). This is the lowest elevation record currently known in Virginia and opens up the possibility of more new sites below the escarpment and in the upper Piedmont province. One new Floyd County site is estimated to be at least 20 hectares (50 acres) in size making it the largest known turtle site, area-wise, in the Southeast. The bog turtle is curretly recorded from at least 90 individual sites or occurrence records in 4 counties in Virginia.

SECTION SIX: BOG TURTLE POPULATION DYNAMICS

As long-term life history studies are continued on bog turtle populations in the Southeast, a better understanding of the species' spatial biology (immigration and emigration rates), seasonal activities, reproductive biology, demography, and population trends (including natality and mortality rates), will be gained. Presently, most of these traits are poorly understood.

6.1 Spatial Biology

The bog turtle's migratory movements take them into forested uplands, distant ridges, lowland valleys, across various sized streams, across roads, and cultivated areas. This we surmise from the number of turtles that have been observed wandering across roads, walking through forests, and in various sized rocky streams great distances from the nearest suitable wetland. The summer and early fall movements sometimes are surprising long, bringing turtles into areas where their occurrence is unexpected. Carter et al. (2000) reported that 10% of their radio-tracked turtles had movements greater than 200 m between wetlands during the course of their study in Virginia. They also reported that one male turtle moved 2700 m (1.7 mi) out of the study site and then moved 375 m into a white pine plantation after its release back into the study site. Other studies have reported maximum movements of 750 m (Eckler et al. 1990) and 225 m (Ernst 1977) respectively. Prior to, and during the course of this survey, several examples of long distance movement were observed and recorded in North Carolina, as well as other southern states.

A. North Carolina

1. Herman (1994) reported that a bog turtle found dead on the Blue Ridge Parkway (Alleghany County) at an elevation of 1128 m (3700 ft) was at least 1600 m (1.0 mi) from the nearest known turtle habitat.

2. A 13 year old female turtle was found in a rhododendron thicket adjacent to a small stream in Wilkes County in 2000. This turtle was tracked for two months in which she moved up and down stream for distances up to 100 m per day. The turtle moved over 800 m (0.5 mi) downstream from the initial capture point before the radio signal was lost. The turtle was observed using the second order stream during most tracking episodes, was photographed basking on a rock in the middle of the stream on one occasion, and left the stream during periods of heavy rain (> 2.54 cm).

3. Another Wilkes County female that was marked (turtle #6) in a small site in August 1997 was discovered in another site in July 2002. The turtle's original site was in the process of being ditched with a backhoe when she, along with five other adults, were found. The six turtles were marked and released into a small wetland 1440 m (0.9 mi) downstream. We have no idea which route #6 used to disperse into the site where she was found in 2002. If she followed streams as a dispersal route, the estimated distance she moved was approximately 2400 m (1.5 mi). Assuming that she moved upstream 1440 m to her original site and then crossed the ridge at around 518 m (1700 ft) elevation to get to the 2002 site she would have moved at least 2640 m (1.65 miles). See Figure 6.1 for the possible dispersal routes taken by this turtle.

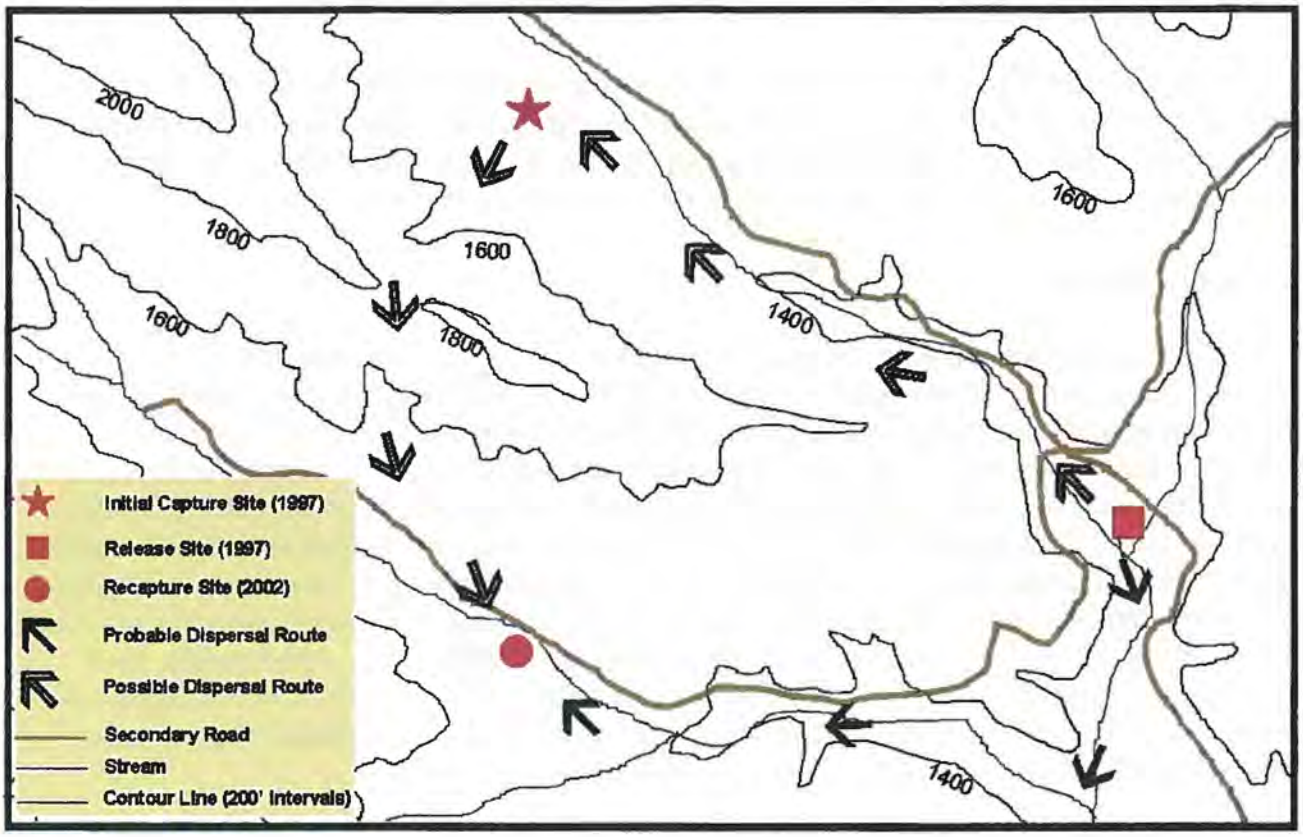


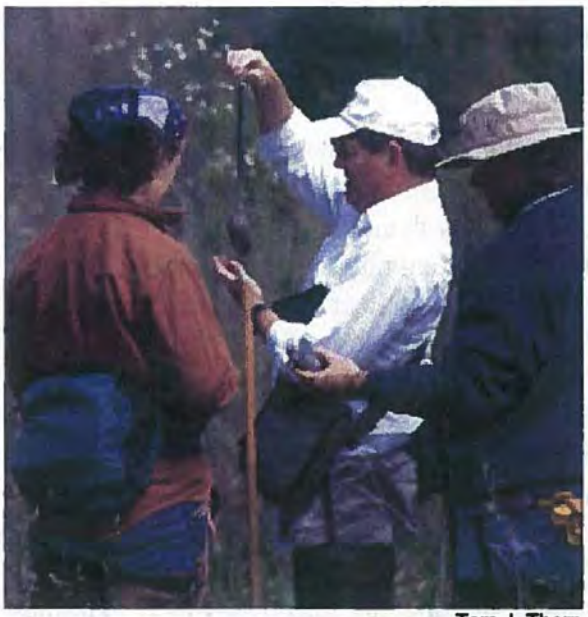
Figure 6.1. Possible dispersal routes taken by a Wilkes Co., NC female bog turtle (#6) between 1997 (marked and released) and 2002 (recaptured).

4. Emily Stanley (2002) reported tracking turtles at distances >400 m (0.25 mi) from her main study site in Yancey County, NC. These turtles were observed moving through a forest dominated by Canadian hemlock (*Tsuga canadensis*) and rosebay (*Rhododendron maxima*) and using small rocky streams and springheads during her study. She also observed non-transmittered turtles using the same streams.

B. Tennessee

1. Bern Tryon (TWRA reports, 1986-1998) reported that a male bog turtle moved from 3600 m to 4000 m (2.25 - 2.50 mi) between his two study sites in a four year time span, depending on which route the turtle followed (stream or overland).

2. At least 50% of the radio tracked turtles in Tryon's Tennessee study (2001-2002) were observed moving distances >800 m (0.5 mi) away from the hibernacula "home bases" into restored wetlands, ditches, and other small seepage slope habitat. One 8 year old female departed the study site and moved through a forested upland over a 1128 m (3700 ft) ridge, crossed the Appalachian Trail, and was observed on several occasions in small rocky streams in steep sided, rocky ravines



Tom J. Thorp

Fig. 5.1. The principal investigator checking the body mass of a bog turtle at its point of capture in Alleghany Co., NC.

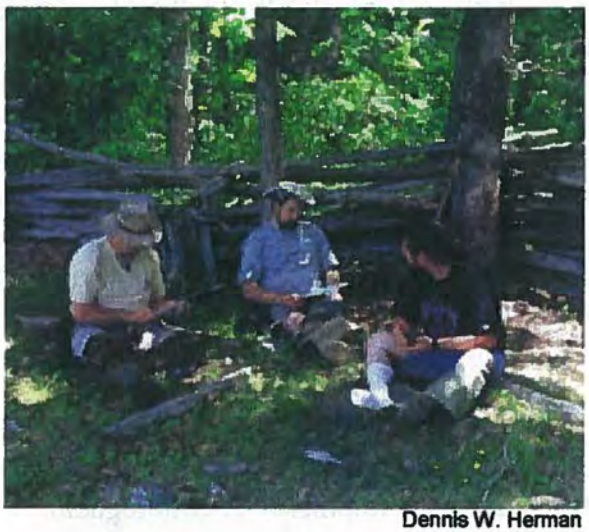


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Fig. 5.2. Project Bog Turtle field associates using teamwork to process turtles efficiently at a Patrick Co., VA site.

over a one month period. The turtle was estimated to have moved greater than 4000 m (2.5 mi) straight-line distance and greater than 4800 m (3.0 mi) along the turtle's actual route.

The movements observed during our studies compare favorably with those of Carter et al. (2000), but some of the movements were for greater distances. Lovich et al. (1992) found that males moved greater distances per day than females in one Henderson County, North Carolina study site. The males exhibited a median rate of movement of 2.1 m/day and females 1.1 m/day during the study. Tryon's observations indicated that both sexes moved equally during the summer months returning to their respective hibernacula in early fall. These observations parallel those of Carter et al. (2000). Large scale movements may occur more frequently than that suggested by Carter et al. (2000) because tracking studies are usually short (2 years on average). Long-term radio tracking studies may reveal that bog turtles move more frequently than previously thought. The bog turtle may have a need to move between wetland patches to maintain genetic viability in the populations. It has been suggested that the continued loss of wetlands throughout the turtle's range may increase the probability of population extinction, particularly if a species is unable to move between more and more isolated wetland patches (Gibbs 1993; Thomas 1994; Semlitsch and Bodie 1998; Carter et al. 2000). Future conservation efforts may be improved by determining the overall area bog turtles use during movements and the corresponding dispersal corridors. The protection of the isolated wetlands will not be sufficient to the long-term survivability of the population unless all the isolated habitat patches and dispersal corridors are protected.

Home ranges of bog turtles have not been calculated for most of the populations in the Southeast. However, Carter et al. (1999) used two methods, minimum convex polygon (MCP) and cluster techniques, to determine home ranges of turtles in their Virginia study. They reported median home range estimates for bog turtles in Virginia to be 0.06 ha for males, 0.11 ha for females using cluster analyses and 0.34 ha for males, 0.35 ha for females using the MCP technique. Home range sizes were reported in Maryland studies as 0.176 ha for males and 0.066 ha for females, based on harmonic mean analysis (Chase et al. 1989) and 0.003 ha to 3.12 ha with considerable variation between sites and years (Morrow et al. 2001), and a Pennsylvania study as 1.33 ha for males and 1.26 ha for females, based on the MCP technique (Ernst 1977). The importance of long-term mark-and-recapture studies and the use of radio telemetry cannot be stressed enough in determining bog turtle movements, dispersal patterns, and home range.

6.2 Seasonal Activity

The bog turtle, as an ectothermic reptile, undergoes a definite annual cycle related to seasonal changes of temperature in its environment. Thermoregulation and winter survival require most populations to undergo a period of dormancy (hibernation) through the winter. In the higher elevations, the period of winter dormancy is probably longer than in the Piedmont, but in all sites where the bog turtle occurs, the species alternates seasonal warm-weather activity with cold-weather inactivity, or hibernation.

The earliest date we have observed surface activity in southern bog turtles was on 15 March. The range of greatest bog turtle activity occurs from mid April through June and the latest surface activity was observed on 28 September.

Bog turtles are generally active during the daylight hours. No nocturnal activity has been observed in the southern populations. The earliest time of surface activity observed was 0730 hr (EST) and the latest was 1850 hr (EST). Note that these times were adjusted to Eastern Standard Time for consistency.

Captures have been recorded for every month of the year using the "probing" technique described in Chapter 4. Elevation affects the timing and length of the major phases of the activity cycle. In the Piedmont province, bog turtles have a longer active season than in the mountains.

6.3 Reproductive Biology

Sexual maturity in female bog turtles is reached at 75 mm (2.95 in) carapace length (5th year) according to Barton and Price (1955). Ernst (1977) stated that females reach sexual maturity at 70 mm (2.76 in) plastron length or from 6-8 years of age, while Ernst and Barbour (1972) remarked that adult size is reached at 80 mm (3.15 in) carapace length. Arndt (1977) gave the lower size limit at sexual maturity as 85 mm (3.35 in) carapace length for female bog turtles in his Delaware study, but indicated no age limit. Observations by the principal investigator over the past 26 years indicate that male bog turtles begin to show their sexual dimorphic characteristics (large tail and concave plastron) at 60 mm (2.36 in) straight-line carapace length (3-6 years of age), although they are not sexually mature. Behler and King (1979) reported the age at which bog turtles sexually mature as 5-7 years. Herman (1994) reported that a captive female at Zoo Atlanta reproduced in her 5th year. This was probably due to the ideal conditions under which she was maintained and access to a constant food supply which promoted rapid growth that only rarely is attained in nature. The ten smallest female turtles, with preovipositional eggs captured in North Carolina between 1976-2002 had straight-line carapace lengths and minimum estimated ages of 74.4 mm (age 20), 82.3 mm (age 20), 83.1 mm (age 20), 84.0 mm (age 12), 85.0 mm (age 20), 85.3 mm (age 8), 86.3 mm (age 11), 88.3 mm (age 13), 88.6 mm (age 10), and 88.7 mm (age 11) respectively. The youngest gravid female bog turtle that I have ever found was age 7. From these observations I believe that wild bog turtles are capable of reproducing between 5-7 years (under the most ideal of conditions), but the earliest age is closer to 10 years. Lifetime fecundity of wild bog turtles is unknown. One pair of captive bog turtles maintained at Zoo Atlanta reproduced annually from 1975-1995 (Herman, personal observation). Their minimum estimated age upon arrival at the zoo in 1967 was age 15 (male) and age 18 (female). These two turtles were the longevity record holders for the species (Snider and Bowler 1992) and were over 43 and 46 years of age, respectively, at the time of their theft from the zoo in May 1995. The male bog turtle was recovered from a pond on the University of California at Davis campus in 1998 and died a few months after capture (Spinks et al. 2003). The turtle's estimated age at time of death was 46-47 years. Wild female bog turtles may reproduce from 10 to 15 times over a 40 to 50 year life span.

Eggs are usually deposited in sedge clumps or moss mounds (Nemuras 1967) and neonates emerge after 45-60 days incubation (Herman 1994). Egg clutch sizes range from 1-6 eggs (Behler and King 1979; Herman 1983) with a mean clutch size of 3 eggs. Four nests containing a total of 12 eggs (mean = 3) were found in an Alleghany County, North Carolina study site in June 1991. A neonate was found near a nest of hatched eggs in a Wilkes County, North Carolina site in 1999. Upon examination of the nest at least 12 hatched eggs were found within the cavity. This would

suggest that in some populations bog turtles may use communal nesting sites, especially in areas where ideal nesting conditions are scant. Herman (1986a) reported on a case of multiple clutching in a captive bog turtle where a total of 7 eggs were deposited during two nesting episodes. Twin bog turtles were produced by a captive Henderson County, North Carolina female; the first twins ever reported (Herman 1987).

Captive bog turtles may reproduce annually and up to three year intervals, but little is known how frequently in wild bog turtles. Under captive conditions males and females are kept together in smaller habitat units than wild turtles would experience. Male-female encounters would be less in nature, as would food availability. The lack of a constant food source would prevent female bog turtles from quickly recovering from calcium loss and body weight caused by egg shell development and oviposition. In bountiful years, females may rapidly replenish their energy stores and be capable of reproducing in consecutive seasons if they attract males and mate. From my observations and mark-and-recapture data over the years, it appears that wild bog turtles are capable of annual reproduction, but it is rare in nature. Gravid females (containing preovipositional eggs) captured in an Alleghany County, North Carolina population from 1990-2001 were found to reproduce on 2 to 3 year intervals, with the exception of one female that was found gravid two consecutive years. Fourteen individual females were found gravid on one to three occasions each from 1996-2002 in a Wilkes County, North Carolina population. Only one turtle had reproduced in consecutive years (1996 and 1997), two turtles skipped one year (1997, 1999), one turtle skipped two years (1999, 2002), and eleven turtles were found gravid only once each. Our ongoing mark-and-recapture in North Carolina indicate that bog turtles reproduce every second or third season, but are capable of reproducing annually under ideal conditions.

6.4 Demographics

The bog turtle has the following life history characteristics:

1) Long natural life span (40 years +).
2) Low reproductive rate.
    a) Females reproduce at 1 to 3 year intervals.
    b) First reproduction in females at ages 7 to 10 years (in captivity at 5 years).
    c) Small egg clutch size (1 to 6 eggs; mean 3).
4) High mortality in eggs, neonates, and juveniles (low survivorship).
5) Low mortality in adults (high survivorship).

6.5 Population Trends

Since the bog turtle was first reported from the Southeast in 1879 from North Carolina (Yarrow 1882) at least 1623 individual turtles (612 males, 815 females, 196 unsexed) have been captured and or reported from GA, NC, SC, TN, and VA in historical and literature accounts, museum collections, current captive breeding programs, and current mark-recapture studies. I omitted the turtles in Tryon's experimental Tennessee release study, which would have added significantly to Tennessee's population. Of these turtles 171 (47 males, 72 females, 52 unsexed) are known to no longer be in the populations because of predation, road mortality, preservation in museum collections, and removal for captive studies. This is a 10.5% reduction in the total known

southeastern population since 1879. This figure does not include the unknown number of specimens removed from two study sites in North Carolina in 1989 by commercial turtle collectors from Ohio, and others removed by unscrupulous collectors prior to and during our surveys. See Table 6.1 for the individual state's population trends.

A. Sex Ratio

Bury (1979) found that most freshwater turtles have a male-female sex ratio of 1:1 and Chase et. al. (1989) reported a 1:1 sex ratio in their Maryland bog turtle study, as did Ernst (1977) for Pennsylvania turtles.

State	Males	Females	Unsexed	Total Turtles	Male:Female Ratio
GA	18	13	1	32	1:0.72
NC	302	444	82	828	1:1.47
SC	2	1	0	3	1:0.50
TN	39	48	4	91	1:1.23
VA	204	237	57	498	1:1.16
TOTAL	**565**	**743**	**144**	**1452**	**1:1.32**

Table 6.2 Sex Ratios for the Currently Known Populations in the Southeast.

Data from mark-and-recapture studies currently ongoing in North Carolina indicate that the sex ratio varies from site to site. Sex ratios in the five largest individual NC populations are given as representative ratios for the Southeast: 1:1.1, 1:1.3, 1:1.24; 1:1.42; and 1:2.30 respectively.

State	Counties	Records	Known Turtles Captured	Known Turtles Removed from Population	Turtles Currently in Population	Actual Populations (% of records)	Estimated Viable & Potentially Viable Populations (% of actual populations)	Viable & Potentially Viable Core Habitat Area hectares (acres)	Estimated Population @ 33-44 turtles/ha (15-20 turtles/acre)
GA	3	8	44	12	32	6 (75%)	3 (50%)	12 ha (30 ac)	450 – 600
NC	21	140	936	108	828	53 (38%)	30 (57%)	41 ha (100 ac)	1500 – 2000
SC	2	6	11	8	3	4 (67%)	1 (25%)	4 ha (10 ac)	150 – 200
TN	1	3	102	11	91	1 (33%)	1 (100%)	6 ha (15 ac)	225 – 300
VA	4	90	530	32	498	30 (33%)	26 (87%)	32 ha (80 ac)	1200 – 1600
TOTAL	**31**	**247**	**1623**	**171**	**1452**	**94 (38%)**	**61 (65%)**	**95 ha (235 ac)**	**3525 – 4700**

Table 6.1 Southern Bog Turtle Population Estimates Based on Known Turtles, Estimated Number of Viable & Potentially Viable Populations (PAS), and Core Habitat Area.

B. Age Structure

With the exception of Bern Tryon's Tennessee study sites, the age structure of bog turtle populations in the Southeast is poorly known. Preliminary data from ongoing mark-and-recapture studies in Gaston County (NC) and Wilkes County (NC) have provided some information on age structures in two representative populations. The age structure of sites GAS02 and WIL05 current through 2002 are:

Site	Age Class	Number	Percent of Population
GAS02	Hatchling (< 1 year)	N = 0	
	Juvenile (1-5 years)	N = 2	3.9%
	Subadult (6-9 years)	N = 3	6.0%
	Adult (10-20 years)	N = 27	52.9%
	Old Adult (20+ years)	N = 19	35.2%
WIL05	Hatchling (< 1 year)	N = 0	
	Juvenile (1-5 years)	N = 12	13.6%
	Subadult (6-9 years)	N = 28	31.8%
	Adult (10-20 years)	N = 35	39.8%
	Old Adult (20+ years)	N = 13	14.8%

These two sites were chosen for comparison because they illustrate the differences in age structure of individual populations. GAS02 is a small and isolated population. Very little reproductive recruitment or outside (immigration) has been documented. The older age classes appear to make up the largest group (88.1%) while the younger age classes comprise only 9.9% of the known population. This site has been fairly well monitored since 1992, but not as extensively as WIL05, a much larger site and population, so there may be some bias in the figures. Whereas, the older age classes in WIL05 comprise 54.6% and the youngest age classes 45.4% of the known population. There has been excellent documentation of reproductive recruitment and immigration into the site from outside sources at WIL05. Based on the age structures above for GAS02 and WIL05 the population at WIL05 appears to be more viable. The older age classes appear to be the largest group in other sites we have monitored, as well. Continuation of long-term mark-and-recapture studies will give us a better understanding of the age structure in bog turtle populations that will have important implications when conservation strategies are considered.

C. Population Density

Most Pennsylvania bog turtle sites have about 30 turtles each (Ernst 1977). Chase et. al. (1989) reported population densities of 7 to 213 turtles/ha in Maryland and that the differences in population size may be partially explained by habitat characteristics. Population densities in the Southeast also vary and range from 2.5 - 63 turtles/ha or 1 - 25.5 turtles/ac. The population densities of the largest populations where mark-recapture studies have been ongoing or have taken place for several years in the southern states are:

State	Site	Turtles/ha	Turtles/acre
GA	UNI02	2.5	1.0
NC	ALL11	31.9	12.9
	GAS02	63.0	25.5
	WIL05	61.3	24.8
SC	No Data		
TN	JOH01	48.4	19.6
	JOH02	16.0	6.5
VA	FLO06	52.4	21.2
	FLO21	30.9	12.5

D. Capture/Unit Search Effort

In most years the captures/unit search effort are very similar. The captures/unit search effort for each southern state during the 1996-2002 survey were (Georgia -1996 data only):

State	Search Days	Captures/Day	Search Hours	Captures/Search Hour
GA	26	.23	80	0.075
NC	241	3.60	3329	0.260
SC	-	-	-	-
TN	400	2.39	2971	0.320
VA	42	4.60	758	0.250

The catch/unit effort index can be biased by the searcher's ability and experience, vegetation structure and density, time of year, and weather conditions.

Melissa McGaw

Fig. 6.2. A female turtle from Wilkes Co., NC observed basking on a rock in the river. One of the most unusual basking observations ever made in the southern range.

Emily Stanley

Fig. 6.3. Bog turtle sitting in a small springhead stream in Yancey Co., NC. During this study several turtles were found using small streams in hemlock and rhododendron forests at distances greater than 400m from the main study site.

Emily Stanley

Fig. 6.4. Close-up of the turtle in Fig. 6.3. Stream use by bog turtles has been observed more often in recent years.

Kenneth M. Fahey

Fig. 6.5. Bog turtle from Union Co., GA. Overland dispersal into wooded uplands, similar to the observations in Tennessee, are more commonplace than once assumed.

Joe Zawadowski

Fig. 6.6. Bog turtles observed mating in Wilkes County, NC. Mating usually occurs from mid April through May in the Southeast.

Dennis W. Herman

Fig. 6.7. Nest containing two eggs found in Alleghany Co., NC. Eggs are usually deposited in moss or sedge clumps, and average three per nest.

Dennis W. Herman

Fig. 6.8. Neonate emerging from nest in Johnson Co., TN. Hatching occurs after 45 to 65 days incubation.

Dennis W. Herman

Fig. 6.9. A nine month old turtle found in Avery Co., NC. The majority of this age class is found from mid April through May.

SECTION SEVEN: THREATS TO BOG TURTLE SURVIVAL

Habitat loss has been well documented for the northern bog turtle population (Mitchell and Klemens 2000; Collins 1990) due to draining and alteration of wetlands. Southern bog turtles and their habitats are threatened by 1) agricultural use (row crops, hay fields, pasture land), 2) development, such as retirement villages and subdivisions, shopping centers, highway and bridge construction, golf courses, lakes, etc., 3) natural succession, and 4) illegal collecting for the pet trade (Herman and Tryon 1997; Kemp 1997; Mitchell et al. 1999). These threats are having an adverse effect on bog turtle populations. Habitat loss has accelerated over the past 20 years from fragmentation due to human encroachment and natural succession.

7.1 Agricultural Use

Bog turtles are found in dynamic wetlands comprised of a complex of habitat units that are interconnected by a mosaic of dispersal routes. This was especially true prior to European colonization in the 1600s. The long-term dynamic ecosystem could withstand the loss of a single habitat unit and provide bog turtles with other potential habitats. Early land use techniques by settlers and farmers probably had little effect to the overall stability of this dynamic ecosystem. By clearing forest, the settlers may have enhanced turtle habitat by creating wet meadows, but the benefits that this may have had on turtle habitat, however, were offset by rapid human population growth and the extirpation of beaver populations. As the human population grew, the need for more tillable land became important. Farm machinery replaced human labor and the loss of bog turtle habitats was accelerated. Where the draining of wetlands was accomplished by hand tools or stock animals, modern earthmoving equipment is now used. Almost all of the currently known bog turtle sites show evidence of former ditching efforts, and old drain tiles can still be found. Today, the backhoe is the equipment of choice to quickly and efficiently ditch wet meadows, especially the springheads. Most ditches will gradually fill with silt, in time, and wetland plant species will eventually become dominant. Bog turtles not killed during the ditching process will return into the ditches when the habitat becomes suitable for them. In some cases, these ditches are the only available habitat to support turtles because the surrounding terrain is too dry. Reasons given by farmers for draining their wetlands are to make the land more "usable" for row crops, hay fields, and pasture land, or to prevent cattle and farm equipment from getting "bogged down" in the soft mud.

Loss of bog turtle habitats due to draining efforts has been well documented in the Southeast for over 40 years (Nemuras 1974a, 1974b; Herman 1989; Tryon 1990; Tryon and Herman 1990; Herman and Tryon 1997; Coffey and Shumate 1999; Mitchell et al. 1999). The largest reported area of southern wetlands to undergo a major ditching effort occurred in an isolated valley in eastern Tennessee in the 1930s into the 1960s. Cole (1981, in Coffey and Shumate 1999) mentioned that during the depression of the 1930s the Works Project Administration (WPA) hired valley residents to ditch bends in the valley creek and blast out limestone foundations so the stream would flow freely and to better drain the land. Coffey and Shumate (1999) discussed the USDA's Soil Conservation Service plan, in 1963, to drain the valley floor. The project cut 16,550 m (54,300 ft) of ditches with 4,999 m (16,400 ft) of channel along the creek. Ditches were cut along more than 20 tributaries of the valley's creek, totaling 11,555 m (37,900 ft). A large section of the wetlands was covered by a virgin forest dominated by red spruce (*Picea rubens*), eastern hemlock (*Tsuga canadensis*), and white

pine (*Pinus strobus*) prior to early logging efforts and these draining projects (Coffey and Shumate 1999). Killebrew and Safford (1874, in Coffey and Shumate 1999) remarked that within the valley, cranberries grew wild and northern pines and balsams flourished, but the cranberries grew in every portion of the wetlands. They further remarked that not less than 4047 ha (10,000 ac) produced the cranberries and perhaps the entire surface was covered with them. It is hard to imagine a wetland this large, much less the efforts to drain it. Less than 100 acres of bog turtle wetlands are currently known in the valley, and less than 20 acres are known to have cranberries growing in them.

Over the past 10 years the U.S. Army Corps of Engineers Section 404, Clean Water Act regulations have come under fire by political conservatives and small isolated wetlands are in danger of losing all protection. There is, however, some limited protection for these isolated wetlands in North Carolina through the N.C. Division of Water Quality's Section 401 regulations. Even when the ACOE Section 404 regulations were enforced, many landowners realized that it was easier to get forgiveness than permission when it came to draining their wetlands.

Drained wetlands are usually planted in corn, tobacco, and hay grasses, or grazed by livestock. Many upland areas in the Blue Ridge Mountains are used for Christmas tree farms; many of which are located up slope or adjacent to turtle habitats. Invasive plant species and accelerated growth as a result of increased nutrient loads entering the wetlands, from adjacent agriculture, is a major problem in bog turtle habitat according to Klemens (1989). Some bog turtle habitats may be seriously impacted by over-grazing if the sites' natural hydrology (sheet flow) becomes altered or rare plants are cropped too short. Additionally, overgrazing may lead to increased nutrient levels from livestock feces or urine that could accelerate invasive plant growth, such as watercress. Past agricultural activities in the mountains and Piedmont have altered or eliminated many of the bog turtle sites that originally existed.

7.2 Development

The Blue Ridge Mountains, from Roanoke, Virginia southwest into Blairsville, Georgia, have become a haven for tourism and retirees over the past 25 years. Today most of the farmland in the mountain counties has been subdivided into small acreage units for building sites, and retirement villages have been built to meet the demands of an ever growing population of aging "baby boomers". Oftentimes, these new residents grow discontented with the peaceful and picturesque mountain setting and the demand for more conveniences has increased. Much of the natural ecosystems have been replaced by strip shopping centers or recreational facilities, such as golf courses. Many farm ponds and lakes have been constructed in wetlands for recreational purposes, also.

Golf courses have been constructed throughout many mountain valleys. Many of the golf courses have destroyed or severely altered bog turtle wetlands throughout the southern mountains (Herman and Tryon 1997). Fertilizer, herbicide, and pesticide runoff from the golf courses and septic tank leaching from housing developments increase nutrient levels in the remaining adjacent wetlands making them conducive for nutrient loving invasive plant species (Klemens 1989; Herman and Tryon 1997). Increased development also increases water demand, thus drawing down the water table that adversely affects bog turtle habitat. The type locality of the federally endangered mountain sweet pitcherplant (*Sarracenia jonesii*) was destroyed during the construction of a large golf resort in

Henderson County, North Carolina (N. Murdock, pers. comm.). This former pitcherplant peatland was inhabited by a large number of bog turtles because two of the largest turtle colonies known in 1970s and 1980s were located nearby. Today, these former turtle colonies have been severely impacted by the encroachment of development for housing and shopping to support the large number of people that have moved into the region to live near the golf resort. Habitat fragmentation as a result of lakes and stream impoundments, golf courses, and cropland is rampant in the southern mountains and Piedmont. The Tennessee Valley Authority was responsible for the flooding of countless acres of potential bog turtle habitat during the 1940s and 1950s with the construction of hydroelectric and regulatory dams in eastern Tennessee, western North Carolina, and northern Georgia. These dams were constructed prior to bog turtle surveys so there is no record of the extent of habitat loss. Today, several bog turtle records are known to occur in close proximity to several of the TVA dams and lakes. These extant populations may have been displaced because of the flooding, while others were obliterated.

Departments of transportation in southern states have contributed to bog turtle habitat loss from road construction, highway widening, and bridge construction projects. For example, at least two individual bog turtle habitats were partially destroyed during the construction of various sections of the U.S. 64 highway relocation and widening project during 1969-1976 (Nemuras 1974a; Herman 1989). The current network of highways and secondary roads make it virtually impossible for bog turtles to disperse safely. Turtles are forced to cross roads to reach habitat units along their dispersal corridors. Seventy-three bog turtles have been documented as alive or dead on roads in North Carolina, South Carolina, Tennessee, and Virginia over the past 50 years representing 4.5% of the total southern bog turtles known (73 of 1623 turtles). This number may only suggest that road mortality is a "low level" threat to bog turtles, but the loss of a single mature turtle could have serious consequences to the population because of the species' low reproductive potential and localized small population densities. Wood turtle (*Clemmys insculpta*) populations in Michigan have declined or have been extirpated by "slow attrition", as mature turtles were killed or carried off by recreationists, commercial collecting, and road mortality accelerated the process (Harding 1991). The same could be said for bog turtle populations in the Southeast. Fragmentation of habitats from development has been responsible for the loss of at least 15 sites since 1975 (Herman and Tryon 1997; Project Bog Turtle database).

7.3 Natural Succession

When beaver populations were nearly extirpated in the Southeast prior to 1900, one of the integral factors of bog creation and maintenance was eliminated. Bog turtle habitats underwent rapid succession into climax hardwood forests without the periodic flooding and felling of trees by beavers. Climatic events, such as the extreme droughts of the mid 1980s and the 1990s through 2002 in the Southeast, helped to accelerate the invasion of woody species such as red maple (*Acer rubrum*), tag alder (*Alnus serrulata*), and tulip poplar (*Liriodendron tulipifera*). Many southeastern bog turtle populations are now very isolated because of natural succession and habitat fragmentation. Natural succession has been the direct cause of the apparent decline in several turtle populations studied since 1975. This is especially true in several North Carolina populations in Alexander, Alleghany, Forsyth, Henderson, Macon, McDowell, and other counties. For example, one Henderson County site (HEN03) was discovered in 1975 (Zappalorti and Johnson 1981) and visited annually until 1983.

Natural succession had already taken its toll on this site prior to its discovery due to highway construction and the adjacent railroad tracks. The site had been bisected creating two separate areas; one a mixed hardwood forest, the other an alder and red Maple dominated wetland. A small population of bog turtles (5 individuals) was found along two rivulets in a small opening in the hardwood forest portion from 1975 to 1977, and a second group (4 individuals) was located adjacent to the railroad tracks and the red maple/alder section in 1982 and 1983. Each turtle was in excess of 15 years old and one male was the second largest specimen measured in North Carolina (108.5 mm CL). This site was apparently a dying population due to depressed reproduction and lack of recruitment. Attempts to locate additional turtles have proven fruitless. The hydrological changes due to the railroad and highway construction, and lack of beaver activity contributed greatly to accelerate natural succession observed at this site.

One of the most dramatic examples of accelerated natural succession leading to a decline in turtle populations has been documented at another Henderson County site (HEN01). This site was known to botanists for several years because of the rare plant community that supported two federally protected species, the mountain sweet pitcherplant (*Sarracenia jonesii*) and swamp pink (*Helonias bullata*). Bog turtles were discovered in the site in 1975, but the first population survey was conducted in 1982. A mark-and-recapture study, along with a telemetry study (Lovich et al. 1992) took place from 1982 through 1992. At least 50 individual turtles were captured and marked during the study, and the site supported the second largest single site population in North Carolina at the time. Between 1982 and 1989 a total of 98 turtle captures were recorded during 56 visits expending 157 hours of search effort (1.75 captures/visit and .63 captures/search hour). At the urging of botanists, cattle were removed from the main section of this 8 acres wetland prior to the turtle survey, although cattle continued to graze a smaller portion under separate ownership. The landowner of the main portion constructed two small irrigation and settling ponds adjacent to the wetland. The large farmland across the road and up hill from the wetland was planted in corn. These land use practices played a role in the eventual turtle population decline. The severe drought from 1983 through 1987 compounded the problems caused by the aforementioned factors. Invasion of hardwoods, especially red maples and tag alders, accelerated natural succession due to the cattle removal and the subsequent hydrological changes from irrigation efforts, nutrient runoff from nearby fields, and drought. Between 1989 and 1992 only 13 bog turtle captures were recorded during 21 visits using 47 hours of search effort (.62 captures/visit and .29 captures/search hour). Of note is the fact that 23 bog turtle captures were recorded between May and September 1985 after the site was selectively pruned and burned in February 1985. Also, the adjacent landowner still grazed cattle on his part of the wetland. This canopy closure could explain the dramatic decline in bog turtle captures after 1988. The North Carolina Chapter of the Nature Conservancy purchased the McClure Bog in 1992 with plans to manage it for the rare plants (Anonymous 1992). Several attempts were made to selectively cut shrubs in small plots around the rare plants, but rapid re-growth continued to create a thick canopy. A few attempts have been made to find bog turtles, but only the shells of dead turtles were found during these visits (2001 and 2002). Chris McGrath (N.C. Wildlife Resources Commission) has been working with TNC - NC Chapter to selectively cut alders and maples from larger plots in an effort to restore the turtle population. These are only two examples of the many sites that have been lost or nearly lost to natural succession in the entire Southeast.

As mentioned previously, the importance of beaver in creating and maintaining suitable bog turtle habitats cannot be stressed enough. Almost all of the turtle sites in South Carolina are associated with beaver wetlands. At least three of Georgia's sites, and the state's largest population, are associated with beavers. There is a growing concern that beavers may be detrimental to large, active turtle populations due to flooding of habitat. This may be true to some degree, but the long-term effects may be beneficial. Currently, there are several turtle sites in GA, NC, SC, and VA that have active beaver colonies and these could be important case studies to observe the effects (long and short term) that beavers have on the turtle populations.

7.4 Predation and Disease

Predators, such as raccoons, foxes, mink, dogs, snapping turtles, and large birds are known to kill, injure, and mutilate adult bog turtles (Bury 1979; Herman and Tryon 1997). Nests containing eggs and neonates are preyed upon by the aforementioned predators, as well as ants, snakes, moles, shrews, and rodents (personal observations).

If a bog turtle reaches adulthood there is a good chance it will live a long life. Major diseases, like pneumonia and cancer, occasionally are observed in very old or recently dead turtles, and are likely secondary to a turtle's advanced age when it becomes immuno-compromised. A necropsy was performed on a recently dead bog turtle of advanced age, found in Macon County, North Carolina, and the pathology report diagnosed the cause of death to be chronic granulomatous pneumonia (bacterial). S.L. Carter (pers. comm.) observed pneumonia in old recently expired turtles during his Virginia study.

Parasitism from nematodes and trematodes do not appear to be common, and observations or reports are lacking from wild turtles. A recently expired bog turtle, part of a confiscation of turtles from New Jersey (locality unknown) maintained at Zoo Atlanta in 1996, was examined and necropsied at the University of Georgia's College of Veterinary medicine. The pathology report indicated that the primary problem was parasitism of the intestine, liver, and pancreas. The diagnoses were mild multifocal heterophilic interstitial pneumonia, severe multifocal intestinal parasitism (possibly arthropod origin), mild multifocal hematic nematodiasis and trematodiasis, and mild multifocal pancreatic nematodiasis.

Some ectoparasites are found frequently in southern bog turtles. The leeches *Placobdella multilineata* and *P. parasitica* have been reported by Saumure and Carter (1998) and Saumure and Beane (2001) from bog turtles in Virginia and North Carolina, respectively. Certain species of flesh fly have been reported in bog turtles by Beane and Zappalorti (1997).

A health survey conducted on 36 wild bog turtles in North Carolina and Virginia and captive specimens at the NC Museum of Natural Sciences (6 specimens) in 2001 found no evidence of blood parasites or positive *Mycobacterium* titers in blood samples. Fecal smears and cloacal flush samples did not reveal any nematode or trematode ova and they were relatively clean of any pathogenic intestinal protozoans (Brenner et al. 2002). A potential pathogenic protozoan, *Caryospora* sp., was found in only one turtle sampled, but was not considered a threat due to the very low number observed.

7.5 Other Threats

An additional threat to bog turtle populations is the commercial live animal trade, both domestic and international according to the U.S. Fish and Wildlife Service (1997). The bog turtle continues to command the highest price of any native turtle species. Reptile price lists have advertised the sale of captive bred bog turtles at $995 each for hatchlings or yearling turtles. Pritchard (1992) reported that bog turtles sell for as much as $1000 each in Japan. CITES upgraded the species from Appendix II to Appendix I in 1992 restricting international trade and the World Wildlife Fund (1993) placed the bog turtle on its top ten list of the world's "most wanted" endangered species, along side such exotic species as the giant panda and black rhinoceros. Herman (1994) reported that Ohio turtle collectors removed and undetermined number of bog turtles from two NC study sites in 1989. The taking of bog turtles probably continues today and the actual sale of turtles has not been as open as it was prior to the federal listing. Essentially, any activity with bog turtles has gone underground and a black market probably exists today. I say 'probably', because there is no proof that bog turtles are being illegally taken in the Southeast that we are aware of. The principal investigator was contacted by a concerned landowner in 1996 when individuals from Ohio, on two separate occasions, visited her site and another nearby wetland to look for, and photograph, bog turtles. This landowner accompanied the individuals during their respective visits, and while several turtles were observed, none were taken that she was aware of. Landowners have since been contacted and warned to look out for people requesting to search their sites and to ask the visitors to present an endangered species permit issued by the state. These 1996 events are the last reported or known cases of bog turtles being targeted.

I attended a meeting in Fort Worth, Texas in 2001 that addressed the Asian turtle crisis. Nearly 80 people from around the world were in attendance. During a social event I became acquainted with a known and respected turtle breeder from Germany and the author of several books and papers on turtles, including captive reproduction of bog turtles. This gentleman was very familiar with the majority of turtle enthusiasts and breeders, not only in Germany, but other European countries. He informed me that only about 25 bog turtles were kept in captivity that he knew about, and almost half of these turtles had been hatched in captivity in these collections. Rumors have circulated for many years that Japanese and European turtle enthusiasts, especially Germans, were responsible for the bog turtle trade numbers. Where are all of the bog turtles that were reported to have left the United States for foreign markets? Most of the commercial sales of bog turtles have probably taken place within the U.S. We are aware of at least one individual that continues to advertise bog turtles for sale on his website. It is also known that this individual received several of the North Carolina turtles that were collected in 1989 by the Ohio men reported by Herman (1994).

It is obvious that habitat loss from agriculture, development, and natural succession has been the main reason for the decline in bog turtle populations range-wide. The threatened status of the bog turtle provided by the federal listing restricts the turtle's collection, sale, trade, and take, but it has created a black market situation making it very difficult to determine the exact extent of trade.

Dennis W. Herman

Fig. 7.1. The trackhoe or backhoe is the preferred instrument to drain wetlands, especially bog turtle habitat in the Southeast.

Dennis W. Herman

Fig. 7.2. A recently ditched spring-head on a seepage slope. Note the large circular patch of cinnamon fern (*Osmunda cinnamomea*) in the center of the photo.

Dennis W. Herman

Fig. 7.3. This once viable bog turtle site in Henderson Co., NC was converted into a large pond during the late 1990s.

Dennis W. Herman

Fig. 7.4. Site HEN03 in Henderson Co., NC was in the final stages of natural succession when discovered in 1975. Note the railroad tracks in the center of the photo.

SECTION EIGHT: CONSERVATION AND MANAGEMENT

Conservation and management of southern Appalachian Mountain and Piedmont bogs and turtle populations have become necessary to ensure their long-term viability. But what are the best strategies to initiate when dealing with the bog turtle and its unique habitat? Development of conservation programs often must proceed without adequate data on the life history of target species. Reasons for lack of data include technical and logistic problems related to obtaining life history data on some species, and the difficulty of obtaining reliable data from populations that are already reduced or in decline. The problems that impede life history studies in general are magnified when species being studied are long lived (Tinkle 1979). On the other hand, conservation initiatives conducted without a sound understanding of a species' biology are potentially disastrous (Mrosovsky 1983). Many times, important decisions regarding the future of a species are made by crudely attempting to balance ecosystems, economics, and politics, often using minimal data (Klemens 1989). Swingland (1988) outlined three basic areas that need to be addressed when devising conservation strategies: 1) a management plan integrating life history tables, questions of habitat integrity, behavioral constraints, the rate of environmental sex determination, activity patterns, home range, and other ecological parameters; 2) the feasibility of implementing a conservation program including an awareness of local vested interests, education, knowledge of political infrastructure, and an assessment of the anticipated returns of the conservation efforts invested; and 3) resource exploitation, including trade and agricultural activity. Most, if not all, of these areas are important in the conservation and management of the bog turtle in the Southeast. To initiate any management recommendations and strategies a thorough understanding of the bog turtle's distribution and ecology is required. However, if we await this type of information, the species will undoubtedly be lost from most sites. Any conservation plans that are implemented must be economically feasible and acceptable to the local landowners. Additional studies on habitat use, migration, and home range are needed to design preserves that include sufficient amounts of appropriate habitat to ensure long-term viability of bog turtle populations. Apart from setting aside habitat of sufficient size to ensure a population's survival, there is a need to address many of the secondary effects of changing land use and habitat alteration (Klemens 1989; Mitchell and Klemens 2000). Simply purchasing bog turtle habitat may be counter-productive. The Nature Conservancy has adopted guidelines to set aside areas of great biodiversity on a landscape theme. A similar concept was suggested by Buhlmann et. al. (1997) for the protection of bog turtles in Virginia using hydrologic units. Since these environments are dynamic, the mechanisms that create and maintain meadow bogs (i.e. beaver, herbivores, fire, etc.) and the dispersal corridors must remain intact. Unfortunately, several factors may make this concept impractical in most southern states. Very few of the existing southern bog turtle populations fit the criteria of the metapopulation concept. Multiple or apathetic landowners along the stream corridors may be major obstacles to overcome. As discussed previously, the prime factors for the decline in bog turtle populations are habitat fragmentation and loss. It has become necessary to protect individual sites, as well as multiple sites (metapopulation), that harbor substantial turtle populations and/or rare plant species, because so much of the habitat has become fragmented.

The principal investigator and biologists associated with Project Bog Turtle have been involved with various aspects or implementing most of the following conservation and management strategies since before and after PBT was founded in 1995. We believe that recommending conservation strategies with little or no action is the quickest way to lose the bog turtle and its habitat.

8.1 Conservation Strategies

The bioreserve or landscape theme concept as currently used by The Nature Conservancy has merit for the protection of bog turtle populations. Protection of small islands of habitat is inferior to management of large zones of interconnected habitat units (Diamond 1975). Kiviat (1978) stated that bog turtle demes must either be provided with artificially stabilized habitats, and/or be given space to adjust to mosaics of unstable habitats. He further remarked that stabilizing the habitat to favor bog turtle production over long time periods could well be counter-productive because wetlands apparently require fluctuating environment (water levels, herbivore populations, etc.) to maintain diversity and productivity. As previously discussed the metapopulation/bioreserve concept may be impractical in the Southeast because of the isolated, disjunct nature of turtle populations or sites. Very few of the currently known bog turtle colonies (demes) could be considered metapopulations because of habitat fragmentation and impediments to turtle dispersal along stream corridors. The few metapopulations that currently exist in the Southeast should be protected in their entirety, but many individual sites or populations deserve immediate protection and management.

Project Bog Turtle and its associates have taken an active role in bog turtle conservation in the Southeast. We have been actively involved in distribution or status surveys, life history studies, landowner education and involvement, habitat protection and management, and captive breeding and release projects.

A. Distribution and Status Surveys

This report gives the results of an important status survey of the bog turtle in the Southeast (Chapter 5). Although this survey attempted to locate as many new or potential bog turtle populations and habitats during a six year period with very good results additional surveys are needed in the south. More than 50% of the turtle's potential range was searched in North Carolina and Virginia during this and previous surveys, but additional surveys are needed in Georgia, South Carolina, and to some extent in Tennessee. There are still river subdrainages and isolated areas in the mountains in North Carolina and Virginia that need further surveys. Aerial surveys would expedite locating additional habitats. Helicopters should be used for mountain surveys because of their maneuverability; airplanes are suitable for much of the Piedmont. A ground search should be conducted after the potential habitats identified from aerial surveys are plotted on topographical maps. A trained search team could be assembled rather quickly for habitat investigations.

B. Life History Studies

Population density studies are a necessary part of any conservation plan to determine the viability of populations. These studies should include additional mark-recapture projects to determine bog turtle demographics (i.e. sex ratio, age structure, longevity, mortality, etc.). Ideally, the longer the study the more accurate the data will be.

Additional radio telemetry projects are needed in many sites or populations. Important data could be obtained on habitat use, home range, and activity patterns. Radio tracking would provide accurate data on emigration rates and dispersal, as has been previously discussed. Carter et al. (1999,

2000) conducted a two year radio tracking study, which included thread trailing to determine home range and habitat preferences of bog turtles in several Virginia sites. Project Bog Turtle associates have conducted additional radio tracking projects in North Carolina in recent years and Bern Tryon has an ongoing tracking study (initiated in 2001) in Tennessee. How do the activity patterns of bog turtles differ from sites at different elevations? Where do the bog turtles at the higher elevation sites hibernate and do they ever emigrate down the mountain? The answers to these questions may be provided by information obtained from radio telemetry studies.

C. Landowner Education and Involvement

Education of private landowners is very important. Landowners' cooperation with wildlife and conservation personnel is extremely important. Face to face discussions have proven helpful in many cases, but lectures, seminars, or educational programs about wetlands, land use, and current wetland regulations would be important strategies in which to further involve landowners. Fact sheets, flyers, posters, and letters could also be useful tools in the education of landowners.

Project Bog Turtle provides a packet of fact sheets for landowners that have bog turtles or potential habitat on their property. These landowner packets include facts about bog turtles and their habitat, turtle identification photos, answers to frequently asked questions about how having bog turtles on the property affects property rights, and a list of protection options (See Appendix B). Conservation work can only be accomplished by gaining the landowners' trust.

D. Habitat Protection

Many private landowners view their wet pastures as unproductive or worthless land. Only by draining these "swamps" can the land be made useful for hay production, row crops, or grazing pastures. Currently The Nature Conservancy offers some property tax incentives to owners that sign conservation easements for natural areas on their land; those with a diverse flora and fauna. Unfortunately, the TNC's policy does not cover single species' habitats, such as many bog turtle sites. In some cases the bog turtle is protected solely on the fact that it happens to occur in preserves that have been purchased for its biodiversity. But often than not, bog turtle habitats contain one or more rare plant species. There are many important bog turtle sites that need protection based on the size of the population and the area of core habitat, not because the turtle is merely associated with a rare plant community. Legislative action is necessary to provide economic incentives to landowners so that bog turtle wetlands can be protected through easements and the associated property tax breaks that may be available. Tax incentives should be available to landowners that voluntarily preserve their wetlands and agree not to alter them. Incentives should be provided for owners to restore habitats and maintain them in good condition. Critical habitat will often include a buffer zone that, in most cases, may not be "worthless" land, so a landowner may be reluctant to voluntarily protect it. If an owner cannot use his or her land for "productive means", then monetary incentives should be made available to offset any losses that are incurred. Why not pay them subsidies to keep critical habitat intact? This recommendation may not be politically feasible, but it may be one of the best options to consider, where possible. In cases where owners are reluctant to sign easements or have no intention on selling the property, Project Bog Turtle offers to lease the turtle habitat, along with buffer area, through a conservation lease program (Appendix C). This lease program is funded by a grant from the USFWS and lease amounts vary from $20 to $50 per acre based on the habitat quality and

turtle population. Most of the leases range in duration from one year to five years, with extensions offered as incentives to the landowners. Project Bog Turtle currently has 63 ha (155 ac) protected under this conservation lease program. The continuation of this program is dependent on available funding from additional grants and tax exempt donations.

A valid conservation strategy is to purchase valuable wetlands, and create preserves for bog turtles and the other species associated with the habitat. Other potential purchasing agencies (or providers of financial assistance) are natural heritage foundations, regional nature societies, land trusts, universities, and department of transportation mitigation banks. The North Carolina Wildlife Resources Commission purchased an important bog turtle habitat in 2001 and plans to manage the site for the bog turtles. Several bog turtle wetlands were purchased in 1997-98 by the North Carolina Department of Transportation for mitigation purposes and will be turned over to the N.C. Wildlife Resources Commission or local land conservancies for management. These initial land acquisitions to protect bog turtle habitat have set a precedent that may lead to additional sites being purchased. The implementation of this recommendation is expensive, but it may be the only way to ensure the turtle's future. Enough habitat units and the corresponding dispersal corridors must be protected for the future viability of the bog turtle in the Southeast.

E. Captive Breeding , Headstarting, Relocation, Repatriation, and Translocation Projects

Additional conservation strategies that may have beneficial implications in the Southeast are captive breeding and headstart programs, or relocation, repatriation, and translocation projects. These are somewhat controversial subjects with various positives and negatives associated with each.

Headstarting as a tool in turtle conservation has recently come under fire, especially in sea turtle populations (Mrovosky 1983; Woody 1990; Frazer 1992). Frazer (1992) stated that headstarting is "halfway technology" and does not address the causes of or provide remedies for the actual threats turtles face. Programs such as headstarting and captive breeding may serve only to release more turtles into a degraded environment in which their parents have already demonstrated that they cannot survive and that captive programs may keep turtles from serving important ecological functions (i.e. food for predators) in the natural environment, or place them at some disadvantage relative to their natural counterparts once released. Essentially, some captive bred offspring may not have survived and reproduced in a natural environment. Headstarting (and captive breeding) programs have value as a public relations activity and should not be avoided altogether for this reason alone, and the high visibility and attractiveness of these programs should not keep us from the fact that they do nothing to alter the processes that threaten turtle populations (Frazer 1992). If the reason for declining bog turtle populations is habitat loss, then address that problem. If the cause is overcollecting, then address that problem, as well. It may well be that captive breeding programs are a good stop-gap strategy to use while the larger more difficult problems can be addressed.

The captive breeding and headstarting programs have many beneficial aspects besides serving as just a public relations tool. Bog turtles, maintained and bred in separate outdoor enclosures from the same populations, could act as a seed bank, much as is done by botanical gardens with rare plants. Captive breeding programs for bog turtles are generally inexpensive to operate and take up little space to properly establish naturalistic habitats for the turtles. Although this may have certain drawbacks,

such as the need to rotate in new turtles from identical populations for maintaining genetic diversity, the progeny could be used in future release projects after site management programs have stabilized the habitat. Jacobson (1993) discussed disease as a very important issue in any release program for reptiles. Health screening of captive and wild specimens should be established to obtain baseline information on blood analyses, parasites, bacterial, and fungal diseases before any release program is considered. Jacobson (1993) suggested that breeding programs should be established within the geographical range of the species, under as natural conditions as possible. Confiscated, nonreleasable, bog turtles from illegal sources should be set up in suitable outdoor artificial (or natural) bogs and bred for use in educational facilities or for eventual sale into the pet trade. Approved legal sources of captive bred bog turtles would help eliminate some of the pressure to illegally take turtles from wild populations or study sites. This is an option that the N.C. Wildlife Resources Commission may want to consider in the future, especially if the turtle becomes federally protected and confiscated bog turtles become hard to place. A pre-set agreement between the state and the breeder/holder of confiscated turtles could be made so that a certain percentage of the "sales" would go to the state. Revenues generated through the sale of legal bog turtles could help support state nongame and endangered species programs. This recommendation will certainly open a "can of worms" and cause much consternation among law enforcement personnel unless an effective identification system is implemented and monitored.

Relocation, repatriation, and translocation projects for reptiles have become an extremely popular conservation strategy to offset habitat loss or the decline or extirpation of individuals and populations. Repatriation, relocation, and translocation programs have been criticized for their overall lack of success and failure to follow programs to determine their outcome (Dodd and Seigel 1991). One of the most important issues regarding the release of any species is disease, although other important issues exist, i.e. the effects of released animals on genetics and social structure of populations and the need for a better understanding of biological requirements of the species released (Jacobson 1993). In addition, if habitat quality is low, the chances of successful translocation or reintroduction of declining or extirpated species are also low (Griffith et. al. 1989).

Concern for the genetic integrity of bog turtle populations arose in 1989 because of the species spotty distribution, subtle morphological differences between turtles from different populations, and the potential problems of releasing captive bog turtles into areas from which they had not originated. How different, genetically, are bog turtles from one population to another or from drainage to drainage? Are northern turtles different enough from southern turtles to warrant two species as Dunn (1917) thought? Between 1990 and 1992, Bern Tryon and the principal investigator collected blood samples from 67 bog turtles at 33 different sites in Georgia, North Carolina, South Carolina, Tennessee, and Virginia. North Carolina bog turtles were well represented in the sampling: 26 turtles from 16 sites in 10 counties. Samples were collected from the northeast by John Behler (NYZS The Wildlife Conservation Society) and others (J. Behler, pers. commun.). Amato et. al. (1997) reported on the preliminary results of this study, where the mitochondrial DNA variation was initially explored in geographically separated bog turtle populations. The 16S ribosomal gene was chosen because this region has been shown to demonstrate fixed differences at the subspecific level in other reptiles. The mtDNA variability of the bog turtle samples was unusually low and they had identical 16S sequences. Additional molecular characters that may be more variable are currently being explored. Although this initial study indicates that there may not be significant genetic differences in bog turtle

populations, it is too early to suggest that these data be used as a basis for species conservation.

In a recent microsatellite DNA study by Dr. Tim King (Leetown Science Center, Aquatic Ecology Laboratory) DNA samples were examined from bog turtles throughout the species' range. Project Bog Turtle collected blood samples from many sites in several counties as part of this study. The preliminary results look very positive and bog turtles can be identified with great accuracy (91.3 to 100%) to state, drainage, and population using the genetic markers studied (T. King, pers. comm.).

There are several examples of captive breeding/headstarting programs and repatriation, relocation, and translocation projects that have been initiated in recent years for bog turtle conservation. Both Zoo Atlanta and Knoxville Zoological Gardens have been involved in some of these projects, as well as the Baltimore Zoo (Wisnieski and Poole 2001). Captive breeding and headstart programs conducted at Zoo Atlanta, between 1982-1993 using North Carolina bog turtles, have successfully released 29 progeny (Herman personal data). Bog turtles that were hatched at the zoo and considered nonreleasable were loaned to several zoos, aquaria, and museums for exhibit purposes. These turtles have been used as valuable educational tools for informing the public about the bog turtle's plight throughout its range.

The Knoxville Zoo has been involved in an experimental release project in an area of suitable habitat that was devoid of turtles. Tryon (2001) reported that 97 headstarted turtles from the zoo's captive breeding program were released at the study site beginning in 1991has proven successful, to date, and results of field work, including radio telemetry, indicate that the released turtles have adjusted to the site and behave like wild turtles. Many of the earliest cohorts released have reached sexual maturity and reproduction should be observed in the near future. The success of this project will determine that captive breeding, head-starting, and releases are valid conservation tools for other states to follow.

The only repatriation attempts of formerly wild turtles were made during 1991 and 1992 when several adult turtles that had been held at Zoo Atlanta for breeding purposes were released into their respective capture bogs (HEN01 and HEN02). One female held in captivity for 5 years (1986-1991) was released into HEN02 whereupon she was recaptured in 1992 and 1993 showing an increase in weight. She had obviously re-adapted to the natural ecosystem. A male and two females held for ten years (1982-1992), for a breeding group, were released in HEN01; neither has been recaptured to date, probably as result of the lack of field work at the site after it was purchased by The Nature Conservancy in 1992.

8.2 Habitat Management

Whether entire metapopulations or individual sites are considered for protection in the Southeast, management plans should be implemented specifically for each situation. Protection of habitat without management could very well be inadequate for many species. Kiviat (1978) outlined the following management tactics, on an as needed basis, that should be considered as reserves are set aside for the protection of bog turtle populations: 1) maintain regional beaver populations or create new meadows by artificial flow modifications; 2) maintain usable dispersal-ways connecting groups of habitat units and potential habitats; 3) retard woody vegetation development by cutting, browsing,

or burning to prevent canopy closure; 4) control introduced thicket-forming plants such as multiflora rose, honeysuckles, etc.; and 5) manage predator and competition populations. Most, if not all, of these strategies are essential in the protection and perpetuation of bog turtle populations in the Southeast. A closer look at specific management strategies is in order to see which tactics are most important at each site or metapopulation.

After a site (population) is protected, the type of management that is required to maintain the population's viability should be assessed. Specific management strategies that would benefit southern bog turtle habitats include, but are not be limited to, the following: 1) restoration, 2) selective cutting, 3) grazing by herbivores, 4) predator control, 5) invasive plant control, 6) prescribed burning, and 7) law enforcement.

A. Restoration

As previously discussed most bog turtle habitats have experienced varying degrees of alteration from ditching, stream channeling, and filling. Therefore, some preliminary restoration work may be indicated. Restoration of wetlands may be as simple as plugging or filling old ditches and draining ponds. Other sites may require more extensive restoration practices such as removal of fill dirt or debris (stumps, building materials, etc.) after the hydric soil boundaries have been mapped, tapping into underground water sources, re-establishing creek channels, or damming exit streams to restore sheet flow. Somers et al. (2000) discussed a restoration project in a Surry County, North Carolina turtle site during the mid to late 1900s that involved hydrological flow modification systems, excluder fencing around nesting areas, and vegetation management.

Additional restoration tactics may include placing culvert pipelines under roadways to create safe and effective dispersal routes between sites transected by highways. These pipeline corridors may prevent death from vehicular traffic by helping bog turtles move from one habitat unit to another without crossing the road. The various states' departments of transportation mitigation banks may be a source of needed funds to purchase and restore important bog turtle wetlands. The majority of the Southeast's bog turtle sites are in need of some type of restoration work.

B. Selective Cutting

This strategy may be the most important tool to prevent canopy closure, and was suggested by Bruce and Holland (1981) for sites in southwestern North Carolina. However, cutting of vegetation to stunt its development is a long-term commitment. The use of herbicides has been suggested, but their use will require close scrutiny and care that desirable species are not harmed (Somers et. al. 2000). Cutting shrubs and small trees after the leaves emerge is preferred to prevent the storage of energy in the root systems. Early to mid summer cutting of vegetation is recommended. Herman (2000) reported on a management project in an Alleghany County, North Carolina turtle site that involved selective cutting and herbicide application to the stumps. Herman observed that no re-growth of sprouts occurred during the first year, about 25% re-growth occurred by the end of the second year, and that the areas opened by this management strategy was in need of continued management by year four. Bog turtles, nests, and a neonate were observed in the newly created open areas during the first and second year after the cutting was performed; the first ever found in those

areas (Herman 1998). Selective cutting should be scheduled at 3 to 5 year intervals, or on an as needed basis.

Girdling large diameter trees (i.e. red maples, river birches, etc.) is more beneficial than merely cutting them down. Bacterial and fungal diseases readily invade the girdled trees killing them to the roots. The girdling process may be slower, but the long-term benefits are greater than felling the trees and having to contend with offshoots and saplings growing from rootstocks. The use of propane torches to girdle small trees and shrubs has been used with successful results in Georgia (R. Determan, pers. comm.). Fahey and Jensen (1999) reported finding a bog turtle nest on the top of small moss covered stump in a Union County, Georgia site after large trees had been girdled by the U.S. Forest Service only a few years prior. This site was discovered in 1979 and during subsequent searches only old adult turtles had been found with no evidence of reproduction because of the forested canopy. Again, this method is time consuming, but the results are desirable.

C. Grazing by Herbivores

The largest bog turtle populations (and possibly the most viable) are associated with cattle grazing (Lee and Norden 1994; Herman 1999; Somers et al. 2000). Grazing as a management strategy is an important tool in maintaining wet meadows (Herman 1994, 1999; Ehrenfield 2001; Tesauro 2001). Small herds of cattle, horses, or goats keep waterways open and prevent them from becoming weed-choked. Spring and fall grazing is recommended as a management tool. Seasonal grazing is preferred to year round grazing to prevent trampling of nests and eggs (Somers et al. 2000). Encouraging deer into the habitat would be very beneficial as they, too, keep trails open and browse on grasses and herbs. It is important that the number of livestock is kept under control. Too many browsers may impact the habitat by eating rare plant species, compact the substrate, disrupting the natural hydrological sheet flow, increasing nutrient levels from excessive fecal loads, and trampling of bog turtles and their nests. The benefits of grazing by herbivores to the turtle habitat outweigh any temporary damage that may occur to desirable plant species or the injury or death of individual turtles from trampling.

D. Control of Invasive Plants

Bog turtles are forced to emigrate when invasive alien plants threaten the habitat and create canopy closure. The most common invasive plant species that threaten habitats in North Carolina are multiflora rose (*Rosa multiflora*), Japanese stiltgrass (*Microstegium vimineum*), and Japanese honeysuckle (*Lonicera japonica*). Control of these species is important because of the dense thickets and ground-cover they form that close the canopy and understory. Herbicides may be useful in ridding habitats of these invasives, but care must be taken that native species are not harmed. The best methods to control invasive plants are to remove the plants by digging, pulling, constant pruning or grazing to stunt their development or kill them outright. Grazing has been used with success in New Jersey in ridding bog turtle habitats of invasive plants (Ehrenfield 2001; Tesauro 2001). The southern bog turtle habitats are fortunate that purple loosestrife and giant reed have not become a problem as they have in the northeast. We must take every precaution to protect our habitats from these and other exotic invaders.

E. Prescribed Burning

Periodic fires in bog turtle habitats have never been documented, but fire may be a natural process that helped create and maintain wet meadows, bogs, and fens (Kiviat 1978; Schafale and Weakley 1990; Lee and Norden 1994; Kost and De Steven 2000). Burning as a management tool should receive consideration in maintaining bog turtle populations, as was suggested by Bruce and Holland (1981) for several southwestern North Carolina sites. An experimental late winter burn was carried out in HEN01 (Henderson County, NC) in 1985. One acre of habitat was burned, but the results were successful. The thick grass matting that choked some of the rivulets were reduced and many of the small shrubs were stunted. Bog turtles were found to use the recently burned portion the following spring as evidenced by the 23 turtles found after the burning project. As with selective cutting, a 3 - 5 year prescribed burning regime may be indicated in many southern turtle habitats.

F. Predator Control

Predation of bog turtle nests has been observed in many study sites in the southern portion of the turtle's range (Project Bog Turtle, field data). Mutilation of adult and juvenile turtles by predators such as raccoons and mink has been frequently observed in some populations. Mitchell et. al. (1991) mentioned that adult bog turtles in Virginia are often found with missing limbs and gnawed shells. Turtle mutilations and evidence of predator related injuries have been observed in an Alleghany County, North Carolina site (ALL11) with at least 40% of the adults captured since 1990 with missing toes, feet, legs, tails, or cracked shells and punctures from bites. Congdon et. al. (1993) believes that the cause of decline in Blanding's turtle nest survival is unknown, but coincided with the collapse in the fur market in general and, most important for turtles, the demand for pelts of major nest predators such as raccoons and foxes. I, too, believe that the increased populations of bog turtle predators (raccoons, mink, foxes) may be attributed to the decline in fur-bearer trapping. Congdon et. al. (1993) conclude if that 1) turtle nests and/or population declines are caused by increased predator populations; 2) the populations of raccoons and foxes remain high due to the absence of large predators; and 3) the growing public opinion against trapping furbearers and wearing or using wild animal furs continues, predator population control other than furbearer trapping may have to be implemented to maintain some turtle populations. Southern bog turtle populations, where predator numbers are extremely high, would benefit greatly from predator species removal. Trapping programs with relocation or humane euthanasia of the target predators would be desirable. Trapping programs could prove costly, but landowners may be willing to assist in the removal of predator species.

G. Law Enforcement

By 1992, all of the southern states had listed the bog turtle either threatened or endangered, and the turtle became federally listed in 1997. Prior to North Carolina's protection of the bog turtle in 1990, the principal investigator met with Allen Boynton (NCWRC) and various wildlife enforcement officers in Alleghany, Ashe, Avery, and Henderson counties for brief seminars on bog turtle identification and habitat recognition. Chris McGrath (Mountain Projects Leader, NCWRC) organized meetings in three districts for state and federal wildlife officers, National Park Service biologists, rangers, U.S. Forest Service resource managers, and land managers in 1998 to discuss the

recent listing of the bog turtle by the USFWS. The attendees were given a slide presentation orientation session that briefed them on how to detect turtle collectors, the season of greatest activity, and the major sites within their respective districts. After the morning classroom session the attendees were taken to one or more bog turtle sites for a field techniques demonstration and hands on exercises. These meetings were very positive and the officers indicated that they were interested in protecting the bog turtle, especially after several of them found their first live bog turtles.

It is recommended that future meetings and periodic refresher courses with wildlife enforcement officers be conducted. This is necessary because of personnel changes that take place periodically. Known bog turtle localities should be monitored during the "high" season of turtle and collector activities. People observed in suspected bog turtle habitats should be questioned and requested that applicable permits be shown; legitimate people, conducting legitimate studies, will have copies of their state permit. Suspicious looking people, i.e. wearing hip waders, rubber boots, etc. and carrying cloth bags, should be questioned. Currently, park rangers along the Blue Ridge Parkway are sensitive to the protection of the bog turtle and often stop and ask about a person's activity if observed in a wetland. This same philosophy is needed at the state level, so that suspected turtle collectors are prevented from illegally taking bog turtles.

Herman (1994) recommended that all North Carolina bog turtles be implanted with transponders (PIT-tags) for positive identification purposes in an effort to assist the N.C. Wildlife Law Enforcement Division and the U.S. Fish & Wildlife Service. These passive integrated transponders are implantable and glass encapsulated, with each having its own identification code. Transponders would be injected on the left side of the turtle in the hind limb socket. The procedure is harmless to the turtles and can be accomplished in the field with practice. A hand held reader (scanner) displays the scanned identification code. The identification is fool-proof and the exact site and state from which the turtle was taken would be known after checking the database of transponder numbers. Because of the transponder's location in a turtle, it is not easily removed and would not be cost effective or safe to do so by some unscrupulous person.

The above recommendation became realized in 2000 when the USFWS gave a grant to the North Carolina Wildlife Resources to begin a transponder implantation project. Project PIT-tag, as it was dubbed, began in the spring of 2000 (Powell 2002). Chris McGrath (NCWRC) was the project's leader and administrator, with assistance from Project Bog Turtle. A minimum of 200 wild bog turtles is to be implanted in the Southeast by the end of 2003. Currently, 237 bog turtles have been implanted in Georgia, North Carolina, and Virginia and entered into the database. The use of transponders will not replace the current marking system because a visual identification system is needed for fieldwork, especially if a reader is not available.

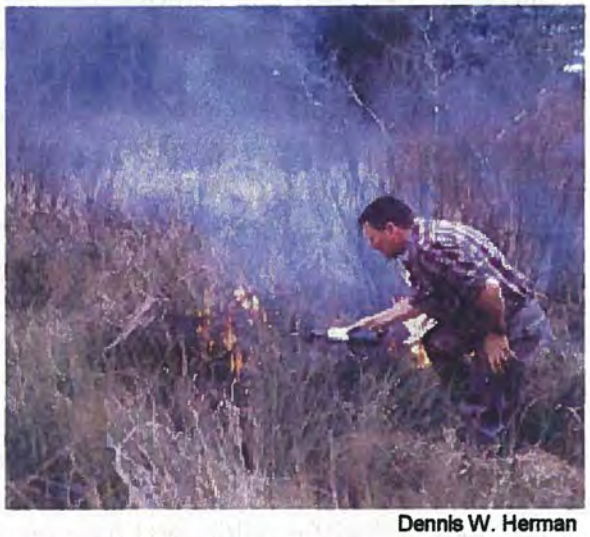
Law enforcement is a key element in the conservation and management of the bog turtle in the southeastern United States. Without strong enforcement of wildlife regulations, monitoring illegal activities, and stiff penalties and fines for offenders, the bog turtle will suffer immensely, even with adequate habitat protection.

Ann B. Somers

Fig. 8.1. A landowner signing a lease agreement with a Project Bog Turtle representative. The conservation lease program has been very successful since it began in 1997.

Dennis W. Herman

Fig. 8.2. This formerly grazed Henderson Co., NC site was once the largest individual turtle population known in the Southeast (130+ turtles).



Dennis W. Herman

Fig. 8.3. Prescribed burning in a Gaston Co., NC site in 2000 to remove thick vegetation. Charcoal deposits have been discovered in soil core samples at one site in recent years.

Dennis W. Herman

Fig. 8.4. Project PIT-tag was initiated in 2000. Nearly 100 turtles were implanted the first full year of the project. The goal is to implant 200 turtles in GA, NC, SC, TN, and VA by the end of 2003.

Melissa McGaw

Fig. 8.5. The pocket reader activates the transponder and records the individual identification number. This project will assist law enforcement in identifying illegally captured turtles.

Dennis W. Herman

Fig. 8.6. Turtles being PIT- tagged in the field. The procedure is a simple and safe way to permanently identify bog turtles.

SECTION NINE: DISCUSSION

This status and distribution survey was very time consuming and labor intensive. It was a Herculean effort undertaken by many dedicated bog turtle people, both from professional and private endeavors. We met many wonderful people during the survey, especially the many landowners and land managers that so graciously allowed us to survey their wetlands. Many miles were driven in search of potential habitat, and many miles of wet meadows, swamp-forest bogs, and fens were slogged through in hopes that a bog turtle would be found. The results (Chapter 5) of the survey are very impressive because everyone that participated in the fieldwork has a full time job and most of the work was accomplished while on personal leave, or in the case of a few of us, business leave. At any rate the amount of time spent looking for bog turtle habitat, and turtles themselves, was much less than having a core of people contracted to do the surveys on a full time basis. How does the total area surveyed compare to the turtle's overall range in the Southeast? The bog turtle's potential range covers an estimated 54,727 km² (21,130 mi²) or 5,472,119 ha (13,521,845 ac) in Georgia, North Carolina, South Carolina, Tennessee and Virginia (Figure 9.1). These figures were obtained by drawing a closed polygon on 100,000 scale topographic maps using MapTech® software (version 5.1). The polygon was created by connecting lines from the eastern-most record in North Carolina to the northern-most Virginia record to the western-most Tennessee record to the southwestern-most Georgia record to the southern-most South Carolina record, to the southeastern-most North Carolina record, and back to the eastern-most record in North Carolina. Looking at these figures is very misleading because the turtle's distribution inside this area is very spotty at best. When one compares these area figures to the actual known area of bog turtle habitat (sites) in the Southeast it clearly illustrates the spotty and isolated nature of bog turtle sites and populations.

Figure 9.1. The actual and potential range of the bog turtle in the Southeast. The potential range is indicated by the blue polygon. The actual range (orange) lies within the polygon.

Currently, 227 ha (562 ac) are known to harbor bog turtles (187 individual sites), and the area decreases when only the viable and potentially viable sites are considered. The total known area (227 ha = 562 ac) covers only 2.27 km² (0.88 mi²) or .0042% of the estimated range. The area of known sites will increase once the dispersal corridors are figured out and factored in. The total known area for viable and potentially viable bog turtle sites is 198 ha (488 ac) and covers only 1.98 km² (0.76 mi²) or .0036% of the estimated range. It is safe to say that there are many more sites to be discovered in the Southeast. In fact, there are an additional 137 wetlands within the current range of the bog turtle in North Carolina (NCNHP database; PBT database) that have potential for bog turtles. These 137 wetlands cover a total area of 239 ha (590 ac). We do not know how many additional potential sites are known in the Southeast, but we can assume, based on North Carolina that there are at least twice as many potential bog turtle sites to be discovered. Therefore, if we double the known sites from 182 to 364 and the known total area from 227 ha (562 ac) to 454 ha (1124 ac) we would still make up less than 1% of the total estimated area. To take this exercise one step further and factor in the 4049 ha (10000 ac) lost in Tennessee from the 1930s to mid 1960s and make the total bog turtle habitat 4276 ha (10562 ac) the percentage jumps to .078%, which is still less than 1% of the estimated range. Although this is still not a lot of area when compared to the bog turtle's hypothetical southern range, it would be a significant amount. These figures point out that habitat loss has been the key factor in the decline of bog turtle populations in the Southeast.

How much of the turtle's southern range did this survey cover? We estimate that sites were searched in approximately 50-60% of the estimated range in North Carolina and Virginia. We have no doubt that many potential sites were overlooked and, therefore, not searched during the survey. Bog turtles can inhabit areas of less than 0.20 ha (0.5 ac), so many sites are hidden in isolated mountain coves and valleys, and at the base of the Blue Ridge Escarpment where roads are few and far between.

Bog turtle habitats have been located in most of the major river basins in the Southeast, but there are still smaller tributaries of these rivers that need additional surveys. For example, the Broad River basin and its headwater streams the Green River, Rocky Broad River, Pacolet River, First Broad River, and Second Broad River have only a few bog turtle records and need more work. Much of the upper Catawba River basin (Linville River, John's River, Wilson Creek, South Muddy Creek, South Fork Catawba River, Henry Fork, and others) has gone unsurveyed. Most of the Yadkin River headwater rivers and streams have been thoroughly searched, but some of the small escarpment streams need additional surveys. We predict that additional bog turtle sites will be found in the river basins previously mentioned, as well as the New River (NC and VA), Watauga River (NC and TN), Little Tennessee River (GA and NC), French Broad River (NC), Savannah River (GA, NC, and SC), Saluda River (SC), Hiawassee River (GA and NC), Dan/Roanoke River (NC and VA), and Smith/Roanoke River (VA) basins.

9.1 Georgia, South Carolina, and Tennessee

The bog turtle is a peripheral species in these three states. Of these, Georgia has the most potential for additional populations because the Blue Ridge Mountains province covers more area. Tennessee has good potential for additional populations, but most will probably be close to the North Carolina state line and associated with either the New River or Watauga River drainages. South

Carolina has a lot of suboptimal habitat that is associated with beaver colonies. Additional sites, and possibly a few populations could be found in the South Carolina upstate region just below the Blue Ridge Escarpment. If the southern bog turtle population were to occur solely in these three states then the species would most definitely be "endangered."

9.2 North Carolina

As previously reported North Carolina has the greatest number of occurrence records in the Southeast, and the potential range in the state covers a very large area (Figure 9.1). The turtle is, or was formerly, concentrated in only a few areas in the state. The New River basin has the largest number of records, followed by the upper Yadkin River headwaters and the French Broad River basin. The populations are extremely difficult to locate outside these main areas of occurrence. Although additional records, individual sites, and a few metapopulations will be found in the future I doubt that the state's overall population will increase significantly unless current metapopulations are protected fully. The bog turtle is definitely a "threatened" species in North Carolina, but is far from "endangered."

9.3 Virginia

Virginia appears to have more bog turtles per square mile than any of the other southern states. The main concentration of turtles occurs in Floyd and Carroll counties in the New River basin. The low topography, lack of large urban areas nearby, low human population, slow growing development, and more or less habitat friendly land use practices have prevented the turtle population from any major declines in the past 20 years. Some of the largest populations are located on public land (National Park Service) where protection is strong. In sites where habitat has been degraded by ditching, populations remain large when compared to neighboring North Carolina. Many individual sites in Virginia have turtle populations, regularly inhabiting old ditches (that have silted in and become favorable again), that are larger and more viable than sites in North Carolina that have had only minor draining efforts. The low topography in Floyd and Carroll counties is conducive for easy overland dispersal from population to population and drainage to drainage, thus making it easier for formerly degraded sites to become recolonized (Figure 3.1). Additional surveys by well trained and experienced bog turtle researchers should locate additional populations in the four counties of known occurrence. Upper Piedmont populations will probably be found in the Dan River (Roanoke River) basin in Carroll and Patrick counties, or in counties bordering Stokes County, NC. The bog turtle is "threatened" in Virginia solely on the fact that it is found over a small area, especially when compared to North Carolina, not because of any major population declines. The bog turtle should not be considered an "endangered" species in Virginia.

What does all of this mean for the future of the bog turtle in the southern United States? It means that there are a lot of questions left unanswered concerning the overall status and distribution of the bog turtle in the Southeast. The principal investigator was told, in response to comments concerning the 1997 proposed listing, the southern population did not warrant full "Threatened" status because additional sites were being found or reported each year. Also, we had not documented the same habitat loss over the past 20 years. In fact, Project Bog Turtle and previous workers have been reporting new occurrence records and sites annually for the past 20 years. But, have these additional

sites increased the southern bog turtle population significantly? I do not think so. At best the known population has probably remained stable with additional sites off-setting lost or degraded sites. Documentation is provided, in this report (Chapter 7), that habitat loss has been substantial since 1963, at least comparable to the northern population during the same time period. We should not forget the 4049 ha (10000 ac) of habitat drained by the U.S. Soil Conservation Service in 1963 in eastern Tennessee. We will never know how large that bog turtle population was. If the known populations remaining in the remnant habitats are any indication, there must have been hundreds or thousands of turtles inhabiting the valley. Has any single bog turtle wetland of comparable size been reported destroyed in the Northeast at any period in time? So, is the bog turtle a threatened species in the Southeast? That is a most difficult question to answer.

The results of this survey would indicate that, although the bog turtle continues to face tremendous threats to its habitat in the Southeast, the species does not warrant "Threatened" status under the Endangered Species Act if the true definition of the ESA is followed. Bog turtles are found over a large area in the Southeast and there is great potential to locate additional populations. The turtle's true status is still unknown, this survey not withstanding. That said, the bog turtle and its habitat deserves strong protection throughout its southern range. Unfortunately, individual state protection was not consistent prior to the federal listing and has remained inconsistent since the turtle's listing in 1997. The bog turtle's presence in mountain and Piedmont wetlands indicates healthy ecosystems and biodiversity. Many bog turtle habitat's support up to 25% of a state's endangered or threatened species of plants and animals. The importance of these wetlands cannot be stressed enough.

A comparison of the southern population to the northern population is in order to help determine the turtle's status. The bog turtle was originally proposed for listing in the Federal Register on January 17, 1997, and listed as "Threatened" in the northern population in November (USFWS 1997). Turtle populations (PAS's) reported at the time of its listing totaled 191. The northern bog turtle recovery plan (USFWS 2001) was completed in 2001. The recovery plan included 159 northern populations that were documented after the 1997 final rule to list the turtle and indicated that 350 extant populations are known in the northern range. At least 104 populations (PAS), plus a portion of Pennsylvania's 75 and New Jersey's 165 populations are considered "good". An additional 48 populations, including some of New Jersey's 165 and Pennsylvania's 75 populations, are considered "fair." Populations considered "poor" number 38. Again, these additional populations were documented between 1997 (final rule) and 2001 (recovery plan). During a comparable time period (1996-2002, this report) only 50 individual sites (65 total occurrence records) were found or reported in the southern range. More populations (159 PAS) were reported in the northern range after 1997, according to the recovery plan, than are currently known in the entire southern range, and the entire northern population (350 PAS) is double that of the southern population (187 individual sites). We should note that the 187 sites known from the south are individual sites and not populations (PAS). If the individual sites in the Southeast are combined to form PAS (= metapopulations = individual sites linked into larger groupings based upon a number of factors including proximity and lack of impediments to turtle movement) the number will decrease sharply (187 sites to 94 PAS), and the disparity between the northern and southern populations increase greatly. See Table 9.1 & Table 9.2 for a comparison of northern and southern populations. The principal investigator has recently been informed that New Jersey has at least 190 bog turtle populations currently known (J. Tesauro,

pers. comm.). In light of the updated population totals reported for the northern range in the recovery plan it is difficult to justify the bog turtle's "Threatened Species" status. Is the bog turtle "likely to become endangered in the foreseeable future" as defined and outlined in the Endangered Species Act? Probably not.

We (PBT) agree with the recovery plan's list of threats that bog turtles and its habitat face. The same threats hold true for the southern range. It is true that the northern range has seen a rapid increase in urbanization over the past century and that habitat loss has been well documented over the past 20 years. In contrast to this, the southern range has faced its own continued threats over the past century, and habitat loss within the past 20 years (this report). If the species' southern population is not considered "Threatened" then the northern population should be down-listed, or the southern population elevated to "Threatened" status.

"If people destroy something replaceable made by mankind,
they are called vandals;
if they destroy something irreplaceable made by God,
they are called Developers".

Joseph W. Krutch

State	No. Counties	No. Good Sites	No. Fair Sites	No. Poor Sites	Total Sites
CT	2	0	4	1	5
DE	1	0	4	0	4
MD	4	12	25	24	61
MA	1	2	0	1	3
NJ	18	72	n/a[1]	n/a	165
NY	19	8	15	12	37[2]
PA	17	n/a	n/a	n/a	75
N. RANGE	**71**	**104[3]**	**48**	**38**	**350**

Table 9.1. Quality of Extant Bog Turtle Sites in the Northern Range (U.S.F.W.S. 2000).

[1] Ranking information not available. [2] Two of the 37 New York sites were not ranked. [3] Rangewide figures for each ranking are equal to or greater than the number displayed due to unranked sites in NJ and PA.

State	No. Counties	No. Good Sites[1]	No. Fair Sites[2]	No. Poor Sites[3]	Total Sites
GA	3	2	1	3	6
NC	21	20	10	23	53
SC	2	1	0	3	4
TN	1	1	0	0	1
VA	4	23	3	4	30
S. RANGE	**31**	**47**	**14**	**33[4]**	**94**

Table 9.2. Quality of Extant Bog Turtle Sites in the Southern Range.

[1,2,3] Sites in the southern range were ranked viable (=good), potentially viable (= fair), and nonviable (= poor). [4] Poor sites could be elevated in status after additional visits and population density studies are performed.

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APPENDIX A

Common and Rare Flora and Fauna of Southern Appalachian and Upper Piedmont Wetlands

I. Common and Rare Flora

II. Common and Rare Fauna

Common and Rare Flora of Southern Appalachian and Upper Piedmont Wetlands

I. Nonvascular Plants

A. Mosses and Liverworts

*yellow starry fen moss	*Campylium stellatum* var. *stellatum*
*liverwort	*Cephaloziella hampeana*
*bog broom moss	*Dichranum undulatum*
*narrowleaf peatmoss	*Sphagnum angustifolium*
Bartlett's peatmoss	*Sphagnum bartlettianum*
*northern peatmoss	*Sphagnum capillifolium*
*pretty peatmoss	*Sphagnum fallax*
*flexuous peatmoss	*Sphagnum flexuosum* var. *flexuosum*
*brown peatmoss	*Sphagnum fuscum*
papillose peatmoss	*Sphagnum papillosum*
hooked peatmoss	*Sphagnum recurvum*
red peatmoss	*Sphagnum rubellum*
*orange peatmoss	*Sphagnum subsecundum* var. *subsecundum*
*fen peatmoss	*Sphagnum warnstorfii*
*southern dung moss	*Splacnum pennsylvanicum*

II. Vascular Plants

A. Ferns and Fern Allies

southern lady fern	*Athyrium asplenioides*
*blunt-lobed grape fern	*Botrychium oneidense*
crested wood fern	*Dryopteris cristata*
fancy fern	*Dryopteris intermedia*
marginal wood fern	*Dryopteris marginalis*
sensitive fern	*Onoclea sensibilis* var. *sensibilis*
cinnamon fern	*Osmunda cinnamomea*
interrupted fern	*Osmunda claytoniana* var. *claytoniana*
royal fern	*Osmunda regalis* var. *spectabilis*
marsh fern	*Thelypteris palustris* var. *pubescens*
*bog fern	*Thelypteris simulate*
netted chain fern	*Woodwardia areolata*
common running cedar	*Diphasiastrum digitatum*
shining clubmoss	*Huperzia lucidula*
Carolina quillwort	*Isoetes caroliniana*
Engelmann's quillwort	*Isoetes engelmannii*
southern bog clubmoss	*Lycopodiella appressa*
*northern bog clubmoss	*Lycopodiella inundata*
*a clubmoss	*Lycopodium dendrodeum*
*Hickey's tree clubmoss	*Lycopodium hickeyi*
common ground pine	*Lycopodium obscurum*
meadow spikemoss	*Selaginella apoda*

B. Trees and Shrubs

red maple	*Acer rubrum var. rubrum*
tag alder	*Alnus serrulata*
sweet birch	*Betula lenta*
river birch	*Betula nigra*

silky dogwood	*Cornus amomum*
flowering dogwood	*Cornus florida*
*long-stalked holly	*Ilex collina*
mountain holly	*Ilex montana*
winterberry	*Ilex verticillata*
sheep kill, wicky	*Kalmia carolina*
mountain laurel	*Kalmia latifolia*
red spruce	*Picea rubens*
white pine	*Pinus strobus*
pitch pine	*Pinus rigida*
white oak	*Quercus alba*
great laurel	*Rhododendron maximum*
swamp azalea	*Rhododendron viscosum*
common elderberry	*Sambucus canadensis*
black willow	*Salix nigra*
silky willow	*Salix sericea*
*Canada yew	*Taxus canadensis*
poison sumac	*Toxicodendron vernix*
Canada hemlock	*Tsuga canadensis*
smooth highbush blueberry	*Vaccinium corymbosum*
northern wild raisin	*Viburnum cassinoides*
southern wild raisin	*Viburnum nudum*

C. Sedges & Rushes

Allegheny sedge	*Carex allegheniensis*
*hay sedge	*Carex argyantha*
prickly bog sedge	*Carex atlantica*
Bailey's sedge	*Carex baileyi*
*Barratt's sedge	*Carex barratti*
Blue Ridge brome sedge	*Carex bromoides* var. *montana*
brown sedge	*Carex brunnescens* var. *sphaerostachya*
a sedge	*Carex bullata*
*brown bog sedge	*Carex buxbaumii*
Collin's sedge	*Carex collinsii*
*cone-shaped sedge	*Carex conoidea*
a sedge	*Carex crinita* var. *crinita*
*small crested sedge	*Carex cristatella*
a sedge	*Carex debilis*
star sedge	*Carex echinata ssp. echinata*
a sedge	*Carex folliculata*
mountain sedge	*Carex gynandra*
Howe's sedge	*Carex howei*
a sedge	*Carex intumescens var. intumescens*
*a sedge	*Carex lasiocarpa* var. *americana*
a sedge	*Carex leptalea*
a sedge	*Carex lurida*
*few-seeded sedge	*Carex oligosperma*
*necklace sedge	*Carex projecta*
*Schweinitz's sedge	*Carex schweinitzii*
tussock sedge	*Carex stricta*
*sedge	*Carex trichocarpa*
*three-seeded sedge	*Carex trisperma*
beaked sedge	*Carex utricularia*
*inflated sedge	*Carex vesicaria*

flatsedge	*Cyperus flavescens*
flatsedge	*Cyperus tenuifolius*
threeway sedge	*Dulichium arundinaceum*
obtuse spikerush	*Eleocharis obtusa*
foursided spikerush	*Eleocharis quadrangulata*
spikerush	*Eleocharis tenuis*
tawny cottongrass	*Eriophorum virginicum*
fimbry	*Fimbristylis autumnalis*
needle rush	*Juncus acuminatus*
short-tailed rush	*Juncus brevicaudatus*
New Jersey rush	*Juncus caesariensis*
Canadian rush	*Juncus canadensis*
needle rush	*Juncus dichotomus*
common rush	*Juncus effusus* var. *solutus*
seep rush	*Juncus gymnocarpus*
marginal rush	*Juncus marginatus* var. *marginatus*
needle rush	*Juncus scirpoides* var. *scirpoides*
somewhat-tailed rush	*Juncus subcaudatus* var. *subcaudatus*
bluntscale bulrush	*Schoenoplectus purshianus*
softstem bulrush	*Schoenoplectus tabernaemontani*
black bulrush	*Scirpus atrovirens*
woolgrass bulrush	*Scirpus cyperinus*
woodland bulrush	*Scirpus expansus*
Georgia bulrush	*Scirpus georgianus*
northern bulrush	*Scirpus hattorianus*
manyleaf bulrush	*Scirpus polyphyllus*
slender nutrush	*Scleria muhlenbergii*
*northern white beaksedge	*Rhynchospora alba*
brownish beaksedge	*Rhynchospora capitellata*
clustered beaksedge	*Rhynchospora glomerata* var. *glomerata*
slender beaksedge	*Rhynchospora gracilenta*
Harvey's beaksedge	*Rhynchospora harveyi*

D. Orchids

*bog rose	*Arethusa bulbosa*
common grass pink	*Calapogon tuberosus*
*fen orchid	*Liparis loeselii*
Appalachian twayblade	*Listera smallii*
green adder's-mouth	*Malaxis unifolia*
yellow-fringed orchid	*Platanthera ciliaris*
green woodland orchid	*Platanthera clavellata*
golden fringed orchid	*Platanthera cristata*
*tubercled rein orchid	*Platanthera flava* var. *herbiola*
*large flowered purple fringed orchid	*Platanthera grandiflora*
golden fringeless orchid	*Platanthera integra*
ragged fringed orchid	*Platanthera lacera*
*purple fringeless orchid	*Platanthera peramoena*
purple fringed orchid	*Platanthera psycodes*
rose pogonia	*Pogonia ophioglossoides*
nodding ladies' tresses	*Spiranthes cernua*
*shining ladies' tresses	*Spiranthes lucida*
spring ladies' tresses	*Spiranthes vernalis*

E. Grasses, Herbs, Vines, and Other Flora

Appalachian blue monkshood	*Aconitum uncinatum ssp. muticum*
sweetflag	*Acorus calamus*
common agrimony	*Agrimonia gryposepala*
southern agimony	*Agrimonia parviflora*
Northern white colicroot	*Aletris farinosa*
peppervine	*Ampelopsis arborea*
glomerate bluestem	*Andropogon glomeratus* var. *glomeratus*
*bog jack-in-the-pulpit	*Arisaema triphyllum* ssp. *stewardsonii*
three awn	*Aristida virgata*
red chokeberry	*Aronia arbutifolia*
purple chokeberry	*Aronia prunifolia*
purple-stem aster	*Aster puniceus*
screwstem bartonia	*Bartonia paniculata* ssp. *paniculata*
Virginia bartonia	*Bartonia virginica*
false nettle	*Boehmeria cylindrica*
*fringed brome	*Bromus ciliatus*
*marsh marigold	*Caltha palustris*
*marsh bellflower	*Campanula aparinoides*
bulbous bittercress	*Cardamine bulbosa*
hairy bittercress	*Cardamine hirsuta*
buttonbush	*Cephalanthus occidentalis*
*Cuthbert's turtlehead	*Chelone cuthbertii*
white turtlehead	*Chelone glabra*
pink turtlehead	*Chelone lyonii*
purple turtlehead	*Chelone oblique*
water hemlock	*Cicuta maculata*
*twig rush	*Cladium marisoides*
*goldthread	*Coptis trifolia* var. *groenlandica*
*robin run-a-way, false violet	*Dalibarda repens*
*bog oatgrass	*Danthonia epilis*
bog witch grass	*Dichanthelium dichotomum*
short leaf witch grass	*Dichanthelium ensifolium*
round-leaf sundew	*Drosera rotundifolia*
*American willow herb	*Epilobium ciliatum*
eastern willow herb	*Epilobium coloratum*
narrowleaf willow herb	*Epilobium leptophyllum*
compressed pipewort	*Eriocaulon* compressum var. *compressum*
ten-angled pipewort	*Eriocaulon decangulare* var. *decangulare*
mountain fetterbush	*Eubotrys recurva*
hollow stem Joe-Pye-weed	*Eupatorium fistulosum*
boneset	*Eupatorium perfoliatum var. perfoliatum*
common roundleaf eupatorium	*Eupatorium rotundifolium*
crested climbing buckwheat	*Fallopia scandens*
*queen-of-the-prairie	*Filipendula rubra*
rough bedstraw	*Galium asprellum*
bluntleaf bedstraw	*Galium obtusum* var. *obtusum*
southern three lobed bedstraw	*Galium tinctorium var. tinctorium*
northern dwarf huckleberry	*Gaylussacia dumosa* var. *bigeloviana*
soapwort gentian	*Gentiana saponaria*
*yellow avens	*Geum aleppicum*
Canada avens	*Geum canadense*
*rough avens	*Geum laciniatum* var. *trichocarpum*
cream avens	*Geum virginianum*
*rattlesnake mannagrass	*Glyceria canadensis*

*lax mannagrass	*Glyceria laxa*
fowl mannagrass	*Glyceria striata*
common sneezeweed	*Helenium autumnale*
southern sneezeweed	*Helenium flexuosum*
*swamp pink	*Helonias bullata*
*holy grass	*Hierochloe odorata*
summer bluet	*Houstonia purpurea var. purpurea*
Appalachian bluet	*Houstonia serpylifolia*
American water pennywort	*Hydrocotyle americana*
Canada St. John's-wort	*Hypericum canadense*
mountain bushy St. John's-wort	*Hypericum densiflorum*
common dwarf St. John's-wort	*Hypericum mutilum* var. *mutilum*
shrubby St. John's-wort	*Hypericum prolificum*
spotted jewelweed	*Impatiens capensis*
rice cutgrass	*Leersia oryzoides*
white cutgrass	*Leersia virginica*
*rough blazing star	*Liatris aspersa*
blazing star	*Liatris spicata*
*yellow Canada lily	*Lilium canadense* ssp. *canadense*
*red Canada lily	*Lilium canadense* ssp. *editorum*
*Gray's lily	*Lilium grayi*
northern spicebush	*Lindera benzoin*
ridgestem yellow flax	*Linum striatum*
*American fly-honeysuckle	*Lonicera canadensis*
common water purslane	*Ludwigia palustris*
northern bugleweed	*Lycopus uniflorus*
Virginia bugleweed	*Lycopus virginicus*
northern maleberry	*Lyonia ligustrina* var. *ligustrina*
whorled loosestrife	*Lysimachia quadrifolia*
swamp candles	*Lysimachia terrestris*
*large flower Barbara's buttons	*Marshallia grandiflora*
Virginia bunchflower	*Melanthium virginicum*
*buckbean	*Meryanthes trifolia*
bee balm	*Monarda didyma*
*spiked muhly	*Muhlenbergia glomerata*
*sweet gale	*Myrica gale*
*bog asphodel	*Narthecium americanum*
*perennial sundrops	*Oenothera perennis*
golden club	*Orontium aquaticum*
cowbane	*Oxypolis rigidior*
golden ragwort	*Packera aurea*
*balsam ragwort	*Packera (Senecio) paupercula*
tall flat panic grass	*Panicum rigidulum* var. *elongatum*
long leaf panic grass	*Panicum rigidulum* var. *pubescens*
Appalachian grass-of-Parnassus	*Parnassia asarifolia*
*bigleaf grass-of-Parnassus	*Parnassia grandifolia*
green arrow arum	*Peltandra virginica*
swamp smartweed	*Persicaria setacea*
*bog bluegrass	*Poa paludigena*
fowl bluegrass	*Poa palustris*
northern drumheads	*Polygala cruciata var. aquilonia*
short pinebarren milkwort	*Polygala ramosa*
arrowleaf tearthumb	*Polygonum sagittatum*
heartleaf pickerelweed	*Pontederia cordata* var. *cordata*
American self-heal	*Prunella vulgaris*
mountain mint	*Pycnanthemum muticum*

mountain mint	*Pycnanthemum tenuifolium*
Virginia mountain mint	*Pycnanthemum virginianum*
Carolina buttercup	*Ranunculus carolinianus*
hooked buttercup	*Ranunculus recurvatus*
Virginia meadow beauty	*Rhexia virginica*
swamp rose	*Rosa palustris*
multiflora rose	*Rosa multiflora*
swamp dewberry	*Rubus hispidus*
greenheaded coneflower	*Rudbeckia laciniata*
southern arrowhead	*Sagittaria australis*
*bunched arrowhead	*Sagittaria fasciculata*
broadleaf arrowhead	*Sagittaria latifolia*
Canada burnet	*Sanguisorba canadensis*
S. Appalachian purple pitcher plant	*Sarracenia purpurea* var. *montana*
*mountain sweet pitcher plant	*Sarracenia jonesii*
branch lettuce	*Saxifraga micranthidifolia*
*swamp saxifrage	*Saxifraga pennsylvanica*
catbrier	*Smilax bona-nax*
whiteleaf greenbrier	*Smilax glauca*
bamboo vine	*Smilax laurifolia*
common greenbrier	*Smilax rotundifolia*
northern roughleaf goldenrod	*Solidago patula var. patula*
goldenrod	*Solidago roanensis*
*bog goldenrod	*Solidago uliginosa*
American bur reed	*Sparganium americanum*
*greenfruit bur reed	*Sparganium chlorocarpum*
swampoats	*Sphenopholis pensylvanica*
narrowleaf meadowsweet	*Spiraea alba*
broadleaf meadowsweet	*Spiraea latifolia*
hardhack	*Spiraea tomentosa*
*Epling's hedge nettle	*Stachys eplingii*
hispid hedge nettle	*Stachys hispida*
*bog featherbells	*Stenanthium robustum*
skunk cabbage	*Symplocarpus foetidus*
sweetleaf	*Symplocus tinctoria*
lady rue	*Thalictrum clavatum*
common tall meadowrue	*Thalictrum pubescens var. pubescens*
*sticky bog asphodel	*Tofieldia glutinosa*
pale mannagrass	*Torreychloa pallida*
poison ivy	*Toxicodendron radicans*
painted trillium	*Trillium undulatum*
common cattail	*Typha latifolia*
*small bladderwort	*Utricularia minor*
bearberry	*Vaccinium erythrocarpum*
*large cranberry	*Vaccinium macrocarpon*
White hellebore	*Veratrum viride*
common wingstem	*Verbesina alternifolia*
*American speedwell	*Veronica Americana*
Culver's root	*Veronicastrum virginicum*
blue marsh violet	*Viola cucullata*
mountain yellow-eyed grass	*Xyris torta*

*Rare species modified from Somers et al. (2000).

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Common and Rare Fauna of Southern Appalachian & Upper Piedmont Wetlands

I. Vertebrates

A. Mammals

beaver	*Castor canadensis*
southern red-backed vole	*Clethrionomys gapperi*
*star-nose mole	*Condylura cristata parva*
Virginia opossum	*Didelphis virginiana*
woodchuck	*Marmota monax*
striped skink	*Mephitis mephitis*
*pygmy shrew	*Microsorex hoyi*
meadow vole	*Microtus pennsylvanicus*
least weasel	*Mustela nivalis*
mink	*Mustela vison*
golden mouse	*Ochrotomys nuttalli*
white-tailed deer	*Odocoileus virginianus*
muskrat	*Ondatra zibethicus*
raccoon	*Procyon lotor*
eastern mole	*Scalopus aquaticus*
masked shrew	*Sorex cinereus*
smoky shrew	*Sorex fumeus*
*southern water shrew	*Sorex palustris punctulatus*
eastern cottontail	*Sylvilagus floridanus*
*southern bog lemming	*Synaptomys cooperi*
gray fox	*Urocyon cinereoargenteus*
black bear	*Ursus americanus*

B. Birds

Cooper's hawk	*Accipiter cooperii*
spotted sandpiper	*Actitis macularia*
redwing blackbird	*Agelaius phoeniceus*
wood duck	*Aix sponsa*
grasshopper sparrow	*Ammodramus savannarum*
northern pintail	*Anas acuta*
green-winged teal	*Anas crecca*
blue-winged teal	*Anas discors*
mallard	*Anas platyrhynchos*
American black duck	*Anas rubripes*
ruby-throated hummingbird	*Archilochus colubris*
great egret	*Ardea albus*
great blue heron	*Ardea herodias*
lesser scaup	*Aythya affinis*
redhead	*Aythya americana*
ring-necked duck	*Aythya collaris*
greater scaup	*Aythya marila*
tufted titmouse	*Baeolophus bicolor*
American bittern	*Botarus lentiginosus*
Canada goose	*Branta canadensis*
bufflehead	*Bucephala albeola*
red-shouldered hawk	*Buteo lineatus*
broad-winged hawk	*Buteo platypterus*

green heron	*Butorides virescens*
northern flicker	*Calaptes auratus*
least sandpiper	*Calidris minufilla*
northern cardinal	*Cardinalis cardinalis*
American goldfinch	*Carduelis tristis*
purple finch	*Carpodacus purpureus*
turkey vulture	*Cathartes aura*
northern harrier	*Circus cyaneus*
marsh wren	*Cistothorus palustris*
sedge wren	*Cistothorus platensis*
yellow-billed cuckoo	*Coccyzus americanus*
eastern wood-pewee	*Contopus virens*
black vulture	*Coragyps atratus*
American crow	*Corvus brachyrhynchos*
common raven	*Corvus corax*
blue jay	*Cyanocitta cristata*
chestnut-sided warbler	*Dendroica pensylvanica*
pine warbler	*Dendroica pinus*
black-throated green warbler	*Dendroica virens*
bobolink	*Dolichonyx oryzivorus*
pileated woodpecker	*Dryocopus pileatus*
*alder flycatcher	*Empidonax alnorum*
*willow flycatcher	*Empidonax traillii*
Acadian flycatcher	*Empidonax virescens*
rusty blackbird	*Euphagus cerolinus*
merlin	*Falco columbarius*
American kestrel	*Falco sparverius*
American coot	*Fulica americana*
common snipe	*Gallinago gallinago*
common yellowthroat	*Geothlypis trichas*
*sandhill crane	*Grus canadensis*
cliff swallow	*Hirundo pyrrhonata*
barn swallow	*Hirundo rustica*
wood thrush	*Hylochichla mustelina*
least bittern	*Ixobrynchus exilis*
loggerhead shrike	*Lanius ludovicianus*
Swainson's warbler	*Limnothylypis swainsonii*
hooded merganser	*Lophodytes cucullatus*
red-bellied woodpecker	*Melanerpes carolinus*
red-headed woodpecker	*Melanerpes erythtocephalus*
wild turkey	*Meleagris gallopavo*
swamp sparrow	*Melospiza georgiana*
Lincoln's sparrow	*Melospiza lincolnii*
song sparrow	*Melospiza melodia*
brown-headed cowbird	*Molothrus ater*
great crested flycatcher	*Myiarchus crinitus*
eastern screech owl	*Otus asio*
osprey	*Pandion haliaetus*
northern parula	*Parula americana*
*savannah sparrow	*Passerculus sandwichensis*
indigo bunting	*Passerina cyanea*
double-crested cormorant	*Phalacrocorax auritus*
rose-breasted grosbeak	*Pheucticus ludovicianus*
downy woodpecker	*Picoides pubescens*
American woodcock	*Pilohela minor*
eastern towhee	*Pipilo erythrophthalmus*

scarlet tanager	*Piranga olivacea*
summer tanager	*Piranga rubra*
Carolina chickadee	*Poecile carolinensis*
pied-billed grebe	*Podilymbus podiceps*
blue-gray gnatcatcher	*Polioptila caerulea*
vesper sparrow	*Pooecetes gramineus*
sora	*Porzana carolina*
Virginia rail	*Rallus limicola*
ruby-crowned kinglet	*Regulus calendula*
golden-crowned kinglet	*Regulus satrapa*
eastern phoebe	*Sayornis phoebe*
Louisiana waterthrush	*Seiurus motacilla*
American redstart	*Setophaga ruticilla*
eastern bluebird	*Sialia sialis*
yellow-bellied sapsucker	*Sphyrapicus varius*
American tree sparrow	*Spizella arborea*
chipping sparrow	*Spizella passerina*
field sparrow	*Spizella pusilla*
eastern meadowlark	*Sturnella magna*
lesser yellowlegs	*Tringa flavipes*
greater yellowlegs	*Tringa melanoleuca*
solitary sandpiper	Tringa solitaria
American robin	*Turdus migratorius*
barn owl	*Tyto alba*
golden-winged warbler	*Vermivora chrysoptera*
red-eyed vireo	*Vireo olivaceus*
blue-headed vireo	*Vireo solitarius*
Canada warbler	*Wilsonia canadensis*

C. Reptiles

northern copperhead	*Agkistrodon contortrix mokesan*
eastern worm snake	*Carphophis amoenus amoenus*
common snapping turtle	*Chelydra serpentina serpentina*
*bog turtle	*Clemmys muhlenbergii*
northern black racer	*Coluber constrictor constrictor*
eastern painted turtle	*Chrysemys picta picta*
*timber rattlesnake	*Crotalus horridus*
northern ringneck snake	*Diadophis punctatus edwardsi*
black rat snake	*Elaphe obsoleta obsoleta*
five-lined skink	*Eumeces fasciatus*
eastern mud turtle	*Kinosternon subrubrum subrubrum*
eastern kingsnake	*Lampropeltis getula getula*
eastern milksnake	*Lampropeltis triangulum triangulum*
rough green snake	*Liopeltis aestivus*
northern water snake	*Nerodia sipedon sipedon*
queen snake	*Regina septemvittata*
eastern musk turtle	*Sternotherus odoratus*
eastern box turtle	*Terrapene c. carolina*
eastern ribbon snake	*Thamnophis sauritus sauritus*
eastern garter snake	*Thamnophis.sirtalis sirtalis*

D. Amphibians

spotted salamander	*Ambystoma maculatum*
*mole salamander	*Ambystoma talpoideum*

American toad	*Bufo americanus*
Fowler's toad	*Bufo woodhousii fowleri*
northern dusky salamander	*Desmognathus fuscus*
seal salamander	*Desmognathus monticola*
blackbelly salamander	*Desmognathus quadramaculatus*
southern two-lined salamander	*Eurycea cirrigera*
*four-toed salamander	*Hemidactylium scutatum*
Cope's gray treefrog	*Hyla chrysoscelis*
red-spotted newt	*Notophthalmus viridescens viridescens*
white-spotted slimy salamander	*Plethodon cylindraceus*
eastern mud salamander	*Pseudotriton m. montanus*
Blue Ridge red salamander	*Pseudotriton ruber nitidus*
northern red salamander	*Pseudotriton ruber ruber*
black-chinned red salamander	*Pseudotriton ruber schencki*
northern spring peeper	*Pseudacris c. crucifer*
bullfrog	*Rana catesbeiana*
green frog	*Rana clamitans melanota*
pickerel frog	*Rana palustris*
southern leopard frog	*Rana sphenocephala*
wood frog	*Rana sylvatica*

II. Invertebrates

A. Arachnids

Marbled orb-weaver	*Araneus marmorata*
golden garden spider	*Argiope aurantia*
banded garden spider	*Argiope trifasciata*
variable wood tick	*Dermacenter variabilis*
six-spotted fishing spider	*Dolomedes triton*
goldenrod crab spider	*Misumena vatia*

B. Centipedes and Millipedes

soil centipedes	*Arenophilus* sp.
millipede	*Boraria stricta*
millipede	*Pachydesmus* sp.
millipede	*Pseudopolydesmus* sp.
millipede	*Sigmoria aberrans*

C. Crustaceans

crayfish	*Cambarus* (*Puncticambarus*) sp. C ("*acuminatus* complex")
crayfish	*Cambarus bartonii*
crayfish	*Cambarus* (*Jugicambarus*) *dubius*
crayfish	*Cambarus* (*Cambarus*) cf. sp. A (*howardi*?)
crayfish	*Cambarus* (*Depressicambarus*) *reduncus*

D. Insects

1. Butterflies and Moths

least skipper	*Ancyloxypha numitor*
Polyphemus moth	*Antheraea polyphemus*

ermine moth	*Atteva punctella*
pipevine swallowtail	*Battus philenor*
meadow fritillary	*Boloria bellona*
spring azure	*Celastrina argiolus*
common wood nymph	*Cercyonis pegala*
yellow-collared scape moth	*Cisseps fulvicollis*
alfalfa butterfly	*Colias eurytheme*
gemmed satyr	*Cyllopsis gemma*
monarch	*Danaus plexippus*
pearly eye	*Enodia portlandia*
silver-spotted skipper	*Epargyreus clarus*
*Baltimore butterfly	*Euphydryas phaeton*
little sulphur	*Eurema lisa*
eastern tailed blue	*Everes comyntas*
Leconte's haploa	*Haploa lecontei*
reverse haploa	*Haploa reversa*
Carolina satyr	*Hermeuptychia hermes*
Appalachian eyed brown	*Lethe appalachia*
red-spotted purple	*Liminetis arthemis astyanax*
*St. Francis' satyr	*Neonympha mitchellii francisci*
eastern tiger swallowtail	*Papilio glaucus*
spicebush swallowtail	*Papilio troilus*
question mark	*Polygonia interrogationis*
Isabella moth	*Pyrrhartica isabella*
great spangled fritillary	*Speyeria cybele*
*Diana fritillary	*Speyeria diana*
regal fritillary	*Speyeria idalia*

2. Beetles

soldier beetle	*Cantharis* sp.
soldier beetle	*Chauliognathus* sp.
locust borer	*Megacyllene robiniae*
Japanese beetle	*Popilla japonica*

3. Bees and Wasps

short-haired bumblebee	*Bombus subterraneus*
bald-face hornet	*Dolichovespula maculata* (*Vespula maculata*)
bumble bee	*Megabombus pennsylvanicus*
paper wasp	*Polistes* sp.
eastern yellowjacket	*Paravespula maculifrons*
common yellowjacket	*Paravespula vulgaris*

4. Other Insects

eastern blue darner	*Aeshna verticalis*
green darner dragonfly	*Anax junius*
bee fly	*Anthrax* sp.
black-winged damselfly	*Calopteryx maculata*
skimmer dragonfly	*Celithemis* sp.
meadow grasshopper	*Conocephalus brevipennis*
robber fly	*Diogmites* sp.
narrow-winged damselfly (bluet)	*Enallagma* sp.
field cricket	*Gryllus pennsylvanicus*

narrow-winged damselfly (forktail)	*Ischnura* sp.
scorpionfly	*Panorpa* sp.
lightningbug	*Photinus* sp.
Chinese mantis	*Tenodera sinensis*
crane fly	*Tipula* sp.

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APPENDIX B

Fact Sheets Included with the Project Bog Turtle Information Packet Distributed to Landowners

I. So, I Have Bog Turtles...

II. Meadow Bogs (Wet Pastures)

III. Methods of Preservation

IV. Project Bog Turtle

V. North Carolina Bog Turtle Facts (sample of state fact sheet)

So, I have bog turtles...

Q: What are bog turtles?

A: Bog turtles are one of the smallest turtles in the world. They inhabit wetlands in eastern North America. Bog turtles have a black to mahogany colored shell and distinctive orange to yellow spots on the sides of their heads. The average adult length is 3 - 3.5 inches. The wetlands they inhabit are usually small, acidic and have soft mud. Bog turtles are secretive. They rarely bask I full view like other turtles. They spend most of their time in the mud, sometimes with part of their shell sticking out to collect heat.

Q: Why are they so special?

A: The number of bog turtles has decreased significantly. This is mostly due to habitat loss and collection of the pet trade. Because of the decrease in population, bog turtles are currently listed as threatened or endangered in all states they inhabit. They are federally protected under the U.S. Endangered Species Act as "threatened" in the northern range and "threatened due to similarity of appearance" in the southern range. This federal protection makes collection of the turtles illegal.

Q: Why do people want to study them?

A: One main purpose in studying bog turtles is to gather information to assist in their recovery so they can be removed from the listing. In order to accomplish this, we need to know more about the turtles. Scientists study the turtles to learn about their life cycles, migration and habitat choice. With this information we can determine the best way to manage bog turtle sites so that the turtles flourish.

Q: What does it mean to have bog turtles on my property?

A: having bog turtles on your property is very special. Very few people will ever get to see a bog turtle other than in captivity. You have the opportunity to help preserve a threatened species. It does not mean that your property can be taken from you.

Q: Can anyone come on my property?

A: No, it is your property. The access of your property to others is your decision.

Q: Can I still use my property?

A: Yes. Having bog turtles does not affect your right to use the property. In some cases bog turtles inhabit wetlands in cattle pastures or hay fields. Current studies are trying to determine if cattle grazing maintains the open sedge areas that the turtles prefer.

Q: What if I want to drain my wetland?

A: Before you consider draining your wetland, check to make sure you would not violate any state of federal laws or risk losing USDA benefits. Most of the wetlands that bog turtles inhabit are small. Thus, the expense of draining these areas would far outweigh the financial benefit of having a bit more pasture or field.

Q: What are the benefits of protecting bog turtles?

A: There are many benefits to protecting bog turtles. Protecting bog turtles helps keep them from going extinct. Extinction is a normal process , but the current rate of extinction is unnaturally high. The most common cause of extinction is habitat loss – in other words, humans have caused this inflated extinction rate. Slowing the rate of extinction is important because every species plays a part in nature. Each species that is lost affects the natural system. Also, to protect bog turtles you must protect the wetlands they inhabit. Wetlands perform many functions that have value to humans, including wildlife habitat, flood control and filtering of pollutants and sediment in the water.

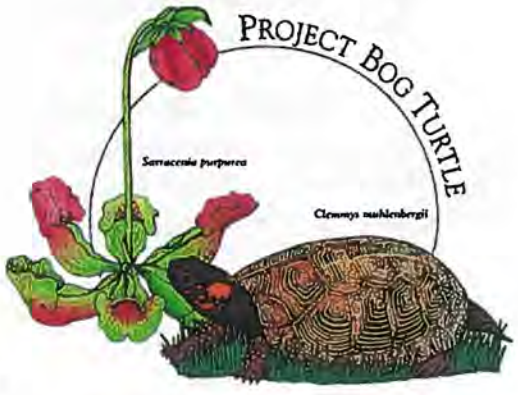
Q: How can I protect bog turtles?

A: There many different ways to protect bog turtles. To protect the bog turtle you must protect their habitat – bogs. There a presrvation programs designed for the purpose of wildlife and wetland protection and restoration that can offer technical assitance. Also, conservancies and land trusts offer many preservation options, some with financial benefits.

Contact:

Project Bog Turtle
N.C. Museum of Natural Sciences
11 West Jones Street
Raleigh, NC 275601-1029

(919) 733-7450, ext. 511



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Meadow Bogs (Wet Pastures)

What is a Meadow Bog?

The term "Meadow Bog" describes a mountain or Piedmont wetland that has been altered by human use. Meadow Bogs frequently occur on agricultural land, primarily in cattle pastures or hay fields. Most Meadow Bogs are characterized by using the three "S" system: They are spring-fed, sunny, and soggy. Most are swampy or wet areas vegetated with sedges, herbs, shrubs, and sparse trees. Meadow Bogs are true wonderlands performing many important functions which provide valuable benefits to people and wildlife.

What is a Meadow Bog?

A Meadow Bog is Important for Water Quality

Meadow Bogs are important for water quality, especially during storm events. Acting as a sponge, Meadow Bogs absorb excess storm water rushing over the land, reducing flood damage and the amount of soil entering the streams. They also improve water quality by filtering out excess nutrients, pesticides, sedimentation, and other pollutants.

Meadow Bogs Provide Habitat for Wildlife

Many rare and unusual species inhabit wetlands such as Gray's lilies, orchids, carnivorous plants, four-toed salamanders, and bog turtles. Even in altered or disturbed wetland, like Meadow Bogs, these unusual species may still persist. Familiar species also inhabit Meadow Bogs such as frogs, songbirds, white-tailed deer, and woodcock. Furthermore, because wetlands keep streams and rivers clean, they help maintain habitat for sport fish, such as trout.

Why Preserve Meadow Bogs?

The southeastern United States has lost approximately 90% of its mountain bogs. When wetlands disappear, so do the benefits they provide. The loss of wetlands has resulted in increased flooding, increased water contamination, and a decrease in waterfowl, migratory bird, fish, and other species that use wetlands. Because huge losses have already occurred, it is even more important to preserve and restore our remaining wetlands. There are many ways in which you, as a steward of the land, can help maintain our wetlands and the species that depend on them.

Recommendations for Maintaining a Meadow Bog

Farming is a needed activity that can benefit some wetland species. For example, moderate grazing or occasional mowing provides open habitat for the rare and endangered bog turtle. These management activities control the growth of woody plants and shrubs that can otherwise take over open wetlands.

- Allow only moderate to light grazing
- When mowing, set blades high to avoid destroying habitat and nests of birds and small mammals
- Mow as infrequently as possible to increase wildlife habitat. Good wildlife areas often look "weedy," but this isn't bad!
- Control woody vegetation by cutting when the area is becoming more shaded than sunny
- Provide native vegetation buffers around the wetland to filter pollutants and benefit wildlife

Want to learn more?

An excellent source for information on Meadow Bogs is the handbook titled *The Restoration & Management of Small Wetlands of the Mountains & Piedmont in the Southeast: A Manual Emphasizing Endangered & Threatened Species Habitat with a Focus on Bog Turtles* written by Ann B. Somers, Kenneth A. Bridle, Dennis W. Herman, and A. Barry Nelson in cooperation with the Natural Resources Conservation Service, Watershed Science Institute, Raleigh, NC, published in 2000. Contact Ann Berry Somers, Department of Biology, University of North Carolina at Greensboro, P.O. Box 26174, Greensboro, N.C. 27402-6174, 336-334-4978, absomers@uncg.edu.

There are programs that provide technical and possible financial support for Meadow Bog restoration and management. For further information on these options, contact your local USDA Natural Resources Conservation Service office, US Fish and Wildlife Service office, Project Bog Turtle, the North Carolina State Museum of Natural Sciences, or your local land trust.

Methods of Preservation of Wetlands

1. Wetlands Reserve Program

The Wetlands Reserve Program (WRP) was established to assist farmers with restoration and protection of wetlands. The program was originally created in the 1990 Food, Agriculture, Conservation, and Trade Act and has been amended in the 1995 Farm Bill. The WRP includes restoration cost-share agreements, thirty year or perpetual conservation easements and cost-sharing for restoration. Also, for each wetland in the program a management plan is developed by the Natural Resource Conservation Service (NRCS) and US Fish and Wildlife Service (USFWS) to guide in their restoration and management. Contact: NRCS or USFWS.

2. Wildlife Habitat Incentives Program

The 1996 Farm Bill created this program to help landowners improve wildlife habitat. The program provides guidance and cost-share money for restoration or development of wildlife habitat. This program is still in developmental stages. Contact: NRCS.

3. Partners for Wildlife

Partners for Wildlife is a U.S. Fish and Wildlife Service (USFWS) program developed to protect wildlife through restoration and preservation of habitat. Some of the components of the program are habitat and restoration management, technical assistance, habitat protection programs, education, and outreach. Restoration costs may be covered or shared with the landowner. Contact: USFWS.

4. Natural Heritage Program

Many states have natural heritage programs that are able to offer some forms of protection for natural areas. The following is an example from North Carolina:

The North Carolina Natural Heritage Program (NCNHP) is administered by the Division of Parks and Recreation, Department of Health and Natural Resources. They offer two forms of protection for natural areas: registry and dedication. Registry of property with the Natural Heritage Program is a voluntary non-binding agreement that acknowledges that the landowner intends to protect the site and possibly manage the property to maintain its natural assets. Dedication is a permanent form of protection similar to a conservation easement. Contact: The Natural Heritage Program of your state.

5. Conservancies and Land Trusts

Conservancies and land trusts are non-profit organizations created to preserve and restore natural resources. The scope of each organization varies. Regional land trusts focus on a local area or specific resource, for example a river or lake. Some larger organizations, such as The Nature Conservancy, are interested in exceptional resources around the world. There are many different preservation methods that involve conservancies and land trusts. In addition to the benefit of protecting a natural resource, some of these options can have financial benefits. Following are brief descriptions of a few options.

* *Management Agreements* - Management agreements are made between the landowner and a conservation organization. The agreements are temporary and each is designed to fit the particular desires of the landowner. Management agreements involve the development of a conservation plan which is implemented by the conservation organization or the landowner.

* *Conservation Easements* - Conservation easements are voluntary legal arrangements which specify that the property in question can only be used in ways that preserve its natural assets. They are usually managed by a conservation organization. The easement is tailored to the desires of each landowner.

Conservation easements can have many tax benefits. They can reduce federal income tax, estate tax, gift tax, state inheritance tax, and sometimes local property taxes. Conservation easements are usually perpetual. Although temporary easements are possible, in most cases the tax benefits only apply to perpetual easements.

* *Leases* - Leases of property to a conservation organization are no different from any other property lease. They are temporary and provide income to the landowner without change in ownership. The use of the property by the conservation organization is specified within the lease.

* *Sales* - Conservation organizations generally have a limited amount of funds for land acquisition. Because of these financial constraints, they usually purchase property at a reduced price. The landowner may receive an income tax reduction by claiming the difference between the selling price and the fair market value as a charitable donation. Selling at a reduced price also reduces capital gains tax by reducing the amount taxed.

* *Donations* - Donating property to a conservation organization is the most effective method of reducing taxes. The benefits include federal income tax deductions equal to the fair market value of the land, estate tax benefits, and avoidance of capital gains tax. The North Carolina Conservation Tax Credit Program also permits a dollar for dollar state income tax credit and an income tax reduction for larger gifts. Contact: A local land trust or conservancy.

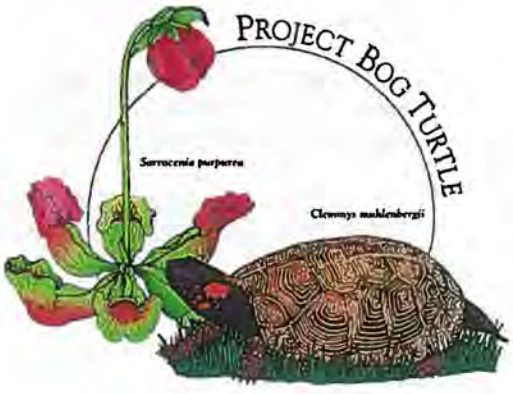
PROJECT BOG TURTLE

Project Bog Turtle is a conservation initiative of the North Carolina Herpetological Society. The directors are **Dennis W. Herman** (N.C. State Museum of Natural Sciences, Raleigh, NC), **Tom Thorp** (Three Lakes Nature Center and Aquarium, Richmond, VA), and **Ann B. Somers** (UNC-Greensboro, Greensboro, NC). The original project began in the late 1970s by Dennis Herman as a continuation of a bog turtle distribution survey, initiated by Robert T. Zappalorti (Staten Island Zoological Society), in southwestern North Carolina and expanded to include other southern states to locate new sites and populations of bog turtles. Most of the work, however, was conducted in North Carolina. The project involved population density studies in several sites and a captive propagation and head-start program at the Atlanta Zoological Park (now Zoo Atlanta). It was evident, as the project progressed, that additional personnel and assistance from various state, federal, and private agencies would be needed.

In 1988, the N.C. Herpetological Society became an important partner in the project and began the N.C. Piedmont Bog Turtle Survey under the coordination and direction of Dennis Herman and Tom Thorp. This survey proved very successful as several new county records and additional sites were located. Today, because of these surveys there are 140 bog turtle occurrence records known from 21 counties in North Carolina. The original bog turtle project and the N.C. Piedmont turtle survey were combined and renamed Project Bog Turtle in November 1995. Project Bog Turtle's main goals are:

1. To protect bog turtle habitat through leases, purchases or easements.
2. To restore and implement management and restoration strategies of degraded habitat.
3. To continue surveys to locate new populations and sites.
4. To continue to monitor and study population densities in selected sites using mark-and-recapture, radio telemetry, and trapping studies.
5. To educate, cooperate with, and involve landowners in bog turtle conservation.
6. To consult with, assist, and disseminate information to federal, state, and conservation agencies.

PBT received funds from the U.S. Fish & Wildlife Service for conservation lease agreements with landowners, a status survey in the Southeast for additional populations, and Partners for Wildlife program for the restoration and management wetlands in Surry Co. and Alleghany Co., N.C. Surveys have been conducted in NC, TN, and VA while assisting researchers and biologists in those states with successful results. Additional surveys, radio tracking studies, and other projects are scheduled for the coming years.



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NORTH CAROLINA BOG TURTLE FACTS

- The bog turtle is North Carolina's smallest turtle, with most measuring less than 4 inches (114 mm) in straight-line carapace length. The largest N.C. specimen on record measured 4.3 inches (109.5 mm).
- Bog turtles are among the most terrestrial of North Carolina's turtles, second only to the eastern box turtle (*Terrapene carolina*). Like box turtles, bog turtles can feed on land. Most other turtles must be underwater in order to swallow.
- Bog turtles are primarily carnivorous, eating insects, slugs, snails, worms and small vertebrates. They may also eat seeds, berries and other plant material.
- Bog turtles lay from one to six eggs, usually in June or July. Unlike most turtles, they rarely dig nests, instead depositing their eggs in moss or sedge tussocks, and often covering them poorly.
- In North Carolina, bog turtle wetlands range in elevation from 720 feet in Forsyth and Gaston counties, up to 4,500 feet in the amphibolite mountains in Ashe County. Most sites are between 2,000 and 3,000 feet elevation.
- Bog turtles were first discovered in North Carolina in 1879 near Statesville in Iredell County. Today they are known from the upper Piedmont and Blue Ridge Mountains in 21 counties from Forsyth County westward to Cherokee County.
- Bog turtles are listed as "Threatened" by the state of North Carolina and "Threatened Due to Similarity of Appearance" under the U.S. Endangered Species Act.

Project Bog Turtle,
N.C. Herpetological Society,
11 West Jones Street,
Raleigh, NC 27601

APPENDIX C

Conservation Lease Agreement

CONSERVATION LEASE AGREEMENT

This is a conservation lease agreement between_____
(Landowner) and PROJECT BOG TURTLE of the N.C. HERPETOLOGICAL SOCIETY, (Lessee).

WHEREAS, there exists on the property of Landowner a population of bog turtles (*Clemmys muhlenbergii*) or quality potential bog turtle habitat, and the parties wish to enter into this Agreement for the purpose of protecting these turtles and the special habitat on which they live.

NOW THEREFORE, in consideration of the promises contained herein, the parties agree as follows:

1. Term. This Agreement will be in force and effect for an initial period of _____ (____) year(s) and may be extended for additional periods upon agreement of the parties.

2. The land over which this Agreement extends is located and described as follows:

Site Name & Locality: _____

_____ Wetland Acres

_____ Buffer Acres

_____ Total Acres

3. Payment. Lessee will pay to the landowner the sum of _____ Dollars ($_____) per year, at $ _____per acre, payable each year in advance upon availability of funds.

4. Landowner will not willfully or knowingly use or permit others to use the land in such a manner as will detrimentally affect the bog turtles that live there or their habitat. The Landowner will not take or remove and will not grant permission to others to take or remove any bog turtles from the land. However, this section shall not prohibit the Lessee from taking or removing bog turtles in furtherance of any conservation or recovery plan as stated on Lessee's endangered species permit.

5. The Landowner hereby grants reasonable access to the land to Lessee, its members and others acting on its behalf, for the purpose of studying and monitoring the bog turtles and for taking reasonable steps for their protection, including habitat management and enchancement, which are not inconsistent with the Landowner's use of the property. The Lessee agrees to notify the Landowner before they or others acting on their behalf come onto the land pursuant to this Agreement if the Landowner so desires and requests such notification.

6. Any material breach of this Agreement due to the negligent or willful action of the Landowner which causes or threatens to cause injury or destruction to the bog turtles or their habitat shall entitle Lessee to recover from the Landowner part or all of any funds or material or equipment provided by Lessee to the Landowner pursuant to this Agreement.

7. Lessee agrees to hold the Landowner harmless for any personal injuries or death which occur to any members or others acting on its behalf which occur while on the premises.

IN WITNESS WHEREOF, the parties have executed this Agreement by their duly authorized representative.

Executed this _____ day of _____, 20_____.

Landowner's Name (Printed): _____

Landowner's Address: _____

_____

_____

Landowner's Signature: _____

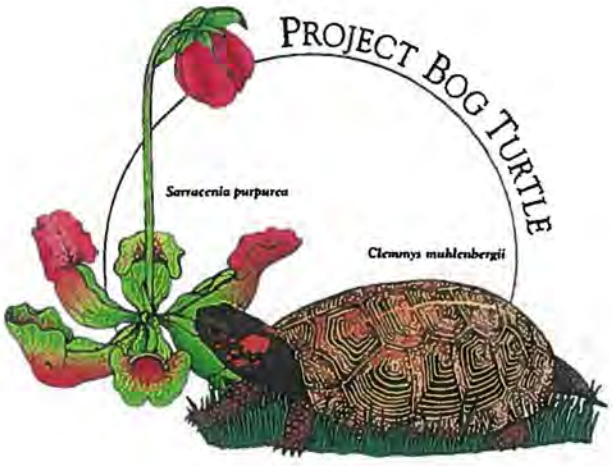
Date: _____

Lessee's Name: **Project Bog Turtle**

Representative's Name, Title: _____

Representative's Signature: _____

Date: _____



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APPENDIX D

Addendum: 2003 Project Bog Turtle Year End Report

PROJECT BOG TURTLE: 2003 YEAR END REPORT

The 2003 field season was very successful with 4 new sites or records found and/or reported to us in North Carolina,Tennessee, and Virginia. New records from North Carolina include a new Avery County site found by Jerry Reece, with Ann Somers finding the first turtle there, and a new Clay County record was reported by Chris McGrath in a National Forest site where turtles had not been found on previous visits. Bern Tryon Knoxville Zoo) reported a new Johnson County,TN site that he and his assistant, Lynn Eastin, found about .6 airmiles north of one of his study sites. The Virginia record was reported to us by Rick Hudson (Fort Worth Zoo) via Bern Tryon after an article and photograph appeared in a local Patrick County newspaper (Rick's parents live in Stuart, VA). This turtle was found crossing a road in the vicinity of the controversial gas pipeline corridor.

Project biologists reported additional turtle movement observations during the year. Bern Tryon reported a late season move by an adult female that left the study site and traveled over 1 mile south until it came to the stream that drains the valley. The turtle followed the stream, staying in the high vegetation along the bank. Unfortunately, the turtle encountered a stretch of lawn mown to the stream's edge, was attacked by a dog and severely mauled. Lynn Eastin, Bern's assistant, found the turtle and took it to the Knoxville Zoo (over 2 hours drive) for treatment by the veterinarians. The turtle was treated, but died after about a month at the zoo.

Georgia

Dr. Ken Fahey reported that 43 captures and recaptures of bog turtles were made in Georgia during 2003. A total of 20 individual turtles were captured, PIT-tagged, and released. A total of 25 bog turtles have now been PIT-tagged in Georgia. Four new turtles were collected at Nichols Bog and eight new turtles were collected at Eaves Bog bringing the total number of adult bog turtles collected in Georgia to 46.

North Carolina

PBT field workers found at least 70 individual turtles, in 2003, from 12 sites in 5 counties. Forty-three (43) turtles were new and 27 previously marked turtles were recaptured. Four of the recaptured turtles were initially marked this year and recaptured during later visits to the site. Forty turtles were implanted with PIT-tags during the year in NC.

Tennessee

Bern Tryon reported 51 individual turtles and 157 total captures from the four valley sites (Orchard Bog, Quarry Bog, Beaverdam Bog, and Little Pond Bog) that he and Lynn monitored in 2003. Six new turtles captured included a yearling at Beaverdam Bog and five (1.4) at Little Pond Bog. Male # 1.7 from Orchard Bog, not seen there since 1998, was found at Little Pond Bog this season. Trapping began at Ripshin Bog (release site) on 20 April, and tracking began as soon as transmitters were replaced. Captures in Ripshin were 25 individual turtles and 69 total captures. Recaptured turtles at the Ripshin Bog now total 37 individual turtles which represents a 39% survival rate of the original total released. Blood samples were taken from 16 turtles and sent to Dr. Tim King for his microsatellite DNA study. Goats were rotated in and out of various sections of Quarry Bog this year and Rodeo was used on some trees, also. One landowner allowed the installation of an exclusion fence for horses through one non-TNC section of Orchard Bog.

Virginia

Tom Thorp spent several days along the gas pipeline construction route (Carroll and Patrick counties) to rescue any bog turtles that happened to be seen. No turtles were observed.

Project PIT-tag

Project PIT-Tag continued with great success during the year. Project Bog Turtle biologists continued to assist Chris McGrath (N.C. Wildlife Resources Commission) in the commission's quest to implant transponders in 200 wild bog turtles from the southern population by the end of this year. That goal was met because this season, 47 bog turtles were

implanted from 12 sites in 6 counties in NC, 21 turtles from 2 sites in 1 county in GA, and 17 turtles from 7 sites in 3 counties in VA. Currently 238 individual bog turtles have been implanted in GA, NC, and VA.

Lease Program

Project Bog Turtle's lease agreement program added several new bog turtle habitat leases during 2003. The following sites were either new leases, renewed leases, or continued leases for the 2003 season:

Hartness Site, Wilkes Co., NC	2.0 acres	continued lease
Hayes Site, Wilkes Co., NC	5.0 acres	continued lease
Wildcat Bog, Wilkes Co., NC	5.0 acres	continued lease
Amburn Site, Surry Co., NC	6.0 acres	new 5 year extension
Everhart Site, Surry Co., NC	1.0 acre	continued lease
Schuyler Bog, Surry Co., NC	7.0 acres	new 5 year extension
Laurel Branch Bog, Alleghany Co., NC	10.0 acres	new 5 year extension
Nichols Bog, Union Co., GA	20.0 acres	continued lease
Sugar Mountain Wetlands, Avery, Co., NC	100.0 acres	new lease
Nunez Bog, Avery Co., NC	10.0 acres	new lease
	166.0 acres	Total

Other Projects

Dave Lee has received a permit from the NC Wildlife Resources Commission to start a captive-breeding project at his facility near White Lake. Dave plans to purchase the needed stock from a breeder in Florida and offspring will be available to provide future release animals (under NCWRC sanctioned programs) for stocking into extirpated sites or sites in which turtles have not been found after extensive surveys (similar to the Tennessee project). Offspring would, also, be available for educational and exhibition purposes by zoos, museums, and nature centers in NC. PBT will assist Dave with the planning and coordination of this project.

Project & Field Assistance

Project Bog Turtle was fortunate to have the following people donate their generous time to assist in the fieldwork or provide useful information about their projects or sites:

Tom Akre	Ken Fahey	Chris McGrath	Tom Thorp
Jeff Beane	Laura Fogo	Kay Nunez	Bern Tryon
Amy Bleckinger	David Getz	Jerry Reece	Beth Walton
Kurt Buhlmann	Jim Green	David Rupp	Jim Warner
David Campbell	Dennis Herman	David Sawyer	Joe Zawadowski
Vickie Cumbee	Merrill Lynch	Tammy Sawyer	
Bob Davis	Jennifer Mansfield-Jones	Deidra Smith	
Lynn Eastin	Missy McGaw	Ann Somers	

Donations

Donations totaling nearly $2500 were received since last year's NCHS meeting. We thank the following: Walter Allen, Bob Cherry (High Country Conservancy), Bob Davis (GlaxoSmithKline match), Jeff Hall (2003 Wildathon), Sue & Ralph Humphries, Alicia Jackson, N.C. Herpetological Society, Kay Nunez, Mindi & Ronald Patterson, Jesse Perry, Vicky Poole, Dr. Gregory Pokrywka, Jerry Reece, Jason Riley, Melody Scott, Brett & Nancy Stearns, Wake Audubon Society (Wildathon: Jeff Beane), and Beth Walton (memoriam for Joseph Noe Bryant), for their generous donations to further research for the bog turtle in the Southeast.

Muhley Award

Two 2003 "Muhley" Awards were presented this year for outstanding contributions to Project Bog Turtle. One award was given to Jerry Reece for his outstanding contributions to PBT and his assistance to Ann Somers with trapping work in the Nunez Bog. The second award was given to Mrs. Kay Nunez who graciously allowed access to her important Avery County wetland, signed a 5 year lease agreement, and for her generous donation to Project Bog Turtle.

Special Thanks

We thank the owners of the leased sites for their support and cooperation in protecting the bog turtle habitats in their care. Our thanks go to all of the landowners and caretakers for their permission to conduct our research and surveys on their properties.

Dennis W. Herman, Director and Co-chair
1 November 2003