A POPULATION OF BOG TURTLES IN THE PIEDMONT OF NORTH CAROLINA:

Habitat Preferences, Capture Method Efficacy, Conservation Initiatives, and Site Enhancement

by

Ann Berry Somers
Department of Biology
University of North Carolina at Greensboro
Greensboro, North Carolina

Submitted
to
Natural Resources Conservation Service
Wetlands Institute

Abridged Version
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In order to protect the research subjects,
some sensitive information has been omitted.

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Preface

In 1993, bog turtles, *Clemmys muhlenbergii* (Schoepff), were found in a wet meadow in the piedmont of North Carolina. Although the site appeared degraded and grazing pressure was heavy, there seemed to be enough remaining habitat to support a healthy population of bog turtles. Interest grew in the site and soon a bog turtle habitat restoration effort was being discussed. Funds to initiate the project were provided by the Partners for Wildlife program of the US Fish and Wildlife Service (USFWS). A review of work performed in the southeast revealed very little data available on restoring, enhancing or managing such sites. Due to a paucity of guidelines for management of these rare wetlands, the goodwill of the landowners, enthusiasm of local conservationists, and the dedicated members of Project Bog Turtle — the scope of the original project expanded. The project now focuses on conducting basic research that will ultimately lead to the development of management guidelines for such sites. As a number of state, federal, and private agencies are starting to promote restoration, the urgent need for such information is very apparent. Studies that have been generated from this project address such interests as restoration hydrology, woody vegetation management, the role of grazing herbivores in habitat management, and other concerns.

Another outgrowth of the project has been a cooperative agreement aimed at preserving these valuable wetlands. A Memorandum of Understanding has been developed to formalize this partnership between the following: NC Chapter Soil and Water Conservation Society, Natural Resources Conservation Service (NRCS) Wetland Science Institute and Watershed Science Institute, US Fish and Wildlife Service, Sierra Club, The Nature Conservancy, NC Natural Heritage Program, Piedmont Land Conservancy, Foothills Nature Science Society, Project Bog Turtle, and others.

> "Despite problems [conserving species], there appear to be success stories... These have been long, arduous affairs. And for the most part, they have been the work of extraordinarily dedicated individuals, not legions of bureaucrats. I suspect that the turtle wars will be fought and won and lost by individual `turtle men' and 'turtle women' who are on divine missions from the chelonian gods to save their species."
>
> - John L. Behler (1997)

I would like to acknowledge the assistance of the following *extraordinarily dedicated individuals:*

The members of Project Bog Turtle:
Dennis Herman; Tom Thorp; Jeff Beane; Joe Zawadowski; Chris McGrath; Nora Murdock; Tammy Sawyer; David Sawyer; Jim Green and others.

Data analysis: Jennifer Mansfield-Jones, Ph.D.
Department of Biology, University of North Carolina at Greensboro

Editorial assistant: Elizabeth Walton, UNCG

Plant species list: Kenneth A. Bridle, Ph.D.

Student assistants: Elizabeth Walton, UNCG
Ingrid Franzen, Nicholas School of the Environment, Duke University
Keefe Govus, UNCG
John Posey, UNCG

Technical assistance and field assistance were provided by:
Dick Everhart; Trent Schuyler; Lisa Schuyler; Miranda Holcomb; Brannon Holcomb; Angela Jessup; Jennifer Mansfield-Jones; Elizabeth Walton; John Sealy, HI; Joe Mickey; Teresa Howell; Matthew Taylor; Roger Leab; Greg Gions; Tony Davis; Dan Smith; Jeff Williams; Charles Boles; Barry Nelson; Chris McGrath; Ron Determan; Dr. Jay Donnaker, DVM; Dr. Teresa Carroll, DVM; Ken Bridle; Janice Nichols; Jim Warner; Bern Tryon; Alan Boynton; Abraham, Noah and George Somers.

Funding and other support for the project were provided by:
Natural Resources Conservation Service; US Fish and Wildlife Service; Foothills Nature Science Society; North Carolina Wildlife Federation; The Duke Power Company Foundation; Soil and Water Society of North Carolina; Project Bog Turtle; North Carolina Herpetological Society; Reidsville Veterinary Hospital; Foothills Nature Science Society; Somers Sheet Metal; Sierra Club of North Carolina; Jean Berry; Ann and George Somers; Pilot View Resource and Development, Inc.

North Carolina Wildlife Resources Commission provided permits.

1. Introduction

1.1 Background and Purpose

Many scientists now recognize the importance of landscape-level management in protecting ecosystems and communities of organisms (National Research Council 1992). Among the rarest and most endangered of ecosystems in the southeast are spring-fed wetlands of the mountains and piedmont. Such areas provide habitat for approximately 90 species of plants and animals that are considered rare, threatened or endangered (Murdock 1994). Many of these sites have been drained or otherwise altered by human activity. Due to the loss of wetlands over the years, only about 500 acres of mountain bog habitat remain (A. Weakly in Herman and Tryon 1997).

A rare element known to occur in some of these sites is the bog turtle, *Clemmys muhlenbergii* (Schoepff). Bog turtles are small, secretive turtles that inhabit spring-fed wetlands within a limited range in the eastern U.S. The turtles occur in disjunct patches of habitat in 12 states from New England to northeastern Georgia (Figure 1). A four hundred km (250-mile) gap separates the turtles into distinct northern and southern geographic regions (Herman 1994). The northern population occurs from New York and Massachusetts south to Maryland. The southern population ranges from southwest Virginia to northern Georgia. Bog turtles are threatened with extinction throughout their range and are protected in all 12 states of their occurrence.

In order for the US Fish and Wildlife Service to list a species as Threatened or Endangered, sufficient data must be available to justify the listing. Presently, the Service only has sufficient status and threat data to support the listing of the northern population. The northern population was federally listed as Threatened in 1997 and now receives protection under the Endangered Species Act (USFWS 1997). The southern population is listed as "threatened due to similarity of appearance." Turtles from southern populations so closely resemble turtles from northern populations that enforcement personnel cannot be expected to distinguish between them. The "similarity of appearance" listing is designed to minimize enforcement problems and help conserve the northern population (USFWS 1997). Status surveys are now underway in the south, attempting to assess the number and range of extant colonies.

Bog turtles are a species vulnerable to extinction. They are late maturing, have low rates of population increase, and require specialized habitats. In addition, their population sizes are usually small and their ability to disperse effectively has been greatly reduced due to habitat loss, and reduction and fragmentation of habitat.

An interesting aspect of this species is that it is often located in agricultural settings in sunny, soggy wetlands of cattle and horse pastures. Such areas have come to be included in a community type known as wet meadows or meadow bogs (Kiviat 1978; Herman and Tryon 1997). Many biologists are inclined to think of endangered and threatened species as being incompatible with agriculture. This is not necessarily true for the bog turtle. Although draining for agricultural purposes and overstocking pastures have degraded many sites, bog turtles can still be found in wet pastures. Turtle densities are often higher in grazed pastures than in similar non-grazed, more natural areas with a canopy or sub-canopy (Herman and Tryon 1997). However, other rare elements such as Gray's lily *(Lilium* *grayi),* bog rose *(Arethusa bulbosa),* and swamp pink *(Helonias bullata)* found in non-grazed or lightly grazed wetlands have already been lost from many sites on farms.

Degradation of sites subjected to grazing can result from hoof traffic and excess nutrient input from fecal materiaL The fact that many colonies of turtles are found on farms is testimony to the notion that there are also benefits associated with grazing. Scientists considering this matter suggest that grazing cattle and horses retard the growth of woody vegetation and prevent canopy closure (Herman and Tryon 1997; Buhlmann et al. 1997; Herman 1999).

Since many viable bog turtle colonies are found in pasture settings, protecting bog turtles from extinction means developing ways to manage sites on farms so those populations can be stabilized or increased. The long-range goal of this project is to increase the number of bog turtles in a degraded meadow bog on a farm with an active cattle operation. The techniques being tested are simple and the materials cheap and readily available. The intent is to gather baseline data on a population of bog turtles in a site where enhancement efforts are underway in order to provide guidance on the restoration and management of similar sites commonly referred to as bogs and meadow bogs. Concurrent studies at the site include a hydrological assessment and a woody vegetation management study. The project hydrologist plans to manipulate the flow of water in one section of the wetland in hopes of offsetting the damage caused by an existing drainage ditch. This should increase the size of the habitat preferred by the turtles. We are presently monitoring the water levels to establish baseline data for pre- and post-treatment analysis in order to determine if these efforts are successful.

Composite Range of the Bog Turtle in the Eastern United States

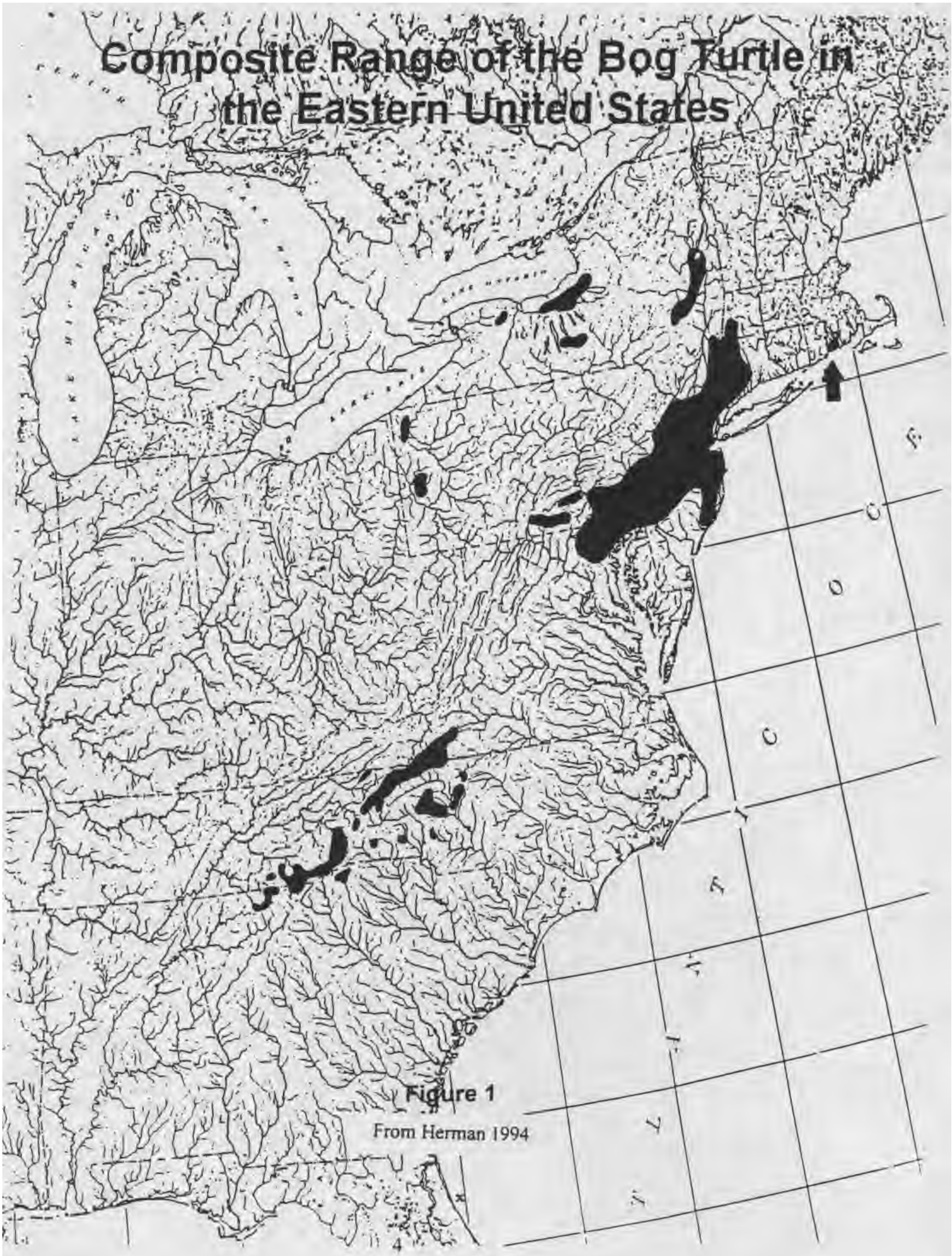


Figure 1

From Herman 1994

1.2 The Site

1.2.1 Site Description

This study was undertaken on a privately owned, family farm in an Upper Piedmont community in North Carolina at the base of the Blue Ridge escarpment, approximately 457 m (1500 feet) above sea level (Site 3, Figure 2). The primary agricultural use of the farm is beef production. The land has been in the ownership of the family for over 100 years and presently there are five members of three generations living there. Earnings generated from the farm supplement the family income. Although no property is safe from future development, there is no discussion at this time of selling the farm or any portion of the property for any reason.

There are three very small and distinct wetland patches on this farm contained within a diameter of .5 km (Figure 3). The three patches border a cobble and gravel dominated stream (Type Bc and C in Rosgen classification, Rosgen 1996). Together they are about 1 hectare in size (1.025 ha).

Bog #1 has been termed "the open patch." It has deep soft mud and receives significant sunlight due to the low-level vegetation and open canopy conditions. It is .256 hectares (.635 acres) in size and has a core of tag alders *(Alnus serrulata)* surrounded by common wetland herbaceous vegetation of *Carex* spp., *Scirpus* spp., *Juncus* sp., etc. (Appendix V). Heavy use by cattle prior to erection of the exclusion fence resulted in a denuded path through alders in the lower end of this patch. The open patch is considered the core area because it most closely resembles preferred habitat (sunny, spring-fed wetland with soft mud and low-level sedges and grasses) and most of the turtle captures have been patch (#3) is particularly dramatic. There seems to be some recovery by the late 1970s. The elder landowner, now in her late sixties, recalls trying to drain the hayfield patch with her husband some decades earlier. She recounts the tremendous effort she and her husband put forth to dig out the ditch with a horse-drawn pan. From the photographs, we may speculate that they attempted to drain the area sometime in the late 1950s to mid 1960s.

1.2.3 Reasons for Choice

This site has several characteristics that make it attractive for a population study and site enhancement project:

- *Landowner stability:* This farm has been held in the family for more than 100 years. The present landowner is in his mid-thirties with children that seem genuinely interested in the farm, the turtles and the project;
- *Landowner interest:* All five family members living on the farm (three generations) are supportive of the project and are interested in helping;
- *Small size:* Site enhancement efforts should have detectable results;
- *Three distinct wetland patches* in close proximity that contain seemingly suitable habitat for bog turtles;

  Wetlands are seemingly suitable in size, vegetation and hydrology to support an increasing number of bog turtles.

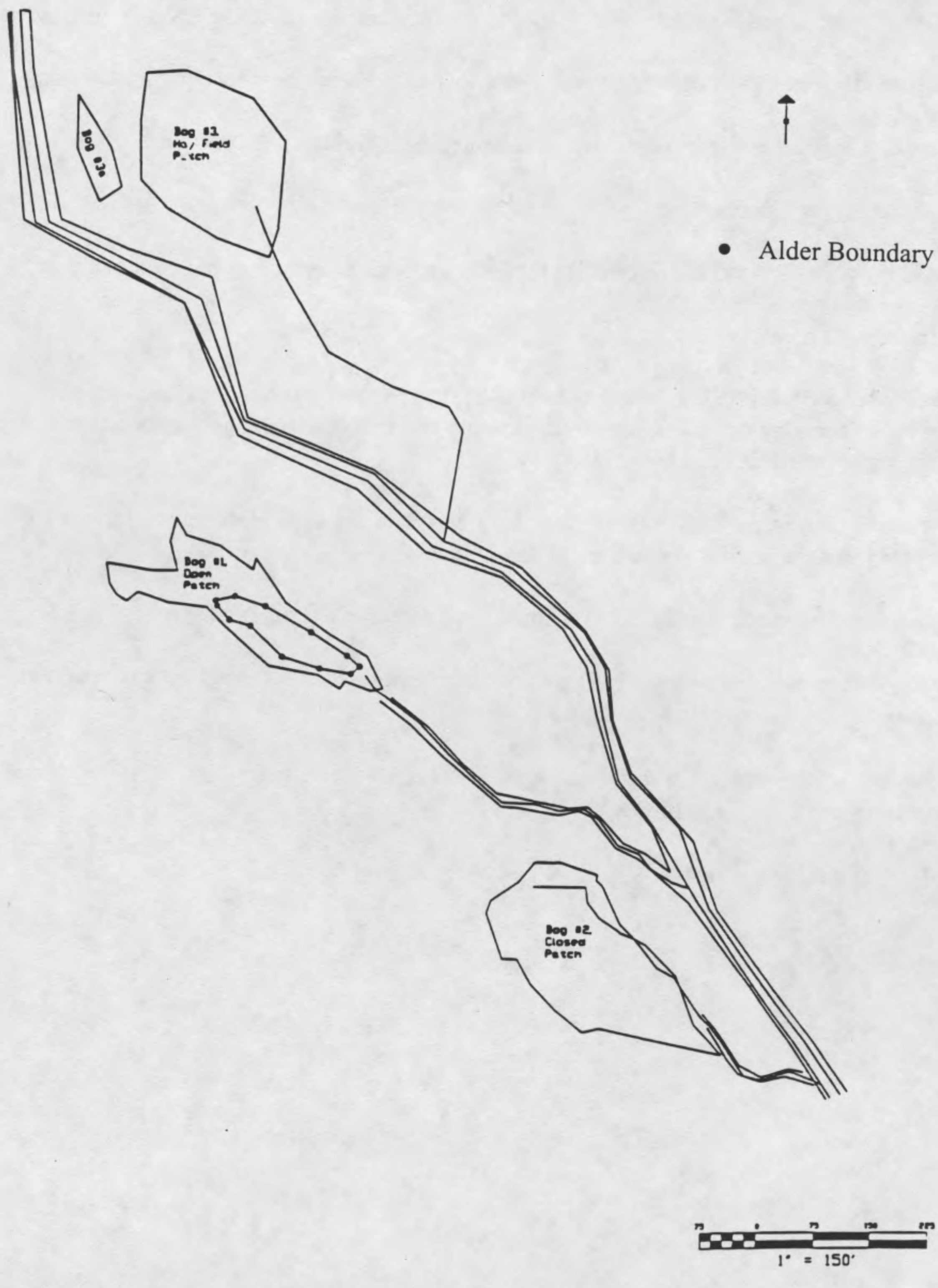


Figure 3. BOG WETLAND STUDY -

Surveyed 1995 & 1996

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE

3/20/97

2. Conservation Initiatives and Site Enhancement

2.1 Landowner Interactions

2.1.1 Education

None of the landowners had ever seen or heard of bog turtles until one was trapped on their farm in 1993 (Figure 4) as part of the County Natural Areas Inventory (Randall et aL 1995). Subsequently, I provided them with written material in the form of Landowner Packets (Appendix II) which were compiled by Project Bog Turtle (PBT) and Ingrid Franzen, a summer intern. Family members were also invited to local talks that were being given as part of the inventory, which they attended on several occasions.

2.1.2 Landowner Involvement in Data Collection and Habitat Enhancement

The landowners not only granted access to the site, they became actively involved in the project. All members of the three generations living on the farm participated in different ways including: helping with fence construction, monitoring water depth in wells, checking traps and helping with visual surveys (Figure 5).

2.1.3 Lease Agreement

Funds provided by the Fish and Wildlife Service made it possible for Project Bog Turtle (PBT) to lease meadow bogs from landowners between 1997 and 1999. The lease agreements are part of an experimental program designed to heighten the interest of landowners in protecting endangered species on their property. The leases are modeled after traditional rural land-lease agreements where one farmer leases land from another farmer for hay production (Appendix In). The family readily agreed to participate in the experimental program with PBT

Figure 4. Photo was taken the first day this landowner had ever seen a Bog Turtle. May 23, 1993

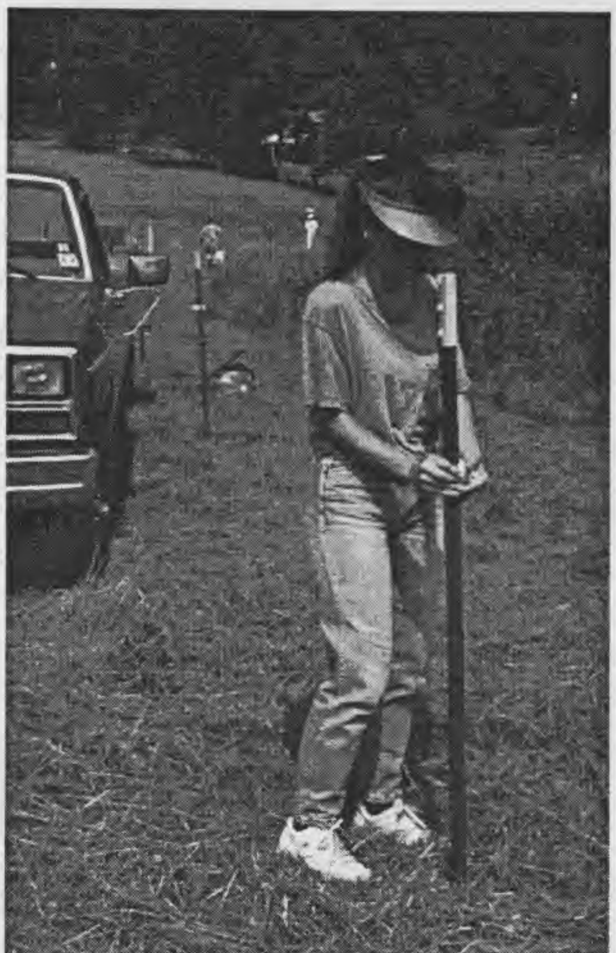


Figure 5. Family members help construct a livestock exclusion fence. July 2, 1994.

2.2 Seasonal Exclusion of Cattle

There are positive and negative impacts of large herbivores grazing in meadow bogs. The negative impacts include: (1) denuding vegetation in areas of the bog that become paths; (2) nutrient input from fecal material; and (3) the potential to trample sensitive species including bog turtles and eggs. The positive impact is the retardation of woody vegetation growth so that the canopy remains open. In order to reduce the negative impacts of cattle in the wetland but still allow the cattle restricted access, a seasonal exclusion fence was erected around the open patch in July of 1994 and later extended in November 1996 (Figure 6). The idea was to exclude cattle during the season that eggs may be in the site (growing season) and open the gates during the winter for grazing and browsing. Table 1 provides dates of cattle exclusion.

Table 1. Dates Of Cattle Exclusion 1994 -1998.

Year:	1994	1995 - 96	1997	1998
Cattle excluded	2-Jul-94	8-Apr-95	all year*	most of year *
Open to grazing	16-Dec-94	23-Jan-96		4-Dec-98

*Cattle were excluded all year in 1997 and most of 1998 to protect sensitive water-monitoring equipment.

2.3 Headstarting

In 1993, a gravid female (0.2) was moved to Zoo Atlanta, under the care of Dennis Herman, to participate in a headstarting initiative that was underway in North Carolina at the time. Headstarting is a term used in many different applications in turtle conservation. In this case it is used to describe the incubation of eggs while in the protective custody of

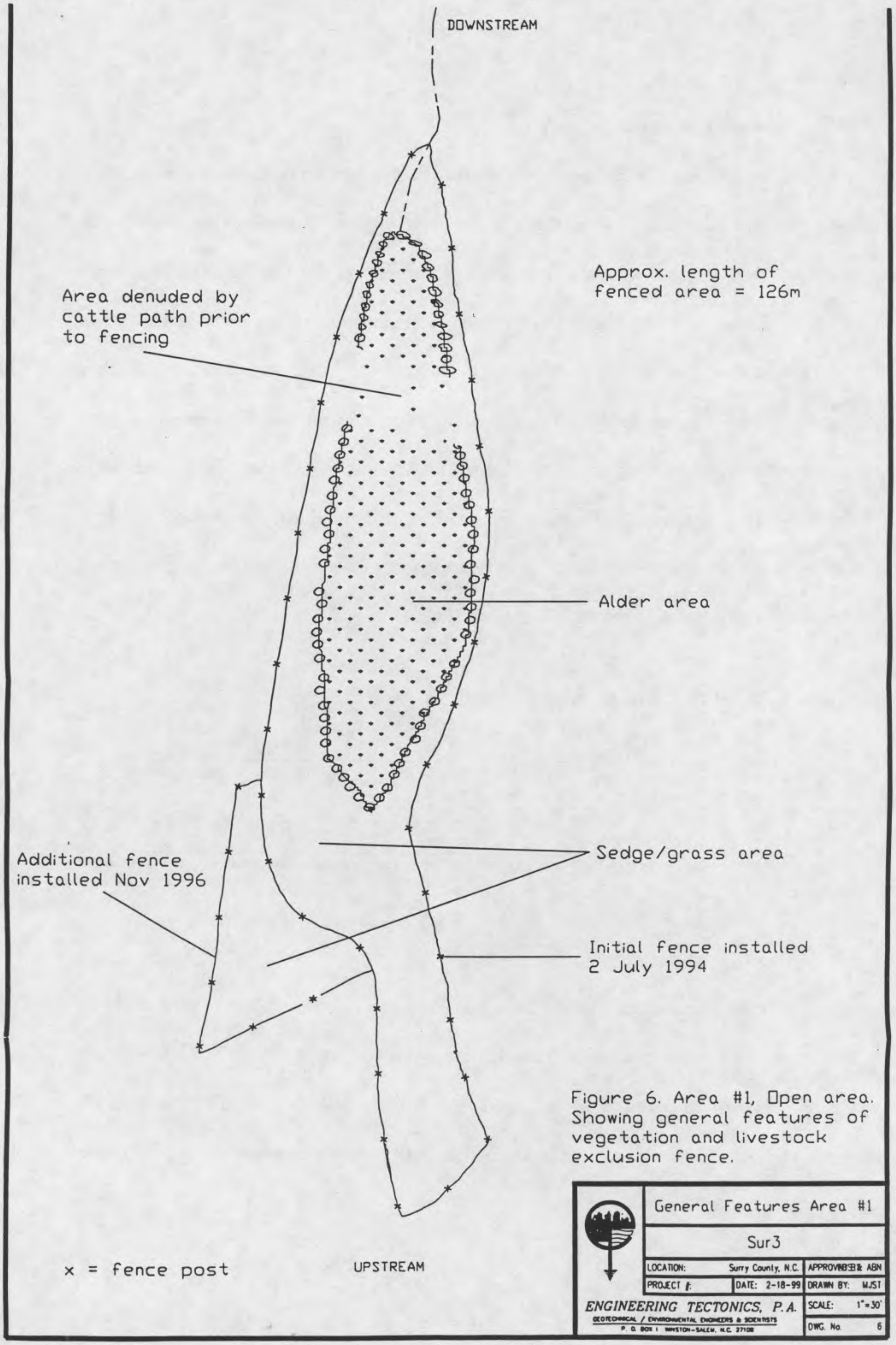


Figure 6. Area #1, Open area. Showing general features of vegetation and livestock exclusion fence.

an experienced researcher and the immediate release of hatchlings back into the wild. Headstarting is not presently considered a viable conservation option for this project.

2.4 DNA Collection and Analysis

Blood was collected from six turtles in 1997 (Table 2). DNA was extracted and sent to Dr. Jim Howard, a conservation geneticist, at Frostburg State University in Maryland. Dr. Howard is working with Dr. Tim Rice from USGS in an attempt to develop an assay to "fingerprint" turtles. Additional DNA samples were collected from two other sites in the county (Figure 2, Sites 2 and 4). Assays should allow researchers to suggest relationships between populations of turtles in different sites as well as turtles within sites. This information will be extremely valuable for future research on effective population sizes and inbreeding coefficients, and for establishing management guidelines.

2.5 Workshops and Meetings

The Research Site "A" has served as a field site for several workshops and meetings. These include:

- Bog Management Workshop. May 11, 1995. Attended by 45 individuals from such agencies as: US Fish and Wildlife Service, North Carolina Wildlife Resources Commission, Natural Resources Conservation Service, Project Bog Turtle, The North Carolina Nature Conservancy, University of North Carolina at Greensboro, University of North Carolina at Asheville, University of Virginia at Blacksburg, Three Lakes Nature Museum and Aquarium, The North Carolina Zoological Park, Blue Ridge Parkway staff from Virginia and North Carolina, and Schiele Museum of Natural History (Figure 7).

- Natural Resources Conservation Service officials met with landowners and visited the site. May 20, 1995. Dick Everhart, County District Supervisor and Angela Jessup, NRCS Engineer discussed the project with Paul Johnson (then Chief), and state officials (Figure 8). Financial support from the NRCS followed, which has allowed the project to continue.

- Sierra Club Meeting, Foothills Chapter. June 1996. Discussed importance of habitat and conservation initiatives underway. Partnering among agencies and non-governmental agencies (NGOs) encouraged. The Sierra Club provided the project with an intern from Duke University, Ingrid Franzen, in the summer of 1996. Her assistance allowed data collection to continue in 1996.

> The Duke Power Company Foundation, Environmental Division representatives John Garton and Dale Mostellar and North Carolina Wildlife Federation (then) Executive Director, Tom Bean met with project scientists. June 1997. Discussed importance of habitat and conservation initiatives underway. Partnering among agencies and NGOs was encouraged. Financial support from both agencies followed which assisted in supporting the work reported in this document.

> Future activities: Endangered Species Workshop for Teachers sponsored by USFWS. June 5, 1999. Teachers will work on fencing, check traps, probe for turtles, and learn about the hydrology and vegetation issues of concern to the project.

Figure 7. Ron Determan from Atlanta Botanical Gardens demonstrates burning technique for managing woody vegetation. Bog Management Workshop. May 11, 1995

Figure 8. NRCS officials tour Research Site "A", guided by Dick Everhart. May 20, 1995

3. Population Assessment

3.1 Introduction

Most of the significant research delineating the range and habitat of bog turtles has been conducted in the last several decades (Lee and Norden 1996). At the same time, a drastic decline in numbers of sites and sizes of populations within many of the remaining sites have been reported (Herman 1994; Lee and Norden 1996; Herman and Tryon 1997). There are still major gaps in our knowledge about the demographics and population dynamics of the species (Herman 1994; Lee and Norden 1996). Only recently has there been enough information available to allow the northern population to be included on the federal endangered species list; adequate surveys still have not been completed for the southern population (USFWS 1997).

In order to assess the threat of extinction of any species, the viability of the individual populations and metapopulations must be determined. A turtle sighting or a site inhabited by a few individuals does not necessarily mean that a viable population is present. Since bog turtles are long-lived, individuals may occupy sites long after the site is incapable of supporting a healthy population (Lee and Norden 1996; Herman and Tryon 1997).

Only a few remaining sites are considered good, and population sizes and other demographic data remain largely unknown. Only 17% of the remaining sites in the northern population are considered good; 75% are considered fair or poor; and 8% are of unknown status (USFWS 1997). Herman (1994) assessed the viability of populations in the south and concluded that only 23% (11) can be considered viable.

In response to these alarming statistics, there is growing interest in reviving sites that have fallen into decline. However, to date there are no studies that report on restoration efforts of meadow bogs in the south. Hence this study was undertaken in an attempt to generate data that can be used to help design restoration efforts elsewhere. In order to assess the success or failure of any restoration project, pre-treatment data must be available to facilitate before-and-after comparisons. The goals of this study were to determine: (1) baseline population numbers prior to site enhancement efforts; and (2) if seasonal exclusion of cattle could increase population size in a site that was heavily impacted by livestock.

3.2 **Methods**

3.2.1 Field Methods

Turtles were hand-collected by visual searches while probing with sticks (like broomsticks) from 1993-1998. Turtles were also trapped with hand-made wire mesh traps like that of Fahey (1993) that were not baited (Figure 9). Captured bog turtles were permanently marked with a small notch on marginal scutes with a triangular file like that of Cagle (1939) and Herman (1981). The turtles were numbered in the order in which they were found. All other turtle species encountered were noted.

Data collected on bog turtles included: exact location and general habitat types of captured turtles; capture method (trap, signal, hand); morphometric measurements as described below; date of capture; age, sex and reproductive status if known.

All bog turtles were measured for straight-line carapace length (SCL), width, shell height, and plastron length using 150-mm dial calipers; mass was measured in grams with a 300-gram Pesola spring scale. Turtles were sexed by external inspection: adult males have a concave plastron, longer tail and a more posteriorly placed cloaca than females. Age was estimated by counting annuli as in Zug (1991). Blood was drawn from the dorsal cervical sinus of six turtles for future DNA analysis (Sec. 2.4). Turtles were almost always released immediately at the site of capture. Early in the active season of 1995, a few turtles were taken into captivity for a short time for transmitter attachment. Researchers and assistants later became more proficient and were comfortable changing transmitters in the field.

3.2.2 Radio-tracking

Five turtles were followed by radiotelemetry during 1995 and 1996 and briefly in 1997. Transmitters (LL Electronics, 150 Mhz) were encased in a coating of surgical wax and dental acrylic and anchored to the carapace with 5-minute epoxy and quick stick epoxy as in Eckler et aL (1990). Weight additions ranged from 6-8 grams and did not exceed the recommended 7% of body weight guidelines (Schubauer 1981, Eckler et al. 1990). In an attempt to extend battery life over the winter, we experimented with a transmitter outfitted with 2 batteries (rather than 1) in the fall of 1995, but discontinued its use because the additional weight exceeded protocol (~ 9% of body weight).

In 1995, turtles 0.2, 0.4 and 0.5 were monitored an average of every 4.4 days between 8-June and 8-September (average 23 times), and an average of every 11.5 days (average 5.3 times) in the fall (18-Sep. through 3- Dec.) and occasionally throughout the winter months. In 1996, turtles 0.1, 0.4, 0.5, and 0.6 were monitored an average of every 4.6 days between 1-June and 22-July (average 6.8 times) and an average of every 23.5 days (average 5.5 times) from the end of July to mid-December. Turtle 0.1 was tracked occasionally throughout the winter of 1996-1997.

Each time a turtle was located in the open patch (Bog #1) its position as a bearing (nearest °) and distance was measured to the nearest 2 fenceposts. All fenceposts were surveyed and plotted on the AutoCAD map generated by NRCS engineers (Figure 3). Locations of turtles in the closed patch (Bog #2) were measured to landmarks such as large trees that were plotted by measuring distance and bearing from fixed survey points. Only one turtle was observed in the hayfield patch (Bog #3) and only the approximate location was recorded for that observation (Appendix IV).

3.2.3 Headstarting

In June of 1993, turtle 0.2 was taken into captivity and laid 4 eggs at Zoo Atlanta under the care of Dennis Herman (Sec. 2.4). Turtle 0.2a was the only surviving hatchling and was released into the site on 4-Aug-93. Hatchlings have a flexible carapace and are difficult to permanently notch, hence it will be difficult to be sure of this turtle's identity if we capture it again. The age of the turtle may be the only clue.

3.3 Results

A total of 204 observations were made of 12 live bog turtles between 1993-1998; one hatchling turtle was found dead on cattle droppings in a field surrounding the core area on 11-May-95. No hatchlings or yearlings were ever captured in a trap. No yearling was ever captured in this site by any means: visual searching or trapping. Juveniles appeared in the traps by age 2 or 3 (0.6, 0.7, 0.9, 1.0, 1.1). No turtle under the age of 5 was ever discovered by any means other than trapping except hatchling 0.8. No new adults or sub-adults have been captured since July 1994 even though over 120,000 trap hours have been expended since that time (Table 2).

Table 2. Profile of Turtles in 1998.

Turtle	Age at first capture	Age estimate in 1998	Sex	Estimated year born	First observed	Last observed	Total observations (trapped, tracked, hand-caught)	DNA sample 1997
0.1	10	15	M	early 1980s	23-May-93	21-May-98	30 (9,18,3)	yes
0.2	10+	dead	F	early 1980s	31-May-93	died May 96	42 (6,35,1)	yes
0.2a	headstarted	5	?	1993	Zoo Atlanta	01-Aug-93	1	no
0.3	5	9	?	1989	1-May-94	15-Jun-94	4 (4,0,0)	no
0.4	20+	24+	F	before '74	8-Jun-94	16-Jun-96	36 (4,29,3)	no
0.5	7	11	M	1987	15-Jul-94	30-May-98	66 (20,45,1)	yes
0.6	2	6	M	1992	3-Sep-94	6-Jun-98	14 (10,4,0)	yes
0.7	3	6	F?	1992	10-May-95	28-Jun-97	5 (4,0,1)	no
0.8	hatchling	3	?	1995	18 Sept. 95	same	1 (0,0,1)	no
0.9	2	4	?	1994	7-Jun-96	16-May-98	3 (3,0,0)	yes
1.0*	2	4	?	1994	7-Jun-96	same	1 (1,0,0)	no
1.1	3	4	?	1994	17-Jun-97	21-May-98	2 (2,0,0)	yes
hatchling		dead	?	1994	11-May-95			

* A turtle was captured on 16 May 1998 and misidentified as 0.8. The turtle was most likely 1.0, but this record is not included because of the uncertaintly.

Turtle 0.2a (headstarted) has not been seen since its release as a hatchling in 1993. The number of recaptures of turtles indicate that all sub-adult and adult turtles that inhabit the open patch or seasonally use the open patch have been captured. Indeed it is quite possible that all individuals over the age of 3 in the open patch have been trapped. It is unlikely that turtle 0.2a (5 years old in 1998) would have gone undetected with such intense trapping effort at the site and is not presently counted in the population estimate. However, it is possible this turtle is still alive and has either moved to a different area, evaded the traps or was misidentified as another turtle (see below).

In 1998, a young assistant mistakenly identified one turtle captured as 0.8. She noted that it was difficult to find a marginal notch on the animal. However, the turtle did not match the description of 0.8 and was most likely 1.0 or (unlikely) a previously uncaptured turtle from a 1993 clutch (0.2a). Turtle 1.0 was weakly marked in 1996 as a 2-year-old by Ingrid Franzen, a summer intern (Franzen, pers. com.) and has not been seen since. It is also possible that the misidentified turtle represents a new turtle.

Turtle 0.2 died in May of 1996 while carrying a radio-transmitter. A necropsy revealed 3 yoked eggs and no discernable illness or infection; the cause of death remains a mystery.

The most responsible estimate for the 1998 bog turtle population is believed to be about 10 (all turtles except 0.2 and 0.2a are presumed to be alive). The *a posteriori* estimate of the population number prior to the seasonal exclusion of cattle in 1994 was 7 individuals (Table 3). Hence, these data suggest an increase of 43% in the population since intervention began. The Research Site "A" population is growing: 60% of the 1998 population are sub-adults or juveniles. At this time density can be estimated at 10 turtles per hectare.

3.4 Conclusions and Discussion

3.4.1 Population Size Increase

The increase in population in recent years, though small in absolute terms, is not insignificant and actually represents a large increase (43%) for such a small population (Table 3). Several factors appear to have contributed. One is the erection of the cattle exclusion fence. Cattle seek out wetlands as a source of food when pasture grass is depleted and enjoy the cooling effects of mud in hot weather. Prior to erection of the fence, most of Bog #1 showed signs of heavy impact by hoof traffic (Sec. 1.2; Figure 6). There are indications that excluding livestock seasonally has been beneficial for the turtles at this site. It appears from the ages of turtles 0.9, 1.0 and 1.1 that there was a successful clutch in 1994. The dead hatchling discovered in May of 1995 may also have been from that clutch. An additional nest was successful in 1995, which resulted in at least one live offspring (turtle 0.8). These increases may be attributed to protection of the nest area(s) provided by the livestock exclusion fence erected in Bog #1 in July 1994.

Another factor probably contributed to recent recruitment. There was at least one successful nest each year from 1992-1995. During this time period, there were two females of reproductive age in the populations: 0.2 and 0.4. It is tempting to suspect that turtle 0.2 came of reproductive age around 1992 and was the mother of one or more of these clutches. DNA evidence may soon provide insight into this hypothesis (Sec. 2.4).

Turtle 0.2 was gravid with three eggs when she died in 1996.

Table 3. Population sizes and age structure of turtles captured at Research Site "A" in 1993 and 1998.

Age Structure in 1993 (year prior to seasonal exclusion of cattle)
Number of turtles at site in 1993 (extrapolated from capture data), N = 7

Age Class	Number	Percent of Population
Hatchlings (< 1 year)	N = 0	none known
Juvenile (1-5 years) (Turtles 0.3, 0.6, 0.7)	N = 3	43%
Sub-adult (6-9 years) (Turtle 0.5)	N = 1	14%
Adult (10+ years) (Turtles 0.1, 0.2, 0.4)	N = 3	43%

Age Structure of Captured Turtles as of May 1998
Total number of captured turtles believed to be extant at site in May 1998, N = 10

Age Class	Number	Percent of Population
Hatchlings (< 1 year)	N = 0	none known
Juvenile (1-5 years) (Turtles 0.8, 0.9, 1.0, 1.1)	N = 4	40%
Sub-adult (6-9 years) (Turtles 0.3, 0.6, 0.7)	N = 3	30%
Adult (10+ years) (Turtles 0.1, 0.4, 0.5)	N = 3 2 Males 1 Female	30%

As encouraging as the increase is, serious concerns remain as to the long-term viability of this population because of its small size. Conservation biologists have long known that small populations are highly prone to extinction (Shaffer 1981, 1987; Gilpin 1987; Lande and Barrowclough 1987; Meffe and Carroll 1994; Primack 1998). There are many concerns, including loss of genetic variability, inbreeding, and genetic drift. Environmental and demographic fluctuations also pose serious threats.

3.4.2 Demographic Concerns.

There are indications that a healthy age range exists in the bog turtle population at Research Site "A", but that the population size is small (Table 2). Over 200,000 trap hours have been logged in the last 4 years and only 11 individual bog turtles have been identified. The death of adult female turtle 0.2 in May of 1996 leaves only one known adult female in this population (turtle 0.4).

Demographic uncertainty is an important concern for small populations (Soule 1987). The loss of turtle 0.2 can be considered a demographic catastrophe for this small population because she was one of only two females of reproductive age. This turtle could have been considered the single most important individual in the population in terms of reproductive value because of her gender and young age. Additionally, her range of activity had significant overlap with males 0.1 and 0.5, permitting certainty that she would have no trouble encountering a mate. Indeed, turtles 0.5 and 0.2 were often noted in the immediate vicinity of one another during many different times of the year in 1995, while both were being telemetered.

In small populations, potential mates may have difficulty in finding one another (Allee effect), further reducing recruitment. Turtle 0.4, the only remaining adult female, spends most of her time in the closed patch, while both adult males spend most of their time in the open patch (Figure 11; Appendix IV), although both adult males make occasional visits to the closed patch. I located female 0.4 in or near the open patch each June she was monitored: 1994, 1995, and 1996. On another occasion, 15-May-97, I tracked male 0.1 and found him in the favorite spot of female 0.4 (Chapter 4, Sec 4.3). Because of these movements, I am cautiously optimistic that the female will find a mate, at least in some years.

Data from another site in North Carolina indicate that North Carolina bog turtles only reproduce every second or third season in the wild even though they are biologically capable of reproducing every season (Herman 1994). Because of this and the reasons mentioned above, I believe it is reasonable to expect recruitment to slow after the death of adult female 0.2 in 1996. This situation suggests that there is a serious problem for the long-range survival of this population. Published information on what percentage of females in healthy populations can be expected to become gravid each year is not available, but certainly there is variation in reproductive output of individuals and reason for concern in any population where there is only one adult female.

3.4.3 Inbreeding Concerns

Mating in Research Site "A" population is likely occurring between closely related turtles (siblings, mother-son, etc.). Inbreeding concerns include reduced fitness of individuals due to fixed alleles (reduced genetic variation) and buildup of deleterious genes. Common problems include reduction in traits associated with fitness such as body size, fecundity, and longevity (Lande and Barrowclough 1987). Depleted genetic variation may also result in reduced ability to adapt to changes in the environment.

Blood samples were taken from six turtles at this site and from a single turtle at each of the two closest sites in the same drainage. DNA was extracted from the blood samples and shipped to Frostburg State University where efforts are underway to develop an assay that will allow turtles to be genetically "fingerprinted." Hopefully we will soon be able to determine parentage and inbreeding coefficients and thus be able to assess the genetic health of the population. Examination of the DNA of new recruits could give us information about the fitness of the individual adults in the population. The inclusion of the DNA data into the emerging picture of this population will give us additional insight into the dynamics at work in this site. Nonetheless, it is already quite apparent from existing data that this population is in serious danger of extirpation because of its small size. As Lande and Barrowclough (1987) point out, demographic factors (such as size and growth rate) may take precedence over genetic concerns since genetic variation is not important if the population becomes extinct.

3.4.4 Size Concerns

Size is just one of the many factors that must be weighed when assessing the potential for a population to persist even in the short term (50-100 years). Other considerations include: site quality, protection, and connectedness; genetic factors; effective population size; climatic trends and fluctuations; and many others. However, in certain populations, size may be the issue of most immediate concern (Lande and

Barrowclough 1987). I believe the Research Site "A" population is just such a case.

3.5 Are Small, Isolated Populations Worth Saving?

Many populations of birds have survived for 80 years with 10 or fewer breeding pairs (Primack 1998) and northern elephant seals have recovered to a population of 30,000 after being reduced by hunting to only about 20 individuals (Bonnell and Selander 1974).

Despite these encouraging cases, it is clear that small populations are in real danger of going extinct even in the short term (Shaffer 1981; Gilpin and Soulé 1986; Pimm et al. 1988). Since most populations of bog turtles are small, it is clear that we cannot save all of them. We must focus our conservation efforts on saving and enhancing populations that may be important to the viability of the species as a whole. We should also keep in mind that all species provide services in their ecosystems and these contributions must not be undervalued. Hence, some small populations may be worthy of conservation efforts if enhancement efforts are underway or imminent, by merit of their eco-services or potential for such services, even if they are not seen as important for the survival of the species as a whole.

How can we determine where to best utilize our efforts? Although it is quite clear that we cannot save every remnant population, it may be irresponsible to give up entirely on all small populations. Most of the remaining populations of bog turtles *are small.* Most populations in Virginia consist of fewer than 20 individuals (Buhlmann et al. 1997) and are found in sites 1-2 hectares in size. North Carolina sites are usually less than three hectares and have populations < 35 turtles per hectare (Herman and Tryon 1997). We must carefully consider our conservation alternatives under these conditions.

According to Klemens (1997), ecological triage may be necessary. We must not try and save every piece of habitat and every dying population, he warns, lest we end up with patches of nothing. An essential component of conservation plans for any species is knowledge of the status of populations and individual sites, yet we lack such data for most southern bog turtle populations.

In order to address the problem of insufficient data, Klemens (1993) developed a protocol called "Standardized Bog Turtle Site-quality Analysis" to assess the capacity of sites to maintain viable populations of bog turtles. Sites are ranked according to four factors: (1) habitat size and degree of fragmentation; (2) the presence of invasive plants and later successional species; (3) immediate threats such as wetland ditching, filling or excavation; and (4) the type and extent of land use in the area. The first category addresses the issue of interconnectedness with other wetlands and populations (i.e. potential for metapopulations). Population size and evidence of recruitment are also taken into account when such data are available and are less than 10 years old. Five categories are listed under population size: sites known to contain 25 or more individuals are ranked in the highest category; sites with fewer than 5 individuals are ranked the lowest. There are three possible outcomes from the "Standardized Bog Turtle Site-quality Analysis": non-viable, possibly viable, and viable. Although Klemens prudently suggests additional quantitative surveys may be needed to accurately determine viability, this tool provides an excellent place to start ecological triage. Pragmatic conservationists will concentrate efforts on the "viable" and "possibly viable" sites and allow the "non-viable" to meet whatever fate may come.

One way to augment a site-quality assessment is to determine the level of interest in reviving a site. Landowners or local conservationists may be definitely interested or not interested at all in such a project. Sites that rank "non-viable" will have an additional strike against them if there is no landowner interest or no interest on the part of local conservationists to improve the site.

3.6 On Considering Augmentation

> "... to neglect the subject [of minimum viable population size] entirely suggests either ignorance of the consequences of small population size or wishful thinking..."
>
> Dodd and Seigel, 1991

3.6.1 Rationale

Individuals found in populations that are doomed to extinction are referred to as "the living dead" (Primack 1998). Such a term is appropriate in cases where the individuals will not have the opportunity to contribute genetic material to future generations because of the inability of their populations to persist in the short term (30-50 years). Sites that are clearly non-viable may be best utilized as a source of individuals for carefully planned augmentation programs. After a thorough health assessment, individuals could be moved to viable or possibly viable populations in the same or nearby drainages where site improvement projects are underway and baseline population data suggests that such action is warranted. Remnant individuals might provide genetic material, eggs or mates for turtles in small populations in nearby sites. Remnant males may be moved to a recovering site only long enough to mate. Remnant females could be allowed to lay eggs in the recovering site. For small populations to persist, some exchange of individuals between populations must occur to avoid inbreeding depression (Primack 1995; Gilpin 1987).

Small, shallow wetlands can rapidly undergo significant vegetation change (Kiviat 1978). A bog turtle would probably move from one declining colony to areas of improving quality due to reduction of the offending woody plants as a result of fire or beaver activity (Lee and Norden 1996). Indeed, most populations of bog turtles are believed to exist as metapopulations in which exchange of individuals is a very important aspect (Buhlmann et al. 1997). A population is considered genetically isolated if there is less than one effective migrant per generation (Laude and Barrowclough 1987). The flow of individuals between populations is believed to have favorable genetic and demographic consequences (Gilpin 1987) and has been aptly termed the 'rescue effect' by Brown and Kodric-Brown (1977). In the case of bog turtles, these movements would naturally take place in the same or nearby drainages.

Serious concerns have been raised about the advisability of moving individuals to different locations for very valid reasons (Conant 1988; Reinert 1991; Dodd and Seigel 1991; Storfer 1996; Kaiser 1997; Reinert and Rupert 1999). These include disease transmission and lack of attention to genetic, demographic and habitat concerns. One of the primary objections is the critical lack of information on long-term success or failure of herpetofaunal-related projects (Dodd and Seigel 1991). Characteristics of a valid experimental translocation should include: (1) collection of baseline population data, (2) demonstrated need for additional genetic or demographic augmentation, (3) knowledge of the causes of decline, (4) elimination of problems which caused the decline, (5) health checks on animals to be released, (6) provisions for follow-up studies at periodic intervals, and (7) a willingness to publish the methodology and results of the program regardless of success or failure (Dodd and Seigel 1991). Experimentation and long-term monitoring are necessary before augmentation programs should be employed as an acceptable conservation strategy. Indeed, such research is critically needed in order to make sound judgements regarding conservation options, since translocation and augmentation are *not proven* management techniques.

Research Site "A" site ranks as "possibly viable" using the "Standardized Bog Turtle Site-quality Analysis" and may be an ideal site for this type of research. Many of the above criteria have already been met at Research Site "A" site: baseline population data are reported in this document; the demographic need is clear; the habitat is clearly suitable; genetic studies are underway; site enhancement efforts are underway; and evidence exists that conditions have improved (see Results, Chapters 3 and 4). There is every expectation that this project will continue with or without funding. Studies are underway to identify a source for an animal suitable for augmentation (Chapter 7).

Relocating reptiles can threaten the survival of that individuaL Some relocated animals do not reestablish home ranges (Belzer 1996) and mortality rates can increase (Reinert and Rupert 1999). Unmonitored animals may move away from suitable habitat as if attempting to locate familiar territory and wander into harms way (like roads) or otherwise be lost to the project. A critical aspect of translocating individuals then, is to monitor them. Moving turtles into a *monitored* project can protect translocated *individuals* and aid in conservation efforts (Belzer 1996). Animals that do not adjust well could be rescued and moved back to the original site. Even if only one clutch is laid (in the case of females) or one successful mating occurs (in the case of males) the recovering population could benefit. The *offspring* of translocated individuals should have no trouble adjusting (Belzer 1996) to the new site.

Time is not on our side. Difficult choices must be made, often in the absence of adequate data. When the outcomes of alternate actions are uncertain, it is hard to anticipate intuitively which one will be best (Maguire et al. 1987). Good data collection and scientific experimentation will greatly assist our decision making process.

I recommend that we begin to search for a source of a female bog turtle in an attempt to augment the population at Research Site "A". One possibility is the Research Site "B" (Figure 2) in the same river drainage. This is a highly degraded site and ranks as "non-viable" using Klemens (1993) "Standardized Bog Turtle Site-quality Analysis." Problems there include: little remaining habitat; advanced woody succession; serious prior attempts to drain the site using tiles; and no interest in restoring the site by either the landowner or local conservationists. According to Soule (1987), " there are no hopeless cases, only people without hope and expensive cases." Restoration of the non-viable Research Site "B" may not be hopeless, it may just be one in which there is no interest.

Studies will be conducted in 1999 that will add to existing population data on Research Site "B" . Additionally, trapping effort will be increased in the hayfield patch of Research Site "A" to possibly determine if there are additional turtles residing there (Chapter 7). A blood sample from the translocated turtle should allow us to identify her offspring should she reproduce in the new site. Strict daily monitoring by radio telemetry will be part of the recommendation, as one of the concerns is that bog turtles may not settle well into non-natal sites. The value of such an experiment is that we may be able to learn more about issues related to translocations of bog turtles while responding to a demographic crisis at an improving *site.*

3.6.2 Halfway Technology?

Halfway technology is a term that was first used in a conservation context by Nat Frazer (1992). The term describes conservation measures that address the symptoms of a problem rather than the cause. Frazer used it to describe the ineffectiveness of headstarting sea turtles, when we protect them from hazards of early life-stages but put them back into the same unhealthy oceans where their parents could not survive. Translocations and augmentations may also fall into the category of halfway technology when these measures are used to move turtles into sites where the original cause(s) of decline has not been addressed.

This is not the case at Research Site "A". Preliminary data indicate that conservation efforts at this site have improved conditions for the bog turtles. Efforts began by seasonally excluding cattle when a livestock exclusion fence was constructed in 1994 (Sec. 2.2). Additional fencing in 1996 enclosed a greater portion of the core area, and we have found turtles utilizing the improved areas (Chapter 4; Appendix IV). An estimate of the population of turtles in the site prior to conservation efforts was 7 individuals. Since then, 5 turtles have been added to the population (43% increase). This represents a significant increase and has given us reason to be optimistic about conditions at this site.

Restoration is the primary management strategy recommended for habitats that are known to contain bog turtles (Kiviat 1978; Herman 1994; Lee and Norden 1996) but have fallen into decline due to removal of livestock, overstocking pastures, succession, or drainage by ditching. When sites are improved, populations may or may not be able to increase to sustainable levels. Experimentation in population augmentation following habitat improvement is sorely needed.

3.6.3 Experimental Short-distance Translocation

On 16-June-1997 I translocated a turtle a short distance in order to observe his behavior. Turtle 0.1 was moved from the open patch (Bog #1), where he spent 90 % of his time, to the hayfield patch (Bog #3) where he had never been observed. The purpose of this experiment was to see if the turtle would make an attempt to return to the open patch.

He was tracked twice daily for about two weeks and never moved more than 20 meters from the release point. He was then returned to the open patch.

4. Habitat Preferences: An Assessment In Association With Habitat Enhancement Efforts

4.1 Introduction

In order to enhance a site, it is useful to know which areas within the site the turtles prefer so that important microhabitat types are increased. The goal of this study was to determine: (1) if all three wetlands at Research Site "A" were utilized by bog turtles; (2) if movement occurs between the three different wetland patches; (3) if one of the three patches is preferred over the others; and (4) microhabitat preference.

4.2 Methods

4.2.1 Field Methods

Turtles were found using visual search techniques and traps (Sec. 3.2). Some turtles were outfitted with radio-transmitters and their exact locations and general habitat recorded.

Habitat was categorized as 1 - wet meadow (sedge/grass dominant); 2 - edge habitat; 3 - alders in open patch *(Alnus serrulata);* 4 - tree canopy; or 5 - in stream or stream bank of closed patch. Wet meadow was defined as soggy soil with low level herbaceous vegetation composed of wetland-associated plants (such as *Carex* spp., *Scirpus* spp., *Juncus* spp., etc). Wet meadow habitat, category 1, was found in the open patch only. Edge habitat, category 2, was within 2 meters of wet-meadow/alder or wet-meadow/tree canopy edge and is found in both the open and closed patches. Category 3, alder habitat, was found in the center of the open patch. The alder boundary is included in all figures of the open patch (Figures 3, 6; Appendix IV). Categories 4 and 5 were habitats of the closed patch. Tree canopy characterized most of the closed patch (Bog #2) except for the NW creek-side edge and included species such as poison sumac *(Toxicodendron vernix),* red maple *(Acer rubrum),* box elder *(Acer negundo),* green ash *(Fraxinus pennsylvanica)* and American ash *(Fraxinus americana).* Chi-square analysis of contingency tables was used to examine the relationship between detection methods (telemetry or hand/trap) and apparent preferences for areas or vegetation types.

4.2.2 Home Range Estimation

For 4 animals (0.1, 0.2, 0.4, 0.5), sample sizes of more than 20 fixes were available. Trap and telemetry locations were pooled for examination of home range size. Home range sizes were determined for these animals using a fixed kernel density estimator (Kernelhr ver. 4.2, Seaman and Powell) using a grid size of 2m and a bandwidth, or smoothing parameter, of 6m. This fixed bandwidth was used because the turtles tended to use the same location repeatedly, precluding use of the otherwise preferable (Seaman and Powell 1996) least squares cross validation method.

4.3 Results

4.3.1 Patch Preferences

Turtles were found in all three wetland patches, but preferred the open patch. In fact, 84.3% of all turtles located were in this wetland area (Table 4).

Table 4. Patch Preferences of Turtles at Research Site "A".

Patch	# of Observations	% of Observations
Bog #1, open	172	84.3%
Bog #2, closed	28	13.7%
Bog #3, hayfield	1	0.5%
Drainage ditch of Bog #1	3	1.5%
Total	**204**	**100.0%**

Trapping was limited in the closed patch due to cattle access, resulting in a distinct bias in the allocation of trap effort (trap effort in the open patch constituted 75 % of total trap effort). This was reflected in the apparent patch preferences suggested by the trapping data (Table 4). Chi-square analysis suggested a difference between patch preference indicated by telemetry data and patch preference as suggested by all non-telemetry observations combined (Pearson Chi-square = 8.2, P = 0.042). Because of this effect, telemetry data were analyzed as an unbiased indicator of habitat use patterns. Table 5 represents the patch preferences of radio-telemetered turtles.

Table 5. Patch Preferences of Radio-telemetered Turtles.

Patch	# of Observations	% of Observations
Bog #1, open	105	80.2%
Bog #2, closed	24	18.3%
Bog #3, hayfield	0	0.0%
Drainage ditch of Bog #1	2	1.5%
Total	**131**	**100.0%**

No one turtle was found in all three patches. One turtle (0.3) was observed in both the open patch (Bog #1) and the hayfield patch (Bog #3). Turtle 0.3 was trapped a total of 4 times: three consecutive times in the open patch and once across the creek in the hayfield patch. This turtle has not been seen since the capture in the hayfield patch but is believed to still be there (Appendix IV).

Three turtles (0.1, 0.4, and 0.5; all the adults except turtle 0.2) were observed in both the open patch and the closed patch (Bogs #1 and #2). Turtle 0.1 spent most of his time in the open patch with occasional forays to the closed patch; 3 out of 30 observations were in the closed patch (10%). Turtle 0.5 was observed once in the closed patch out of 66 observations. Turtle 0.4 spent most of her time in the closed patch with forays to the open patch; 26 out of 36 observations (72%) were in the closed patch. Turtles 0.2, 0.6, 0.7, 0.8, 0.9, 1.0 and 1.1 were never observed outside of the open patch (Appendix IV). Turtle 0.4 was singular in her preference for the closed patch.

4.3.2 Habitat Preferences

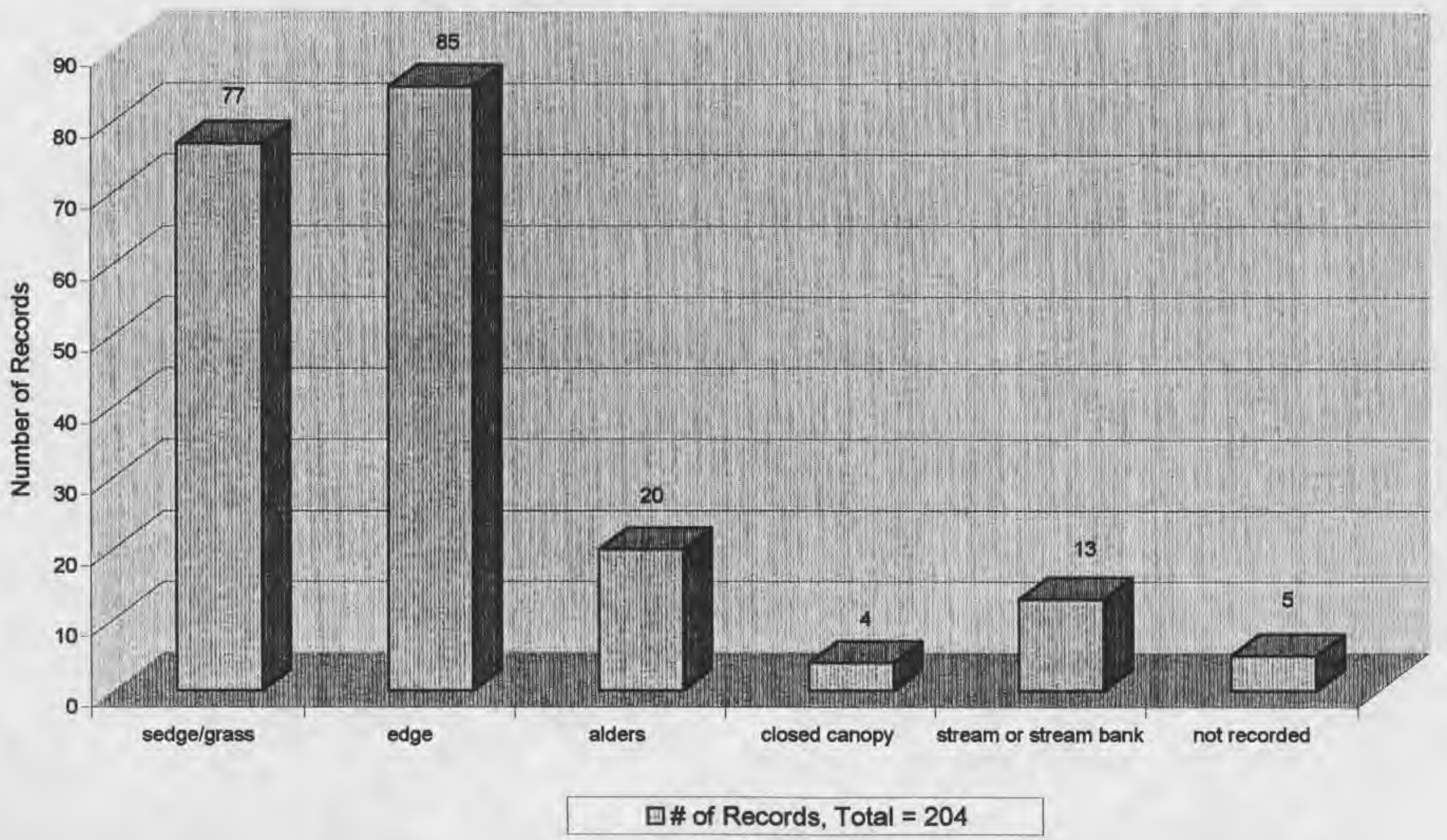
Turtles show a preference for low-level sedges and grasses or edge habitat 79.4% of the time as opposed to alder, closed canopy habitat or stream bank which accounted for only 18.2% of the records (Table 6, Figure 10). (Note: in 2.5% of cases, habitat was not recorded.)

Table 6. Habitat Preferences of Turtles in Research Site "A" Site 1993-1998.

Habitat	# of Records	% of Records
Sedge/grass	77	37.7%
Edge	85	41.7%
Alder	20	9.8%
Closed canopy	4	2.0%
Stream or stream bank of closed patch	13	6.3%
Not recorded	5	2.5%
Total	**204**	**100.0%**

Unlike the others, most observations of turtle 0.4 were in the closed patch (Bog #2) and most of the observations within that area were in the creek bank or in the creek that originates from the springs of that wetland. Only once was another turtle observed in the

Figure 10. Habitat Preferences of Bog Turtles in Research Site "A"



creek bank: turtle 0.1 (a male) was tracked to the favorite spot of turtle 0.4 (a female) in the creek bank under the root mass of a young maple tree on 15-May-97. Presumably this was a mating foray; however turtle 0.4 was not equipped with a transmitter at that time so her presence was not confirmed (Appendix IV).

Analysis of habitat preferences of radio-tracked turtles in comparison to preferences of turtles located by all other means suggested no significant difference due to bias (Pearson Chi-square = 8.2, P = 0.085). However, non-telemetry methods failed to detect turtle use of the least-utilized closed-canopy area.

These data also reflect clearly that turtle 0.4 was unique in her choice of favored habitat. She showed remarkable affinity for the stream and stream-bank habitat in the closed patch, accounting for all the records of occurrences in that habitat save one (Table 7, Figure 11).

Table 7. Habitat Preference of Turtle 0.4 Compared With All Other Turtles.

	% of Records (# of records)	
Habitat/canopy type	**Turtle 0.4**	**All Other Turtles**
Sedge/grass	8.3% (3)	44.0% (74)
Edge	41.7% (15)	41.1% (70)
Alder	2.8% (1)	11.9% (19)
Closed canopy	11.1% (4)	0.0% (0)
Stream or stream bank of closed patch	33.3% (12)	0.6% (1)
Not recorded	2.8% (1)	2.4% (4)
Total	**100.0% (36)**	**100.0% (168)**

Friedman analysis, based solely on radio-tracking data, illustrates the impact of this unusual animal on generalizations regarding turtle preferences. For each of the 5 turtles

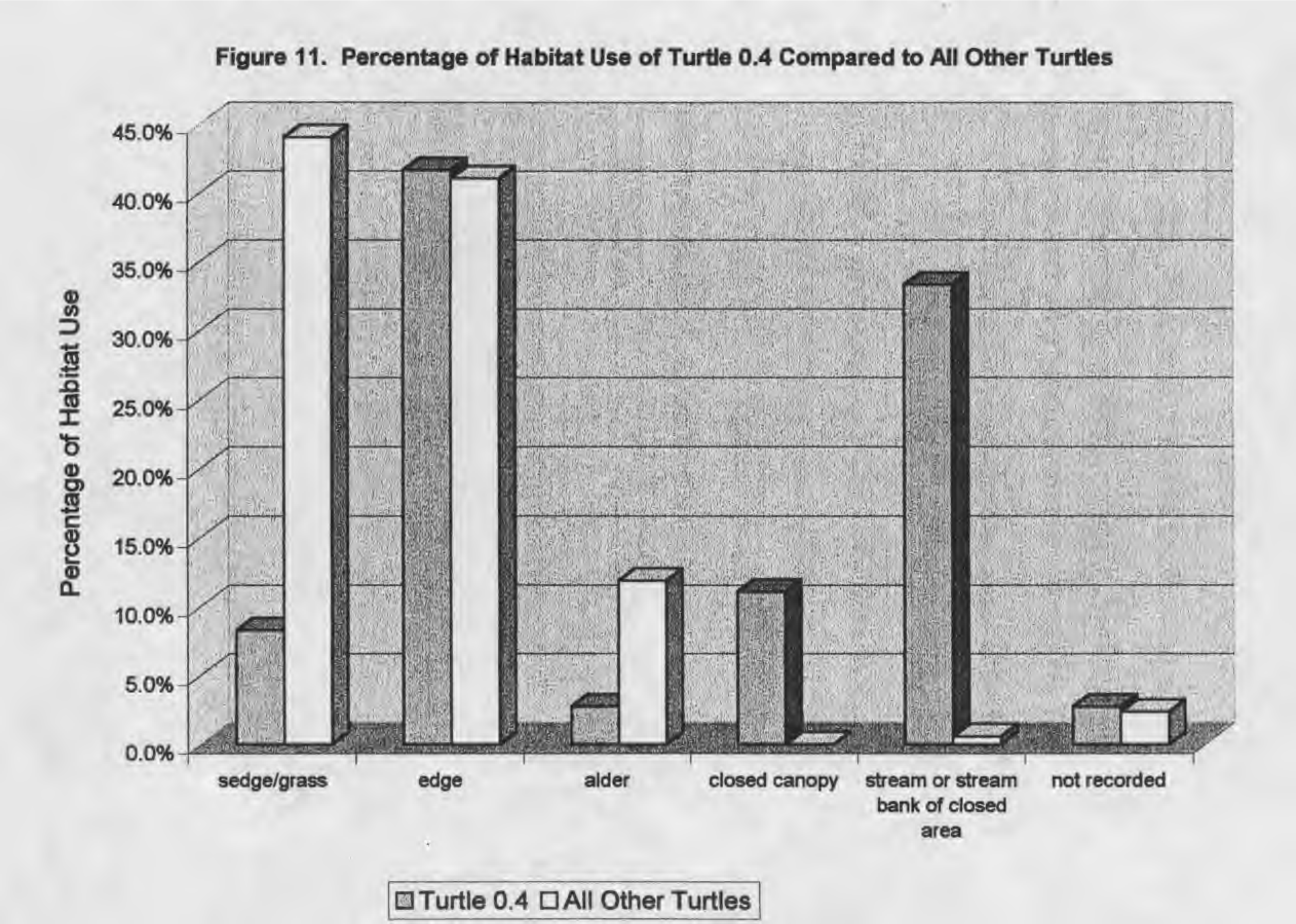


Figure 11. Percentage of Habitat Use of Turtle 0.4 Compared to All Other Turtles
Percentage of Habitat Use
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
sedge/grass
edge
alder
closed canopy
stream or stream bank of closed area
not recorded
Turtle 0.4
All Other Turtles

tracked, each habitat type was assigned a rank score based on the turtle's preference for that habitat, with 1 indicating the highest number of observations in that habitat, and 5 the lowest. Friedman two-way analysis of the preference rankings of the different habitats for each turtle did support the hypothesis of agreement among the turtles, but only marginally (Friedman statistic = 9.72, P = 0.045.) The Kendall concordance coefficient for the preference rankings of these five animals was only 0.49. The same analysis, omitting turtle 0.4, yielded P = 0.019 and a concordance coefficient of 0.734.

4.3.3 Home Range Size

The 95% home range estimates were 0.1 - 0.15 hectares for the 4 animals examined (Table 8) . The average of the home ranges for the 2 females is the same as for the males (0.13 ha) using the fixed kernel density method.

Table 8. Fixed Kernel Density Home Range Estimates of 4 Bog Turtles at Research Site "A".

Turtle (Gender)	Range (ha)
0.1 (M)	0.113
0.2 (F)	0.105
0.4 (F)	0.152
0.5 (M)	0.142

4.3.4 Use of Improved Areas

Prior to the erection of the original exclusion fence (July 1994), an area in the lower end of the alders of the open patch was denuded of vegetation because cattle were using it as a path (Sec.1.2 and Figure 6). As a result of the protection offered by the fence, this area grew up in sedges and grasses. Although no pre-fencing habitat preference data are available for comparison, post-fencing locality data indicate that some turtles favored this area. Of the 19 times turtle 0.1 was located in the open patch, 4 of these were in the recovering cattle path (21%). Turtle 0.5 was found in the area of the recovering cattle path 27% (15 of 55 records) of the time and hibernated there in the winter of 1995-96. Turtle 0.6 was located in the recovering cattle path 23% of the time (3 of 13 records). Turtles 0.4 and 0.9 also utilized the area of the old cattle path (Appendix IV).

An additional fence was erected in November 1996 which increased the area that was protected by the original fence (Figure 6). The herbaceous vegetation in the area protected by the additional fence grew much taller and turtles began using this area more than they had before. Prior to the additional fencing, only turtle 0.2 used the area. After November 1996, turtles 0.1, 0.5, and 0.6 used the area (Appendix IV).

4.3.5 Habitat Changes as a Result of Cattle Exclusion

Seasonally excluding cattle proved beneficial by allowing re-establishment of vegetation in the denuded areas. Sedge and grass dominated areas of the open patch were allowed to grow taller. The taller herbaceous vegetation still allowed sunlight to penetrate, yet provided cover for the secretive turtles and they began to utilize these areas more (see above).

The effects of excluding cattle were not all positive. Researchers began to notice a negative effect on the soil and hydrology of the open area. Water that once moved through the site in sheet-flow began to form channels. The channels became deeper, incising into the substrate. Water began to move through the site faster and areas that were wet in prior years began to dry out and harden, even when weather was favorable (low evaporation, mild temperatures, high rainfall). It appears that cattle tracks may benefit sites by disrupting channel formation and keeping the mud soft and wet.

The largest bog turtle populations (and possibly the most viable) are associated with cattle grazing (Herman 1994) and excluding cattle altogether is not recommended. Because of wells and sensitive water monitoring equipment, the cattle were excluded from the site for almost 3 years (Table 1). Seasonal grazing of the site has now resumed during the late fall, winter, and early spring months.

4.4 Conclusions and Discussion

This study reinforces others (Carter 1997) that indicate a mosaic of habitat types is important. Turtles at Research Site "A" equally preferred edge and sedge/grass dominant habitats.

These findings agree with others that bog turtles prefer low-level vegetation areas in spring-fed wetlands where grasses and sedges dominate (Chase et. aL 1989; Herman 1994; Carter 1997). Turtle 0.4 provides an interesting exception to this, preferring stream and stream bank locations in closed canopy conditions. Carter (1997) found that 26 of 29 turtles in 3 sites in southwestern Virginia never utilized stream habitat. Of the three turtles in his study that utilized stream habitat, only one was found in a stream more than 10% of the time. This sharply contrasts with turtle 0.4 who was located in stream or stream bank habitat over 33% of the time in Research Site "A" (Figure 11).

Additionally, the turtles in Research Site "A" were found to prefer edge habitat (Figure 10). Carter (1997) did not observe this behavior and found that bog turtles neither selected nor avoided edge habitat in his study.

Home range sizes in Maryland, reported by Chase et aL (1989), were 0.176 ha for males and 0.066 for females using harmonic mean analysis. Ernst (1977) reported 1.33 ha home range for males and 1.26 ha for females in Pennsylvania based on Minimum Convex

Polygon (MCP) analysis. Carter (1997) found that average home range sizes in southwestern Virginia were 0.47 ha for females and 0.57 ha for males using MCP analysis. Using the same data points and calculating home range using cluster analysis he found average home ranges to be 0.17 ha for females and 0.13 ha for males. Kernel density analysis of data in Research Site "A" in North Carolina revealed home ranges (0.13 ha average for males and females) similar to those of Carter (1997) using cluster analysis. However, comparison of the home ranges reported at this site with those reported at other sites should be conducted cautiously, as home range size estimates are sensitive to the choice of bandwidth at small sample sizes.

5. Capture Method Efficacy

5.1 Introduction

Efforts are underway to survey potential habitat throughout the range of the bog turtle to determine where they occur. Reasons for this activity vary. Because many sites that contain bog turtles are smaller than 1 acre, they do not fall under the protection of any wetland legislation, and are destroyed by developers or road construction before they are identified. In the interest of preserving the species, conservation biologists are in a race to locate sites before they are lost (Herman 1995; Thorp 1996). Alternately, transportation officials, engineering firms and developers often need historic or potential sites evaluated in order to obtain permits before filling or otherwise destroying sites.

When potential bog turtle sites are slated for development, researchers are called upon to make a determination as to the presence or absence of these animals in a site. Sites that are surveyed without finding evidence of bog turtles can then be destroyed.

Presently, there are no guidelines for adequately determining the presence or absence of this species. Bog turtles are known to be secretive and difficult to find and can easily go unobserved even by experienced researchers (Zappalorti 1975; USFWS 1997). Thus the possibility exists that some sites that do contain turtles, especially sites with small populations, are being overlooked.

A number of incidents document this problem. One very small, degraded site in North Carolina was surveyed several times by some of the most experienced researchers in the state without producing turtles. Subsequently 6 adult turtles (including some young

adults) were discovered when a backhoe operator dug them up in 1997 (David Sawyer, pers. com.; Thorp 1997). Another interesting example is a site discovered in a piedmont county in North Carolina in 1993. Three adult turtle shells as well as empty eggshells from a hatched nest were found there, confirming the site as bog turtle habitat. However, extensive visual surveys over a period of 5 years which included effort by at least 8 experienced researchers and a small amount of trapping effort have not yet produced one live turtle (NC State Museum files and pers. observation). If the adult shells or the eggshells were not present, this site would still not be confirmed. At the time of the discovery there were no records of bog turtles anywhere in that drainage or in that county. If the site had been included in a development project at that time, investigators would have had little choice but to write a report stating that the site had been extensively surveyed with no bog turtles found, thus allowing the hypothetical project to proceed.

The most common method of assessing potential sites is by visual search techniques (Beane 1993; Smith 1994; Herman 1995). Searchers follow turtle tracks, pull back vegetation, and search the mud with broomsticks and by hand. Trapping was first used by researchers as a method of catching bog turtles in the south in the early 1990s by Ken Fahey in Georgia and Dennis Herman in North Carolina (Fahey 1992, 1993; Herman 1992). Dennis Gemmell (1994) also reports trapping efforts in New Jersey. Trapping has since been used for surveys and as a census tool particularly in the Piedmont province of North Carolina (Beane 1993; Thorp 1993, 1994, 1995, 1996, 1997, 1998; Green 1993, 1994; Herman 1995; Somers 1996, 1997, 1998). Trapping now serves as an important method of determining the presence of turtles in potential sites as well as assessing population status within sites. One piedmont site was surveyed many times using visual

searches with no success. When traps were used, the site yielded a bog turtle within the first 24 hours (Thorp 1993). Even though trapping has proven to be an effective tool for assessing the presence of turtles, it is not often used to assess sites slated for development.

Most remaining populations of bog turtles are small (Sec 3.1) and learning more about such populations is especially important to formulate plans for survival of the species. The bog turtle population at Research Site "A" is known to be small (N .74 10). Data from the population study at this site were used to examine: (1) effectiveness of visual searches in comparison with trapping in determining the presence of bog turtles in a site with a small population; (2) optimal time of year to find turtles in sites with small populations and (3) the necessary level of effort to find turtles in sites with small populations. Results from trapping effort at Research Site "A" were compared with similar effort in Comparison Site "C" (N = 48+) to determine the relative effectiveness of trapping turtles in a site with a healthy population of bog turtles as opposed to a site with a small population.

5.2 **Methods**

5.2.1 Capture techniques (also see Sec. 3.2)

Collection of turtles was by means of visual searches using probing sticks and by non-baited hand made traps (Figure 9). Visiting researchers, students, landowners and volunteers assisted in data collection: Visual search times were recorded after each visit and were calculated for each area individually. Because work at the site involved various duties (recording turtle locations, attending to visitors' needs or talking with students or landowners), only time spent in active searching was recorded.

Traps were placed in meadow vole runs or between sedge clumps in about 1 cm of water (although due to hydrologic variation the level changed) and checked every 24-48 hours. Captured bog turtles were permanently marked with a small notch on the marginal scutes made with a triangular file like that of Cagle (1939) and Herman (1981) and released at the same site.

One trap hour was calculated as one trap in the site for one hour. Traps were used in the three patches for a total of 150,096 trap hours over the 6-year study. Most effort was expended in 1994 (30%) and 1995 (29%). Originally, in 1993 and 1994, traps were placed randomly in the three wetlands. From 1995-1998 traps were placed in areas where turtles were expected and areas that had been non-productive in the past were avoided.

Trapping was used to a limited degree in the closed patch (10% of total trap effort) because this area was open to grazing cattle throughout the year and traps placed there were sometimes found trampled (no turtle of any species was ever harmed). We trapped heavily in the hayfield patch in 1994 and 1995: 22,248 hours out of 87,888 or 25.3 % of the total effort in those years. After 1995, only minor trapping effort was expended in the hayfield because only one bog turtle was ever caught in that region. Trapping occurred primarily in Bog #1 (75% of total effort for all 5 years) because the traps were more effective there and were protected from cattle damage by the livestock exclusion fence constructed in 1994.

5.3 Trapping vs. Visual Search

Trapping is anecdotally reported to be very successful under some circumstances. However, it does involve appreciable time investment in trap placement, and the investigator must check the trap at fairly frequent intervals (24-48 hours) to assure the

welfare of any trapped animals. We sought to determine whether trapping or visual/probe search constituted the most effective detection method at a site occupied by a small bog turtle population.

5.3.1 Statistical Methods

The hourly return on hand search effort was based on the number of turtles captured by hand at Research Site "A" and the recorded time expended in active search for turtles, as previously described. Time invested by the investigators tending traps was not logged during the study. For a comparable measure of investigator effort expended on trapping, we estimated the time requirements of trapping as 1.5 hours to set up a string of traps, followed by a 0.5-hour check each 48 hours until the traps were removed. One hour was allowed for removal. As for hand search, the yield was computed as the number of turtles captured in a calendar month per hour of investigator effort.

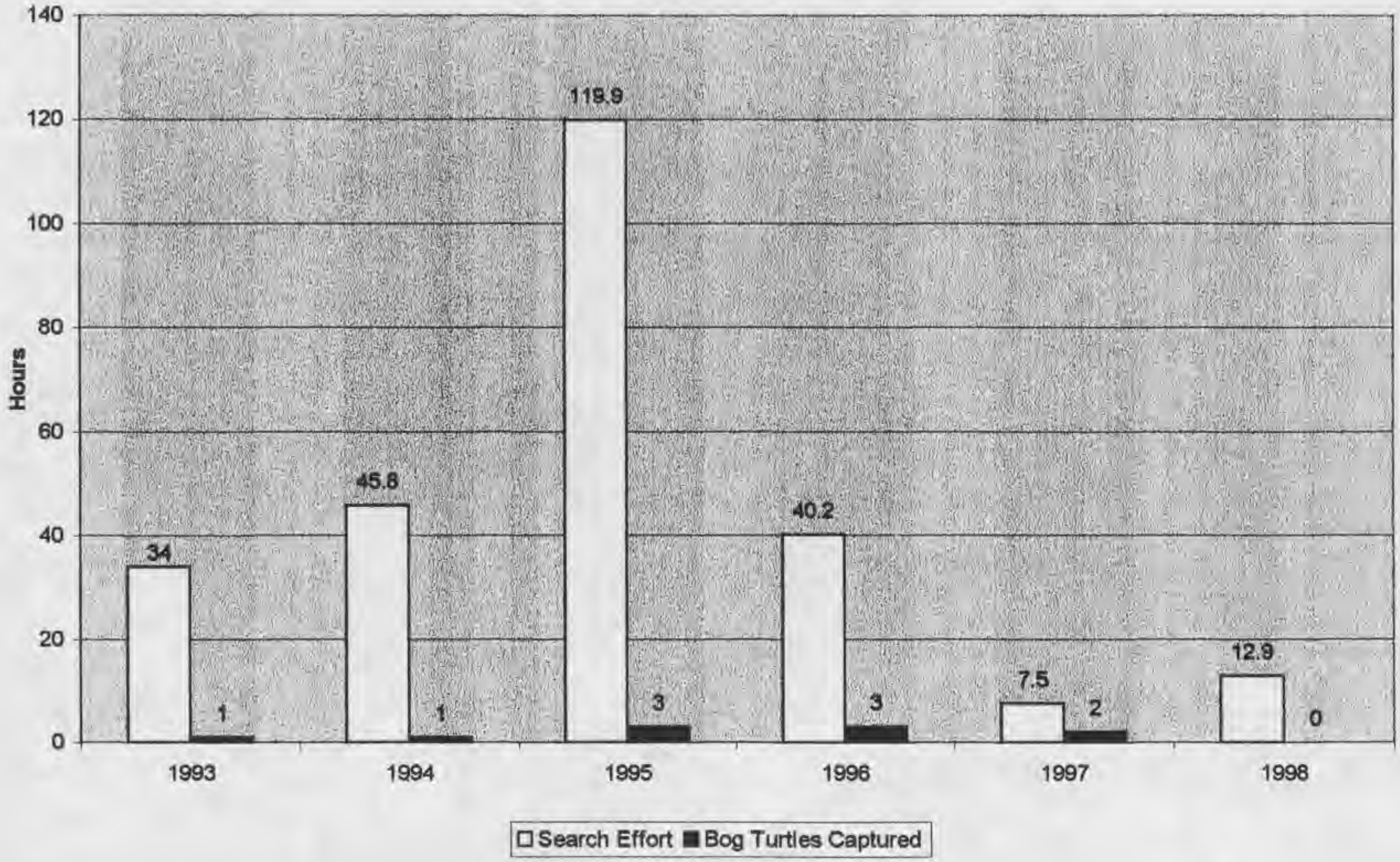
Time of year was incorporated into the analysis of capture technique. The calendar year was divided into two-month categories in order to achieve a statistically useful sample size within each time category. Two-way ANOVA was performed on turtle yield data to examine the effect of time period and capture technique.

5.3.2 Results

Locating turtles by hand was difficult. Visual search hours per turtle captured averaged per year were as follows: 34 (1993); 45.8 (1994); 39.9 (1995); 13.4 (1996); 3.75 (1997); no turtles were captured by hand in 1998. The average turtle detection rate per hour of visual search was 0.038 turtles/hour.

Effects of both bimonthly category ($P = 0.006$) and capture technique ($P < 0.001$) were highly significant, and trapping proved to be the more effective means of capturing

Figure 12. Visual Search Hours Invested and Number of Bog Turtles Captured at Research Site "A"



turtles. In the May-June time period, the average yield of trapping was 0.59 turtles/hour of investigator effort while the hand capture success rate was 0.08 turtles/hour.

5.4 Time of Year

To comply with the Clean Water Act, developers are required to obtain permits before they are allowed to use fill material in wetlands. As a result, researchers are sometimes called upon to assess sites for the presence of bog turtles in a wetland. I have received such requests in January and other months that are seemingly inappropriate for determining the presence of reptiles in any site. Sometimes shells of dead turtles or empty eggshells can be found, confirming a wetland as a bog turtle site. However, sites that yield no evidence of turtles during periods of low activity must always be reexamined at optimum times. There have been a number of papers that address the seasonal activity patterns of bog turtles (Chase et aL 1989; Lovich et aL 1992; Ernst et aL 1994; Carter 1997), but in most cases these studies were done on comparatively large populations using visual searches. Carter (1997), based on visual and mark-recapture techniques, concluded that bog turtles remain active in late summer. We sought to determine whether pronounced seasonal patterns were present in the detectability by trapping of the small population at Research Site "A".

5.4.1 Statistical Methods

In order to achieve a statistically useful sample size within each time period examined, the calendar year was divided into two-month categories. The 23 months in which trapping was attempted ranged from April to October, so four such categories (March-April, May-June, July-Aug, Sept.-Oct.) were examined. For each month, a trapping success index was calculated as the total number of turtles trapped that month divided by the total hours of trapping effort. Trapping effort was defined as the number of traps used multiplied by the number of hours traps were in place. Variation in trapping success index was examined with a Kruskal-Wallis test, using the monthly categories above. A Tukey multiple comparison procedure was used to compare trapping success values among the four bimonthly categories at a family confidence level of alpha = 0.05.

5.4.2 Results

A greater percentage of turtles were captured per trap hour in May and June than any other month (Figure 13), and the Kruskal-Wallis test indicated that the seasonal variation was significant ($P = 0.008$).

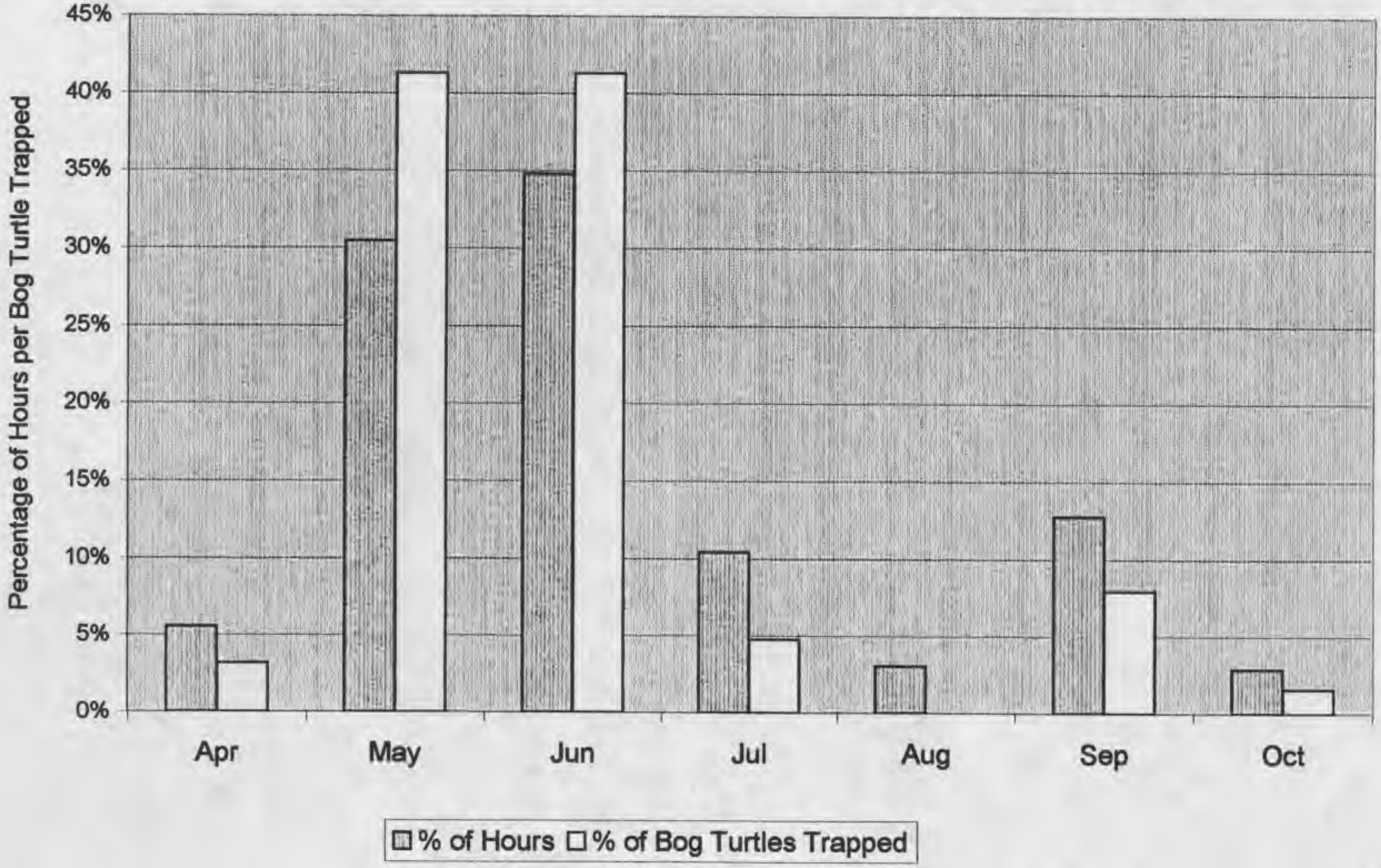
Trapping success was significantly greater in the bimonthly time period of May-June (5.4 x10^{-4} turtles/trap hour) than in the March-April time period (0.9 x 10^{-4} turtles/trap hour) or the July-August period (1.02 x 10-4 turtles/trap hour). Trapping success did not differ significantly between the July-August and September-October (2.15 x 10^{-4} turtles/trap hour) time periods.

5.5 Population Size and Trapping Success

5.5.1 Methods

Trapping results from Research Site "A" were compared with similar data generated from a high quality site also located in the Piedmont province of North Carolina. The Comparison Site "C" presently has a population of 48 marked turtles and is considered the largest and most viable bog turtle population in the Piedmont of North Carolina and the third largest individual population in the state (Herman 1995). Turtles were trapped in the Comparison Site "C" over several months coinciding with trapping for the present study (Green 1993, 1994; Thorp 1995). Data from that study were used to

Figure 13. Trap Hours Invested vs. Bog Turtles Trapped at Research Site "A", 1993-1998



compare the relative difficulty of trapping turtles at a site with a small (N 10) population versus a site with a larger (N = 48+) population. Due to possible inter-year variation in turtle activity, only periods of simultaneous study were compared. Trapping occurred on both sites simultaneously during four months (June 1993, May 1994, June 1994, May 1995). A Mann-Whitney U test was used to compare trapping success expressed as turtles/trap hour, across the two sites.

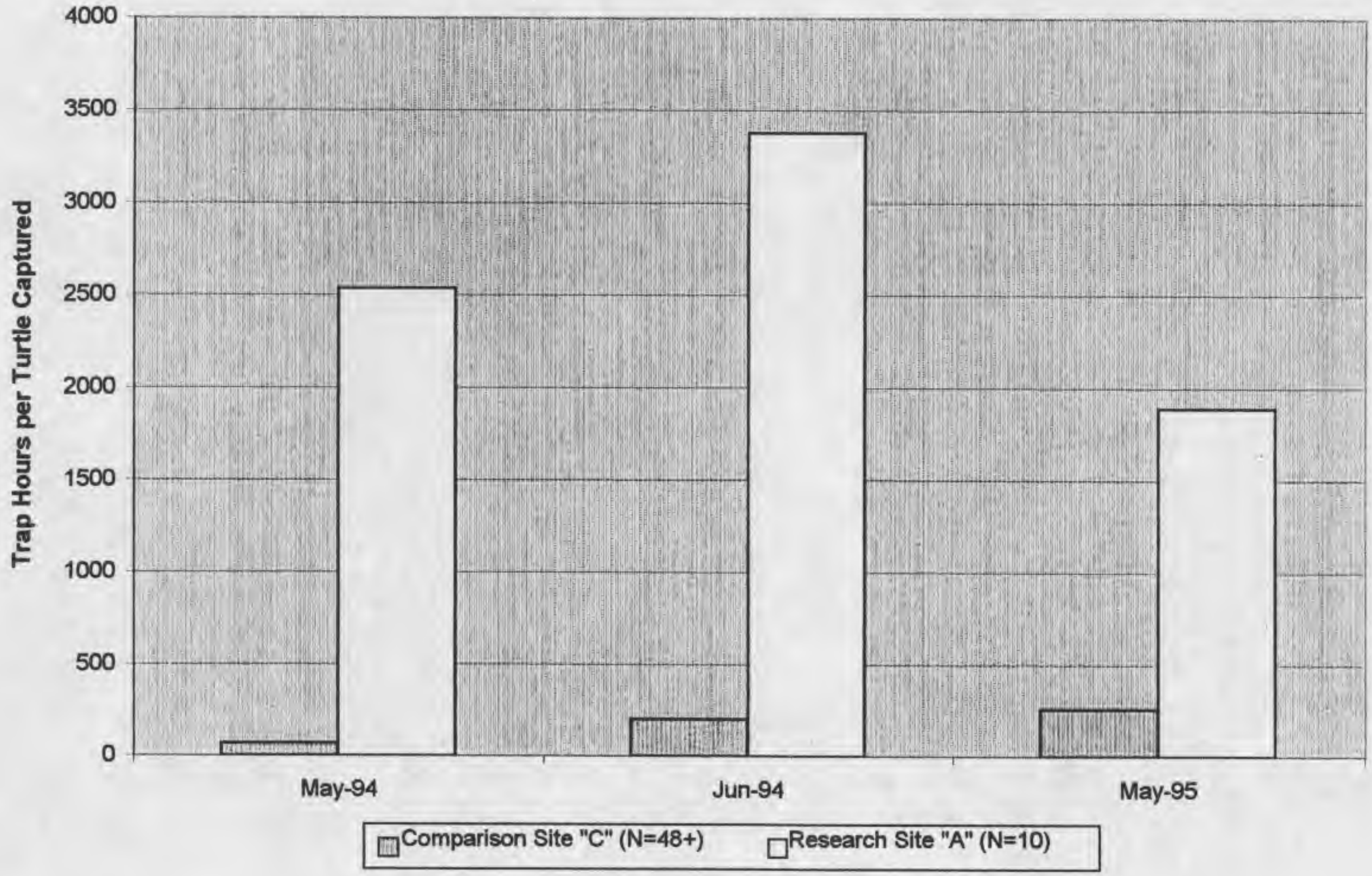
5.5.2 Results

Trapping effort per turtle capture at Research Site "A" for the period of overlap averaged 2600.7 hours per turtle trapped as opposed to an average of 176.3 hours per turtle trapped at the Comparison Site "C" (Figure 14). Average trapping success for the 4 months considered was more than an order of magnitude lower at Research Site "A" (3.05 x 10^4 turtles/trap hour) than at Comparison Site "C" (6.38 x turtles/trap hour). Despite the small sample size (4 months of study overlap) the inter-site difference was statistically significant ($P = 0.021$). There are three months considered in Figure 14; June 1994 was omitted because no turtles were caught at Research Site "A" during that month.

5.6 Reliable Detection of Small Populations

At Research Site "A", turtles were not captured during every month of active work at the site. Of the 23 months in which trapping (the most successful detection method) was conducted, no turtles were caught during 8. In view of various accounts of bog turtle populations being overlooked despite conscientious searching, and the 35% failure rate at Research Site "A", we determined the level of effort required to reliably detect any of the 10 animals known to be present.

Figure 14. Trap Effort Per Turtle Capture in Comparison Site "C" and Research Site "A"



5.6.1 Statistical Methods

Because of the previously established significant differences between May-June search effort and effort expended throughout the rest of the year, the data were divided on this basis. We considered only trapping data, due to the much greater effectiveness of trapping as a means of turtle capture at this site. We modeled the total number of turtles trapped in a month as a function of the hours of trap presence at the site during the month. Thus two regressions were involved: one for May-June data and a second for all other months of the year. Inverse prediction (Netter et at 1985) was used to establish a 95% confidence interval for the trapping hours required to capture a single turtle. Because capturing any of the turtles present would suffice to establish the presence of the population, the upper bound of this confidence interval can be considered a level of effort at which detection of the population is 95% probable.

5.6.2 Results

In May-June we would need to invest 8,910 trap hours of effort to have a 95% likelihood of detecting at least 1 of the 10 turtles known to be using this 1-hectare site, equivalent to approximately 19 days of continuous trapping with 20 traps. In April or in late summer/fall (July-October), the same detection probability would demand approximately 15,763 hours of trap effort or approximately 33 continuous days of trapping with 20 traps.

5.7 Conclusions and Discussion

Surveys are being conducted throughout the range of the bog turtle to satisfy permit requirements for developers and transportation officials before filling is allowed. These surveys are usually conducted by using visual search techniques that involve walking through the wetlands and pulling back vegetation, probing with sticks, and groping.

Bog turtles are difficult to find even for experienced researchers. Turtles in small populations present even more difficulty. This study suggests that small populations of turtles in potential sites may easily go undetected using only visual searches. Search effort in one Maryland survey (Smith 1994) averaged 408.6 minutes (6.8 hours) in sites where turtles were not found as opposed to 104.4 minutes (1.7 hours) in sites where turtles were found. If only a single turtle had been found at each occupied site, this success rate could be expressed as 0.6 turtles per hour of search, a substantially higher yield than was observed for visual search at the Research Site "A" (0.04 turtles per hour). Data from Lovich et al. (1992) reflect an average of 0.27 turtles per hour of search (Mar-Dec), again a much higher yield than the Research Site "A". This is strong evidence that sites with small populations can be easily overlooked. Such oversights can have disastrous results if sites are scheduled for development. Results of this study indicate that traps should be used to assess sites if visual searches fail to produce bog turtles or signs of bog turtles.

Developers may call on researchers to examine sites for turtles at any time of the year. In winter months, it is only possible to determine that sites contain turtles if a bony shell (carapace and/or plastron) is found. (Eggshells are sometimes found, but are not conclusive evidence of bog turtles.) Earlier studies report that the optimal time for finding turtles by visual searching is in the spring (Lovich et al. 1992; Ernst et al. 1994; Carter 1997). We found this is also true for trapping.

Discovery of one bog turtle suffices to establish a site as bog turtle habitat, but determining the level of effort necessary to conclude the probable absence of this species is more challenging. A minimum of 9,000 trap hours per hectare of trapping effort in May and June is needed to reliably detect a population of the size reported in this study (N 10). Since this effort level is roughly equivalent to setting 20 traps for 20 days in May and June, this can be called the "20-20 Rule."

Matrix 2 of Klemens "Standardized Bog Turtle Site-quality Analysis" assigns the lowest rank (1) to populations of up to 5 turtles (Klemens 1993). Populations with 6-10 individuals are assigned a rank of 2 on the scale of 1-5, and, depending on many factors (mentioned above), are of a size that may warrant consideration for conservation or site enhancement. It is probable that detecting populations with 6 individuals will require much more than a 20-20 effort, but finding these populations is still worthwhile. Traps should be concentrated in the region of best habitat (see Chapter 4).

6. Recommendations

6.1 For Research Site "A"

The Research Site "A" is a small, degraded wetland in the piedmont of North Carolina with a population of bog turtles so reduced that it will not likely survive long into the future unless action is taken to increase their numbers. The factors limiting population size appear to be the restricted area of favored vegetation type within the site and overgrazing by cattle. Site enhancement efforts controlling (but not eliminating) access by cattle appears to be beneficial. Additional enhancement efforts are planned which will increase the size of the wetland in order to offset the effects of drainage.

The site seems ideal for a population augmentation experiment (Sec 3.6). Such experiments are desperately needed to expand our knowledge and our arsenal of tools to fight extinction.

6.2 For Determining the Occurrence of Bog Turtles in Potential Sites

Our results suggest, when slated for development, small patches of marginal habitat should be considered bog turtle *absentia* only after a minimum of 9,000 trap-hours per hectare of trapping effort are invested in May and June. Since this is roughly equivalent to setting 20 traps for 20 days, it can be called the "20-20 Rule." Traps should be concentrated in regions of best habitat. Trapping in sites with fewer than 10 turtles per hectare or at other times of the year will require much more effort.

7. Further Studies Planned

Trapping will continue in 1999. It is unlikely that there are additional, uncaptured, large juvenile or adult turtles residing in the open patch. Uncaptured turtles of all age classes may reside in the hayfield patch and perhaps even in the closed patch. Since the closed patch is not fenced, we are unable to trap there at present. However, a "blitz" trapping effort is scheduled for the hayfield patch in the spring of 1999. We plan to saturate that area with 50+ traps for at least 2 weeks in order to try and recapture turtle 0.3 and learn of other turtles that may inhabit the area.

Nearby sites in the same drainage will also be trapped. We plan to trap Research Site "A" and Research Site "B" if permission is granted by the landowners.

Additional fencing is planned for the closed patch.

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Appendix I

Arial Maps of Research Site "A"

1940

1951

1955

1966

1977

September 29, 1940

May 31, 1951

September 16, 1955

November 16, 1966

March 31, 1977

Appendix II

Landowner Packet

distributed by

Project Bog Turtle

Endangered Species and Piedmont North Carolina Landowners

Kenneth A., Bridle, PhD Aug 15, 1996

A Summary of the Federal Endangered Species Act

An understanding of endangered species and the laws designed to protect them are important for the proper functioning of any land conservancy. Rare plant and animal species occur in our region and stewardship of these resources is a part of our mission. We also strive to work with private landowners to achieve this mission. However, a common fear often prevents the public from working with conservation organizations. The concern of some landowners is that if the existence of an endangered species is discovered on their land, restrictions and land-use limitations will be imposed. This belief is largely based on lack of knowledge and understanding of the law and misinterpretations of its record. Also, in the current climate of political confrontation. the issue of endangered species protection is a rhetorically charged debate, often with little regard for the truth The following is derived from the relevant Federal and North Carolina laws regarding endangered species and is stated as a brief summary of those sections that most directly impact landowners and private land use.

The Endangered Species Act of 1973 (ESA or the Act) as amended, serves as the basis for the Federal program and the model for most state programs, including North Carolina In the first paragraph of the Act Congress recognized the value of endangered species by stating that 'endangered species of fish, wildlife and plants are of aesthetic, ecologicaL recreationaL educational. historical and scientific value to the nation and its people.' These values include commercial commodities, environmental health and quality indicators, and educational and recreational public interests.

The Act sets up a mechanism for placing species on the List of Endangered and Threatened Wildlife and Plants. It also defines most of the appropriate terms in non-ambiguous ways (for example- *endangered species is* a taxon 'which is in danger of extinction throughout all or a significant portion of its natural range). Listing species provides a method of tracking and planning for each species recovery. Each listing involves many levels of review by the public, government agencies and the scientific community. The Act empowers the U.S. Fish and Wildlife Service and National Marine Fisheries Service to manage permits and enforcement, implement recovery plans, recommend research, monitor endangered species populations and cooperate with other public and private entities to conserve listed species. The goal is to ensure recovery to a point where the species no longer needs protection under the Act An important and often overlooked provision of the Act requires the Secretary of Interior to consider economic and other costs in the protection plans for each species when designating critical habitat. This provision promotes a balance between costs and benefits of this regulatory action. This judgment was recently used to exclude from protection 3 million of 9 million acres of spotted owl critical habitat in an effort to lessen the impact on the logging industry.

With regard to listed animals the Act states it is illegal to:

- Engage in interstate or foreign trade without a permit
- 'Take' any listed species (Take - harass, harm, pursue. hunt, kill, trap...)
- Possess illegally taken endangered or threatened species

With regard to plants the law says that it is illegal to:

- Engage in interstate or foreign trade without a permit
- Remove and reduce to possession such plants from federal lands
- Maliciously damage or destroy any such species on federal lands
- Remove, cut, dig up, damage or destroy an endangered plant on anyone's land in knowing violation of the law. including trespass

The maximum penalty: 550.000 and/or 1 year in prison.

In addition, the Act requires federal agencies to develop programs to conserve listed species and prohibits them from carrying out any action that would jeopardize the continued existence of listed species or adversely modify critical habitat The Act also protects species from the potentially harmful actions of private landowners. However, the Act offers several flexible tools for resolving conflicts between private landowners and endangered species. For example, private landowners can lawfully 'take' listed species if its 'incidental to and not the purpose of carrying out otherwise lawful activities' and the landowner implements a conservation plan for those species. Implementation of the Act is designed to 'foster creative partnerships between the private sector and government agencies in the interest of endangered species conservation'.

From 1979-1992 there were 120,000 Federal projects reviewed for impact on endangered species, of these, less than 1% were found to significantly impact an endangered species overall, even though a particular project may have caused local destruction of a population, and only 34 (0.03%) of those development projects were stopped as a result of the ESA. Far from being an uncompromising straitjacket that its opponents portray, the ESA is replete with requirements to balance the needs of endangered species conservation with private property owners and developers. Private developers can obtain federal permits to legally harm or even kill endangered species on their property provided they show that they tried to minimize their impact on the species in other ways. As an ultimate balancing of endangered species and economics there exists the Endangered Species Committee, which is authorized to exempt activities from the ESA when the benefits of the project clearly outweigh the conservation of a species, even though this will result in the complete extinction of a species. Due to the other flexibility in the ESA only three cases have ever come before this committee.

The underlying reality is that rare species like other rare objects are valued because of their rarity. Most of the people prosecuted under the Endangered Species Act are wildlife traffickers who illegally and knowingly collect rare wildlife and plants to sell for personal profit. The existence of an endangered species on private property legally has no effect unless the landowner (or someone else) is planning a project that requires a federal permit, or uses federal funds, or that will clearly result in the illegal taking of a listed species. Even where a private landowners property is designated as critical habitat for an endangered species, *private landowners are not regulated by the ESA, only Federal actions that would adversely alter critical habitat.* At the present time only three fish and one plant have designations of critical habitat in North Carolina, none occur in the area served by the Piedmont Land Conservancy. Currently there are 5 federally listed plants in our area and 4 animals.

Federally Endangered or Threatened Plants in our area

Small-anthered Bittercress	*Cardamine micranthra*
Smooth Coneflower	*Echinacea laevigata*
Schweinitz's Sunflower	*Helianthus schweinitzii*
Small Whorled Pogonia	*Isotria medeoloides*
White Irisette	*Sisyrinchium dichotomum*

Federally Endangered or Threatened Animals in our area

Eastern Cougar	*Fells concolor cougar* .(probably no longer in this region)
Kirtland's Warbler	*Dendroica kirtlandii* (occasional migrant through this area)
Bald Eagle	*Haliaeetus leucocephalus*
Red-cockaded Woodpecker	*Picoides borealis*
Bachman s warbler	*Vermivora bachmanii* (last seen in the early 1960's, possibly extinct)
Cape Fear Shiner	*Notropis mekistocholas*
Peregrine Falot	*Falco peregrinus* (occasional migrant through tins area)

Summary of North Carolina Endangered Species Laws

After the establishment of the ESA, many states developed their own endangered species laws to deal with cases of local or regional rarity that are not regulated by the national law. North Carolina has a rich diversity of biology in habitats ranging from the mountains to the sea This state is home to organisms that occur nowhere else and other organisms where our state is only part of a larger range. It is these special cases of rarity that are covered by the North Carolina endangered species laws.

Animals: Using the federal Endangered Species Act as a model, North Carolina enacted General Statutes 113-331 to 113-337, effective 1987 which authorizes the Wildlife Resources Commission to develop a system to monitor and protect rare animal species in the state. The Commission was mandated to undertake rare animal species listing and designation of critical habitats upon recommendation of the Nongame Wildlife Advisory Committee. The Commission then coordinates the development and implementation of management plans for listed species. Chapter 392 (11832), 1995 of North Carolina Legislation amended the Commission's mandate to take into consideration a wider range of conservation, protection and management measures that may be applied to the species and habitats. Costs of protection, economic impact, and reasonably available options for minimizing costs and adverse impacts must be considered in each plan. Most importantly to landowners *"no rule may be adopted that restricts use or development of private property".*

The protection of endangered animals in this state is essentially similar to the federal ESA in that it is targeted at illegal trafficking in rare animals and products, and protection of native populations from poaching. Landowners can do almost anything they want with state listed rare species on their property except possess, sell or kill them without a permit.

Plants: The Plant Protection and Conservation Act (Chapter 106, Article 19B; 202.12-202.22; of the General Statutes of North Carolina), authorizes the North Carolina Department of Agriculture to monitor and protect rare plant species in the state. The listing of plants is done by the Commissioner of Agriculture at the recommendation of the North Carolina Plant Conservation Board. Upon listing, the Agriculture Department is required to work with other state agencies to monitor and develop management plans for each listed species. Currently the Natural Heritage Program (Division of Environment, Health, and Natural Resources) maintains the database which tracks rare plant populations and the Agriculture Department maintains a Plant Protection Office for the purpose of management and legal protection of native plant species in peril The Plant Protection Office also issues permits regarding collection, propagation and trade of rare plants for sale, most notably ginseng.

Like the federal ESA, this law is primarily aimed at protecting rare plants from the actions of illegal traffickers who collect the plants for profit and to minimize the impact of state development projects on rare plant populations. In the section outlining the "unlawful acts" a specific line was included to protect private property owners. It states that *the incidental disturbance of protected plants during agricultural, forestry or development operations Ls not illegal so long as the plants are not collected for sale or commercial use'.* Here again the bottom line is that a private property owner can do whatever they want with the native rare plants on their land except sell them without a permit.

The preparation of this document was made possible with help and advice from the following:

Marjorie W. Boyer,	North Carolina Department of Agriculture, Plant Industry Division, Raleigh NC
Nora A. Murdock.,	U.S. Fish and Wildlife Service, Ecological Services Field Office, Asheville, NC
Randall C. Wilson,	North Carolina Wildlife Resources Commission. Division of Wildlife Management, Raleigh, NC

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 very secretive. They rarely bask in 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 from the sun.

Q: Why are they so special?

A: The number of bog turtles has decreased significantly. This is mostly due to habitat loss and collection for the pet trade. Because of the decrease in population, bog turtles are currently listed as threatened or endangered in all states they inhabit. Listing as a threatened or endangered species 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 effect 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 has a beneficial effect for bog turtles. It is believed that seasonal 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 or 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 are many different ways to protect bog turtles. To protect the bog turtle you must protect their habitat - bogs. There are preservation programs designed for the purpose of wildlife and wetland protection and restoration that can offer technical assistance. Also, conservancies and land trusts offer many preservation options, some with financial benefit.

1. **What is a Meadow Bog?**

   The term meadow bog is used to describe 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. They are swampy or wet areas vegetated with sedges and shrubs. Although they may appear to be wastelands, meadow bogs are true wonderlands performing important functions which provide valuable benefits to humans.

2. **What are their Values?**

   - *Flooding and Water Quality*

     Meadow bogs are vital to the local water conditions. Meadow bogs can reduce flooding by holding excess water during storms. As a result, a bog recharges groundwater and reduces erosion and sedimentation. Groundwater recharge is an important process in maintaining the quality and quantity of well water. Erosion and sedimentation is reduced because meadow bogs decrease the velocity and amount of surface water flow, in turn reducing the amount of sediment that reaches streams and rivers. Additionally, they can act as sinks or filters of excess nutrients, pesticides and other pollutants. As a result, our streams and rivers stay cleaner and clearer.

   - *Habitat for Wildlife*

     When wetlands are altered, the composition of the animal and plant communities is changed. Many rare or unusual species inhabited wetlands that have since become meadow bogs. Some of these species include Gray's lilies, sundews, orchids, four-toed salamander and bog turtles. Even in meadow bogs, these unusual species often still exist. Another remarkable feature of meadow bogs is that some contain plant species that are generally exclusive to Northern wetlands; for example, cranberry and cottongrass.

     In some cases, human impacts maintain habitat. Bog turtles prefer more open areas, vegetated by sedges and rushes. Seasonal grazing and occasional mowing maintain this type of habitat by impeding the growth of trees and shrubs.

     Other more common but still important species inhabit meadow bogs. Numerous frogs and salamanders live in meadow bogs. Game wildlife such as white-tailed deer, wood ducks, snipe and woodcock also inhabit meadow bogs. Bogs also provide a food source in the winter when food is scarce. Furthermore, because wetlands keep streams and rivers clean, they help to maintain habitat for sport fish,, such as trout.

3. **Why Preserve Meadow Bogs?**

   North Carolina has lost more than half of its wetlands. The loss of bogs in particular has been even greater, with a loss of 90% in North Carolina. When the wetlands disappear so do the values and benefits that we acquire from them. The effects of the decrease in wetlands has been seen all over the country, including increased flooding, increased water contamination and a decrease in waterfowl, migratory birds, fish and other species that use wetlands. Because of the huge losses that have already occurred it is even more important to preserve those wetlands remaining.

4. What are the Preservation Options?

There are many different ways to preserve meadow bogs. All preservation options are completely voluntary and many occur while maintaining private ownership and use of the land. In addition to the benefits derived from preserving a quickly disappearing natural resource in North Carolina, some methods of preservation have financial benefit to landowners.

A few of the programs that assist in preservation are the Wetlands Reserve Program, Partners for Wildlife and the North Carolina Natural Heritage Program's registry and dedication. These programs were developed to help landowners preserve their natural resources and do not involve transfer of land ownership. The programs may provide information about the important natural resources on the property, develop a conservation plan and offer financial help. Other preservation options occur with the assistance of a conservancy or local land trust. Conservancies and land trusts are non-governmental, non-profit organizations created to preserve and restore natural resources. The objective of each organization is different. Local land trusts concentrate on a certain area or particular resource, such as a river or lake. Some larger organizations such as The Nature Conservancy, are primarily concerned with large, pristine sites around the world.

There are many different preservation options that occur through conservancies and land trusts. Some methods of preserving natural resources include management agreements, conservation easements, leases, sales and donations. With any of these options the conservancy or land trust is responsible for preserving the natural assets of the land. Conservation easements, leases, sales and donations provide financial benefits to the landowner.

For further information on meadow bogs and preservation options contact your local Natural Resource Conservation Service office, US Fish and Wildlife Service office, or .

Project Bog Turtle
North Carolina State Museum of Natural Science
PO Box 29555
Raleigh, N.C. 27626-0555
phone: 919-733-7450 ext. 70
fax 919-733-1573

Methods of Preservation of Wetlands

1. *Wetlands Reserve Program*

The Wetlands Reserve Program (WRP) was established to assist fanners 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 (FWS) to guide in their restoration and management.

Contact: NRCS or FWS

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 (FWS) 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, and education and outreach. Restoration costs may be covered or shared with the landowner.

Contact: FWS

4. *North Carolina Natural Heritage Program*

The North Carolina Natural Heritage Program (NCNHP) is administered by the Division of Parks and Recreation, Department of Environment, 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: NHP

5. *Conservancies and Land Trusts*

Conservancies and land trusts are nonprofit 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 Land Trust or Conservancy

Following is a list of organizations that can provide more information about wetland protection methods and help with protection decisions.

Land Trusts and Conservancies

Stale and National Groups

The Conservation Fund
Southeastern Regional Office
310 1/2 W. Franklin St.
Chapel Hill, NC 27516
(919)967-2223
Mailing Address:
P.O. Box 374
Chapel Hill, NC 27514

Conservation Trust for North Carolina
P.O. Box 33333
Raleigh, NC 27636-3333
(919)828-4199

National Audubon Society
950 Third Avenue
New York, New York 10022
(212)832-3200

The National Wildlife Federation
1412 Sixteenth Street, N.W.
Washington, D.C. 20036
(202)767-6800

The Nature Conservancy
North Carolina Office
4011 University Dr., Suite 201
Durham. NC 27707
(919)403-8558

Trust for Public Land
Atlanta Field Office
1447 Peachtree Street, NE
Suite 601
Atlanta. GA 30309
(800)577-2237

Regional

Catawba Lands Conservancy
(704)375-6003
1617 East Boulevard
Suite 200
Charlotte, NC 28203

Pacolet Area Conservancy
P.O. Box 310
Columbus, NC 28722
(704)894-3018

Highlands Land Trust
P.O. Box 1703
Highland, NC 28741
(704)526-3496

National Committee for the New River
P.O. Box 180
Glendale Springs, NC 28629
(910)982-9090

Natural Heritage Trust ofHenderson County
P.O. Box 2822
Hendersonville, NC 28793-2822
(704)697-9527

Piedmont Land Conservancy
Box 4025
Greensboro, NC 27404-4025
(910)299-2651

Southern Appalachian Highlands Conservancy
34 Wall St., Suite 802
Asheville, NC 28801
(704)253-0095

Trust for Appalachian Trail Lands
P.O. Box 807
Harbors Ferry, West Virginia 25425
(304)535-6331

Government Agencies

Local Governments

Soil and Water Conservation Districts

State Government

Division of Parks and Recreation
N.C. Department of Environment, Health and Natural Resources
P.O. Box 27687
Raleigh. N.C. 27611
(919)733-4181

Natural Heritage Program
DEHNR-Division of Parks and Recreation
P.O. Box 27687
Raleigh, N.C. 27611
(919)733-7701

Wildlife Resources Commission
N.C. Department of Environment, Health and Natural Resources
512 Salisbury Street
Raleigh, NC 27611
(919)733-3391

Federal Government

National Parks Service
United states Department of the Interior
Regional Office, Richard B. Russell Building
75 Spring Street
Atlanta. GA 30303

US Fish and Wildlife Service
United states Department of the Interior
Regional Office. Richard B. Russell Building
75 Spring Street
Atlanta. GA 30303

US Forest Service
United States Department of Agriculture
National Forests in North Carolina
P.O. Box 2750
Asheville, NC 28802

Appendix III

Sample Lease Agreement:

An agreement between landowners **and** Project Bog Turtle

CONSERVATION AGREEMENT AND LEASE

This is a conservation easement and lease between ______________________(Landowner) and NORTH CAROLINA HERPETOLOGICAL SOCIETY (Lessee).

WHEREAS, there lives on the property of Landowner a population of bog turtles, and the parties wish to enter into this Agreement for the purpose of protecting these turtles and the special land 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 ________(_____) years and may be extended for additional periods upon the agreement of the parties.

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

3. Payment. Lessee will pay to Landowner the sum of ____ Dollars ($___________) per year 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 taking or removing bog turtles in furtherance of any conservation or recovery plan.

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 which are not inconsistent with the Landowner's use of the property. The Lessee agrees to notify the Landowner before it or others acting on its 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 of its 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.

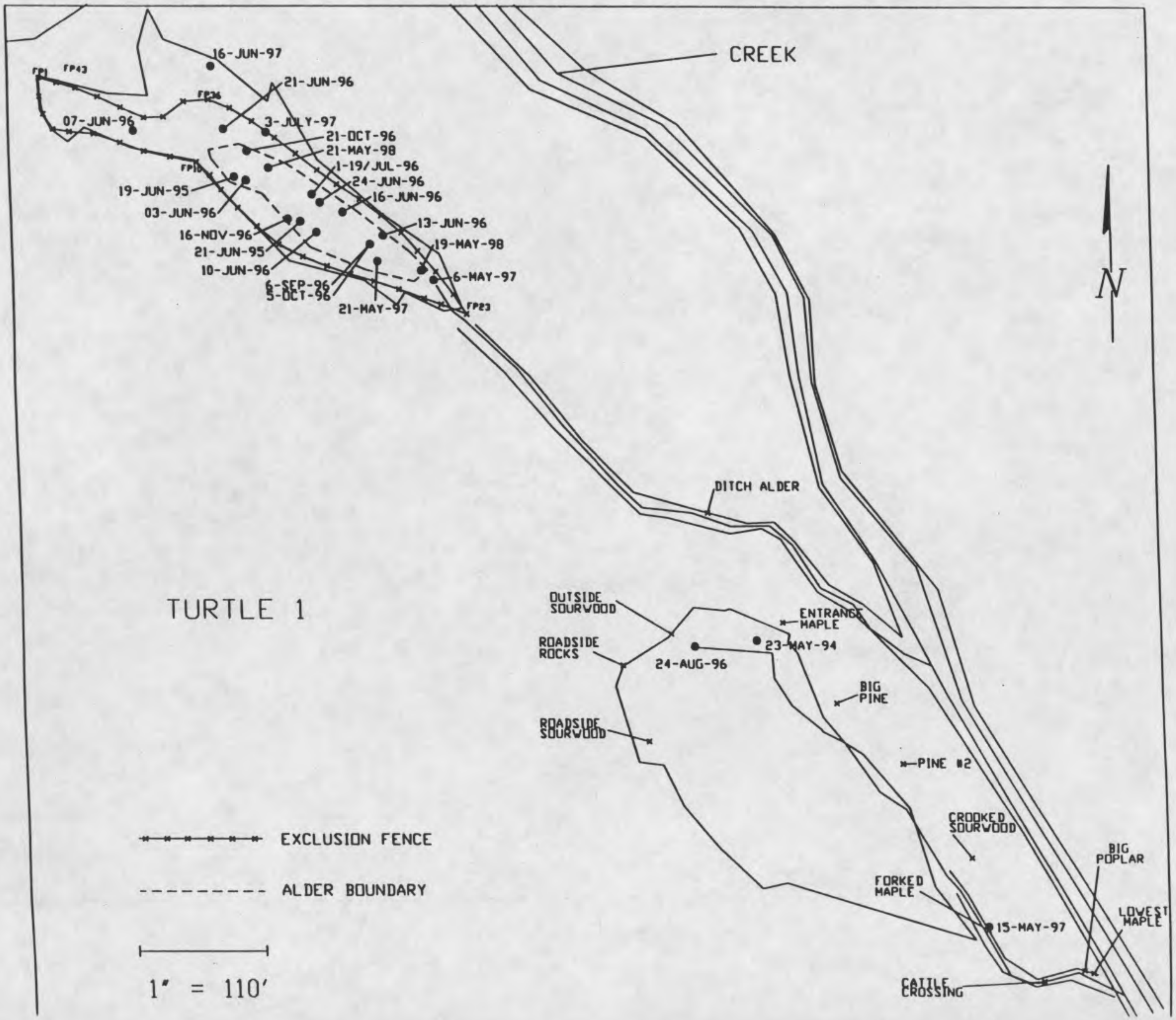
Landowner

NORTH CAROLINA HERPETOLOGICAL SOCIETY, Lessee

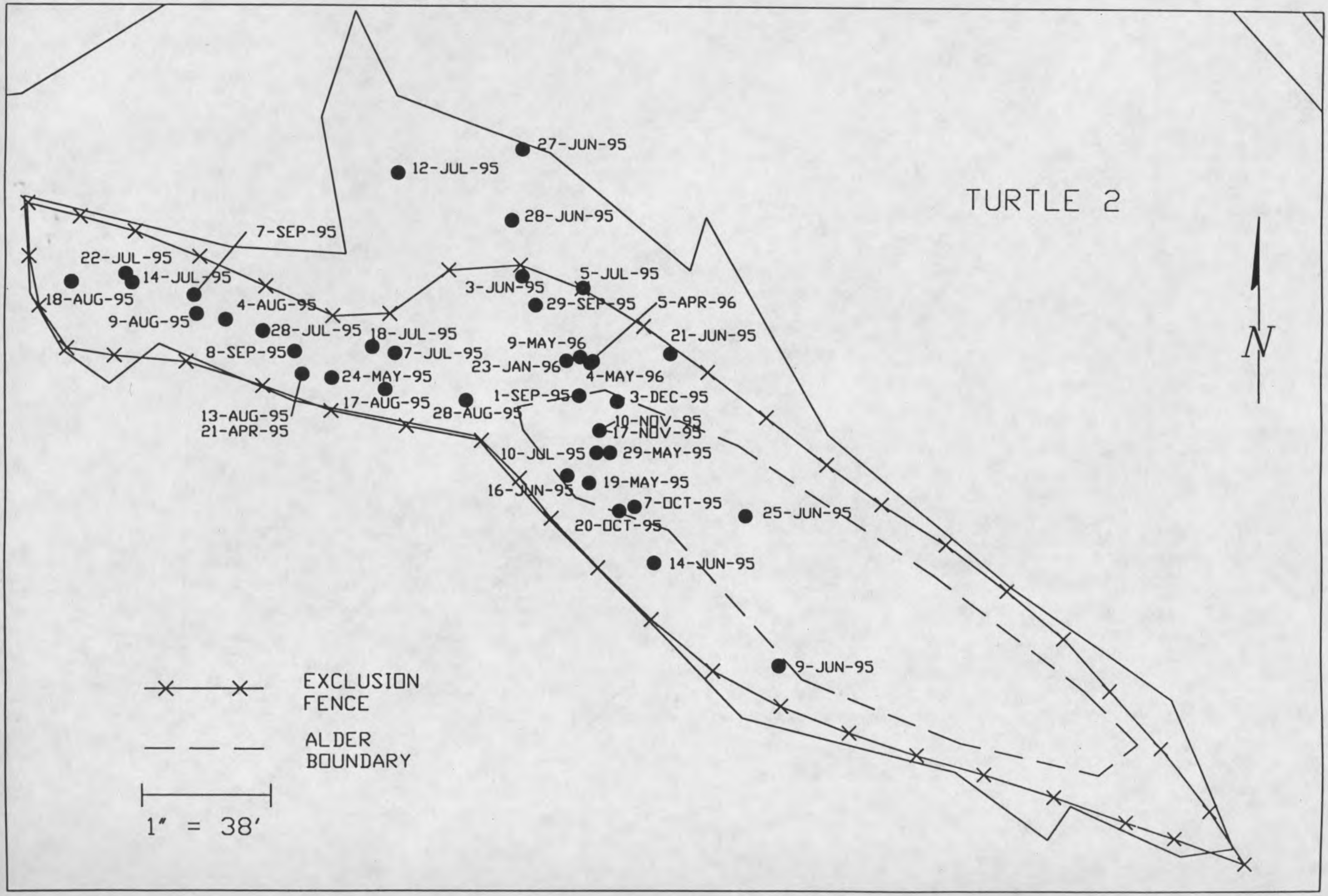
By: ______________________________

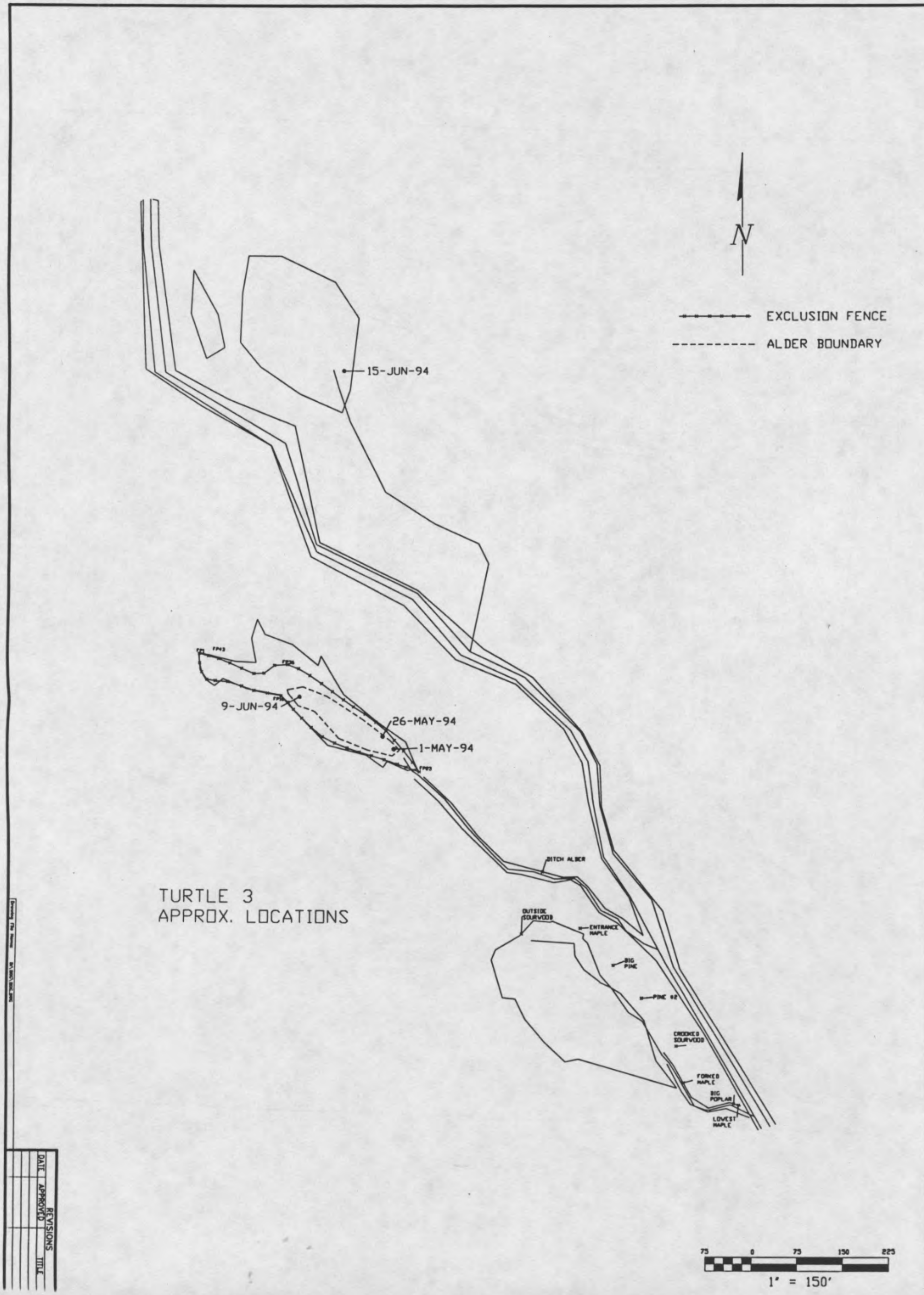
Appendix IV

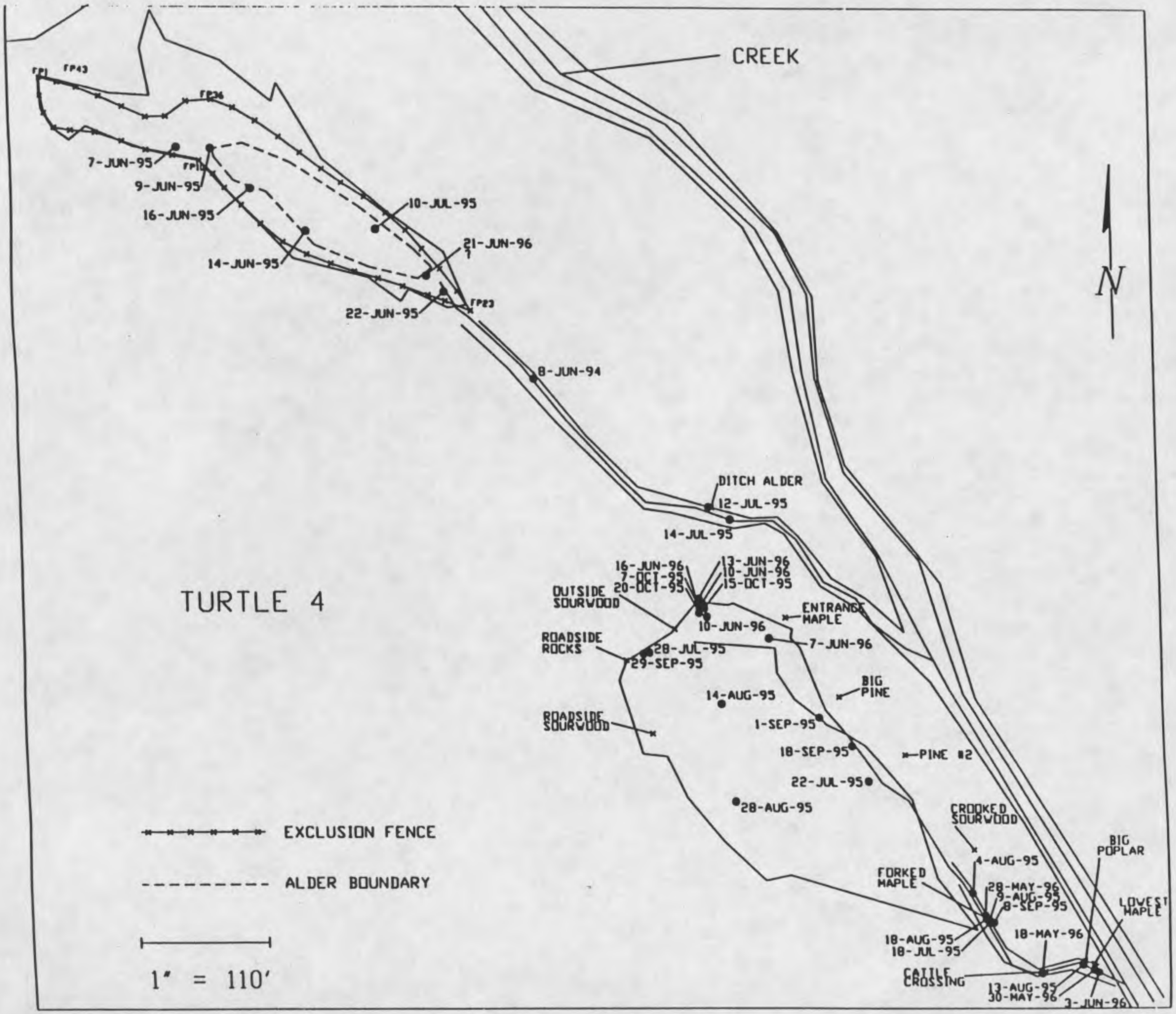
Locations of Turtles at Research Site "A" 1993-1998

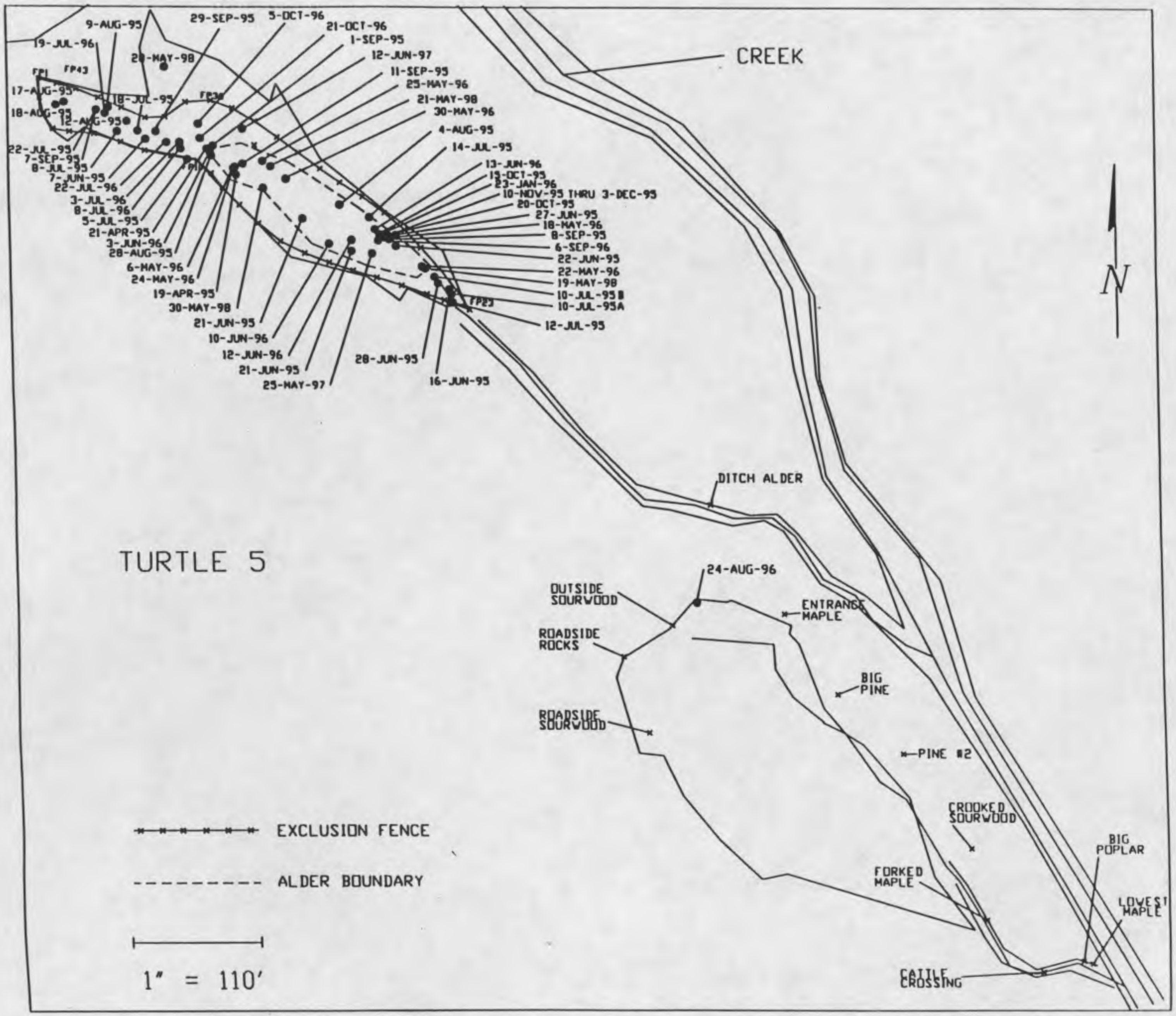


CREEK
FP1
FP43
FP36
FP10
FP23
16-JUN-97
21-JUN-96
07-JUN-96
3-JULY-97
21-OCT-96
21-MAY-98
1-19/JUL-96
24-JUN-96
16-JUN-96
19-JUN-95
03-JUN-96
13-JUN-96
16-NOV-96
21-JUN-95
19-MAY-98
10-JUN-96
6-MAY-97
6-SEP-96
5-OCT-96
21-MAY-97
N
DITCH ALDER
TURTLE 1
OUTSIDE SOURWOOD
ENTRANCE MAPLE
ROADSIDE ROCKS
23-MAY-94
24-AUG-96
BIG PINE
ROADSIDE SOURWOOD
PINE #2
CROOKED SOURWOOD
BIG POPLAR
FORKED MAPLE
15-MAY-97
LOWEST MAPLE
CATTLE CROSSING
EXCLUSION FENCE
ALDER BOUNDARY
1" = 110'

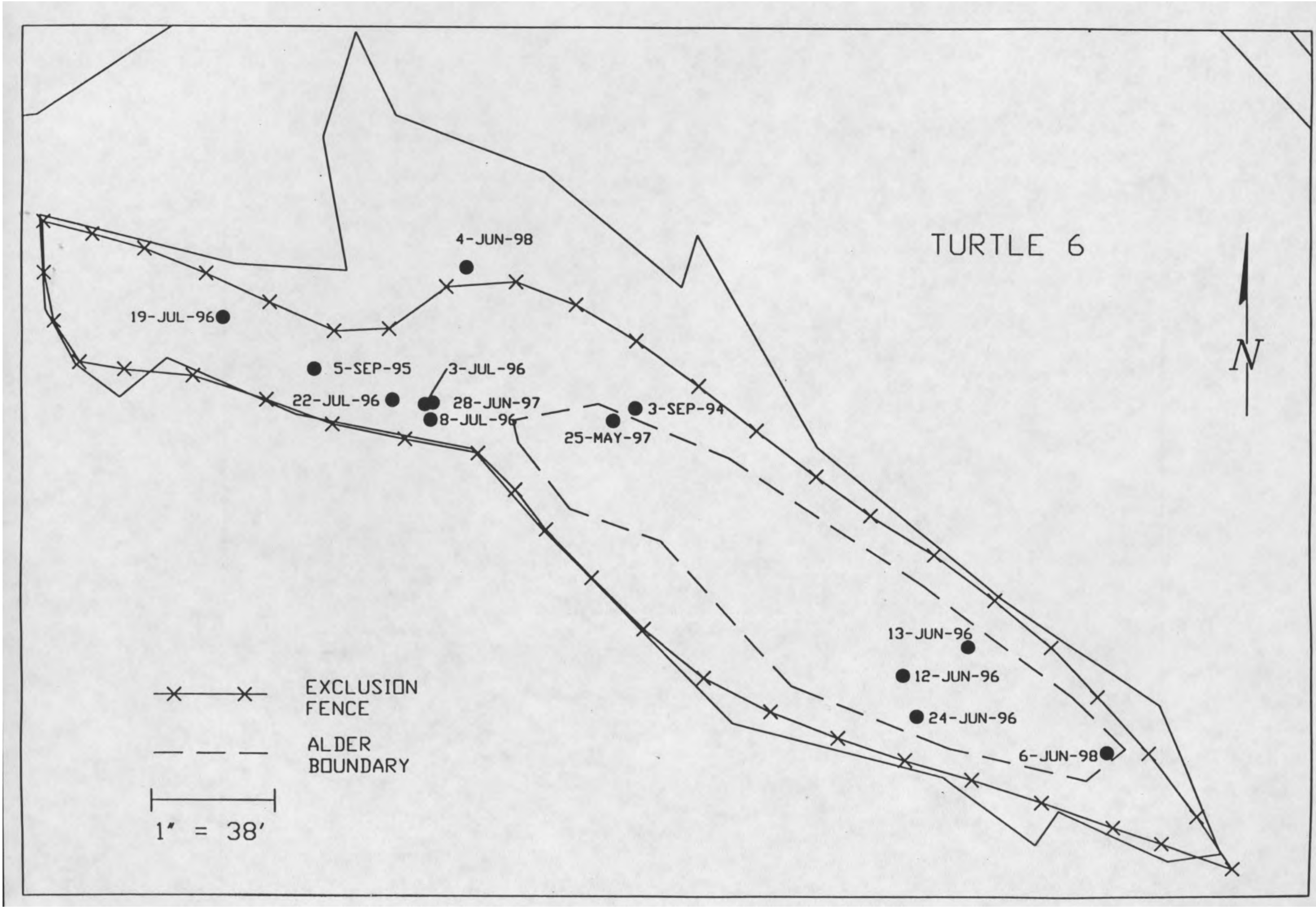

TURTLE 2
N
27-JUN-95
12-JUL-95
28-JUN-95
7-SEP-95
22-JUL-95
14-JUL-95
18-AUG-95
9-AUG-95
4-AUG-95
28-JUL-95
18-JUL-95
7-JUL-95
8-SEP-95
24-MAY-95
17-AUG-95
13-AUG-95
21-APR-95
28-AUG-95
3-JUN-95
5-JUL-95
29-SEP-95
5-APR-96
21-JUN-95
9-MAY-96
23-JAN-96
4-MAY-96
1-SEP-95
3-DEC-95
10-NOV-95
17-NOV-95
10-JUL-95
29-MAY-95
19-MAY-95
16-JUN-95
7-OCT-95
20-OCT-95
25-JUN-95
14-JUN-95
9-JUN-95
EXCLUSION
FENCE
ALDER
BOUNDARY
1" = 38'

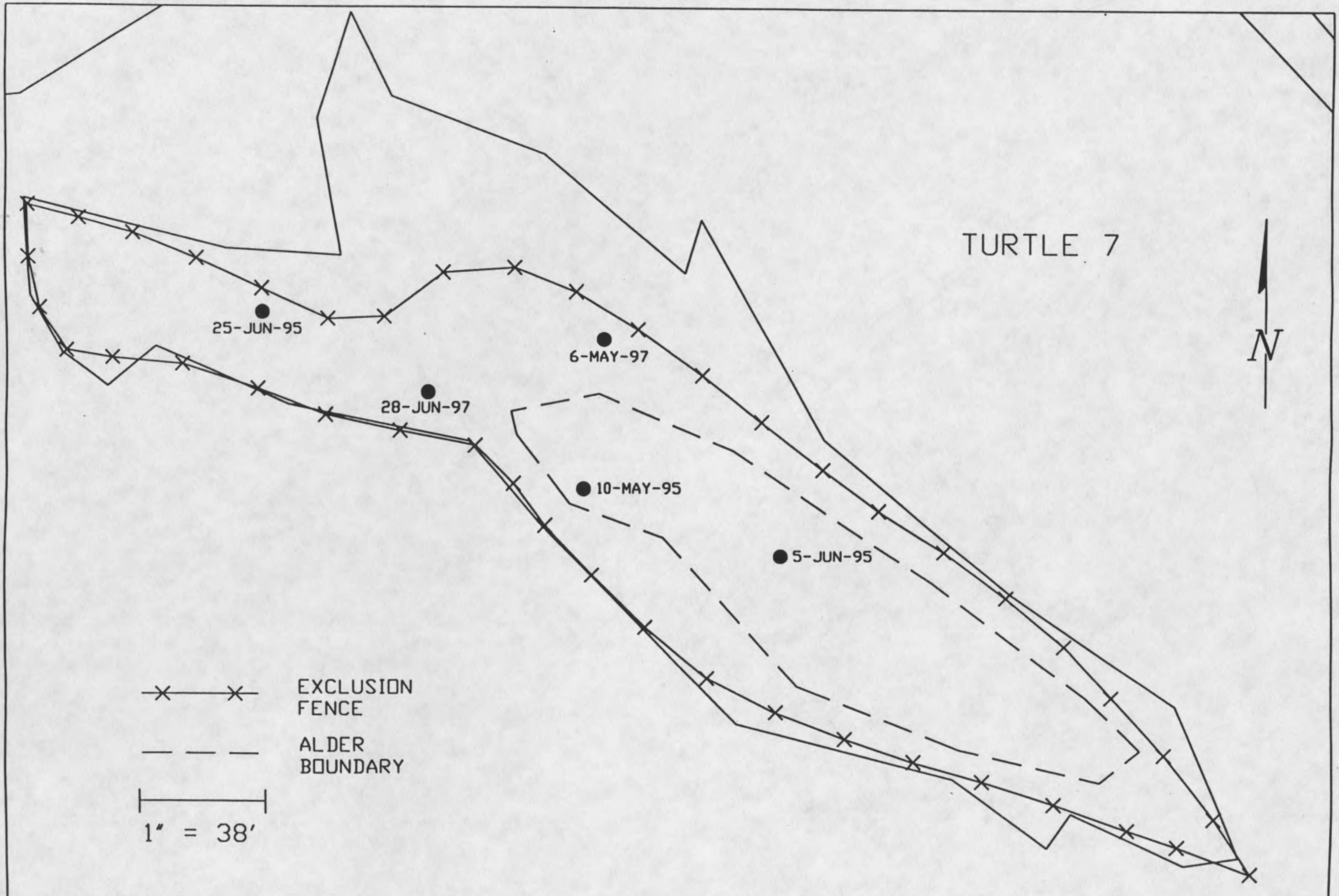

N
EXCLUSION FENCE
ALDER BOUNDARY
15-JUN-94
9-JUN-94
26-MAY-94
1-MAY-94
DITCH ALDER
TURTLE 3
APPROX. LOCATIONS
OUTSIDE SOURWOOD
ENTRANCE MAPLE
BIG PINE
PINE #2
CROOKED SOURWOOD
FORKED MAPLE
BIG POPLAR
LOWEST MAPLE
REVISIONS
DATE
APPROVED
TITLE
75 0 75 150 225
1' = 150'

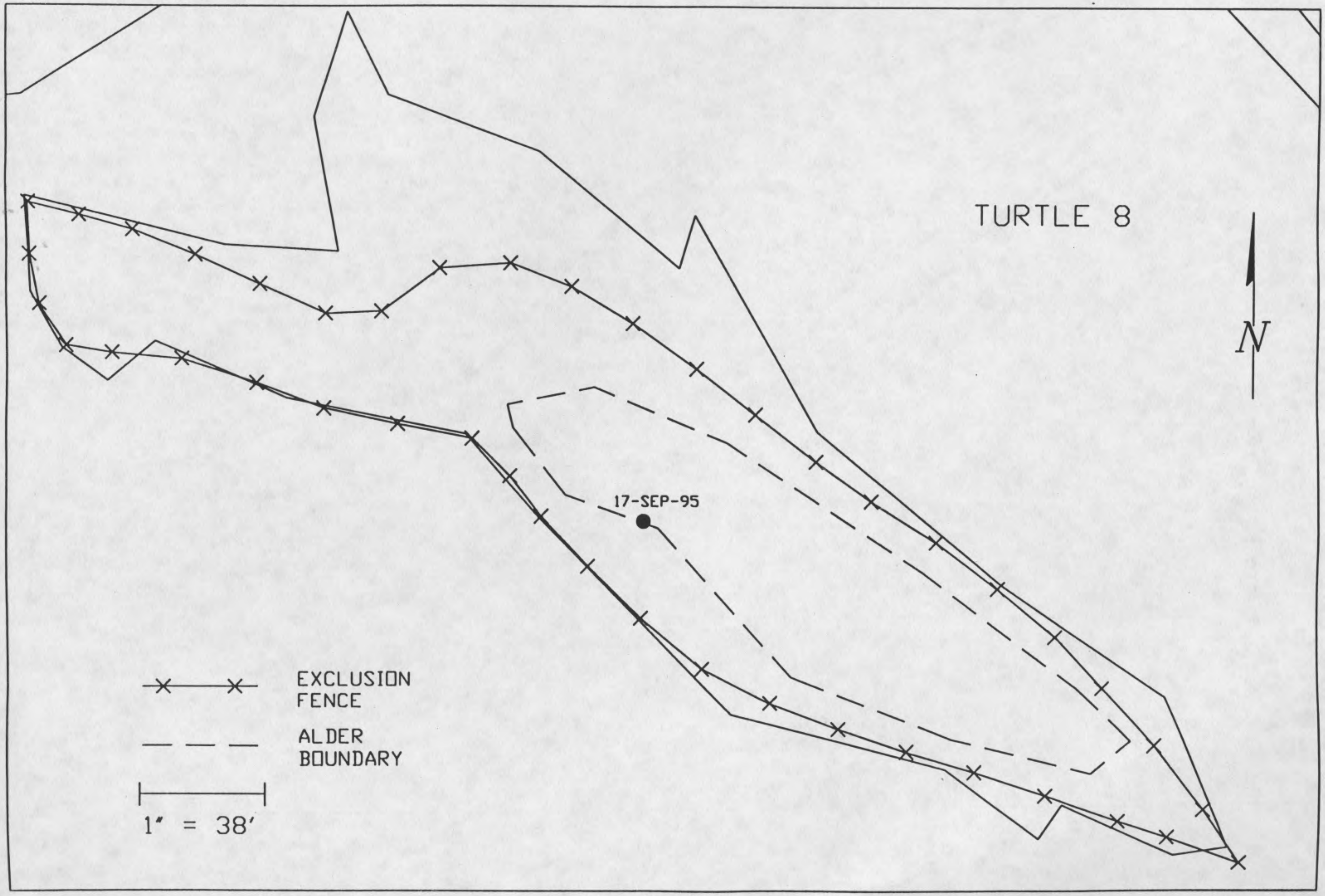

CREEK
N
FP1
FP43
FP36
FP10
FP23
7-JUN-95
9-JUN-95
16-JUN-95
14-JUN-95
10-JUL-95
21-JUN-96
22-JUN-95
8-JUN-94
DITCH ALDER
12-JUL-95
14-JUL-95
16-JUN-96
7-OCT-95
20-OCT-95
13-JUN-96
10-JUN-96
15-OCT-95
OUTSIDE SOURWOOD
ENTRANCE MAPLE
10-JUN-96
7-JUN-96
ROADSIDE ROCKS
28-JUL-95
29-SEP-95
BIG PINE
14-AUG-95
ROADSIDE SOURWOOD
1-SEP-95
18-SEP-95
PINE #2
22-JUL-95
28-AUG-95
CROOKED SOURWOOD
4-AUG-95
BIG POPLAR
FORKED MAPLE
28-MAY-96
9-AUG-95
8-SEP-95
LOWEST MAPLE
18-MAY-96
18-AUG-95
18-JUL-95
CATTLE CROSSING
13-AUG-95
30-MAY-96
3-JUN-96
TURTLE 4
EXCLUSION FENCE
ALDER BOUNDARY
1″ = 110′

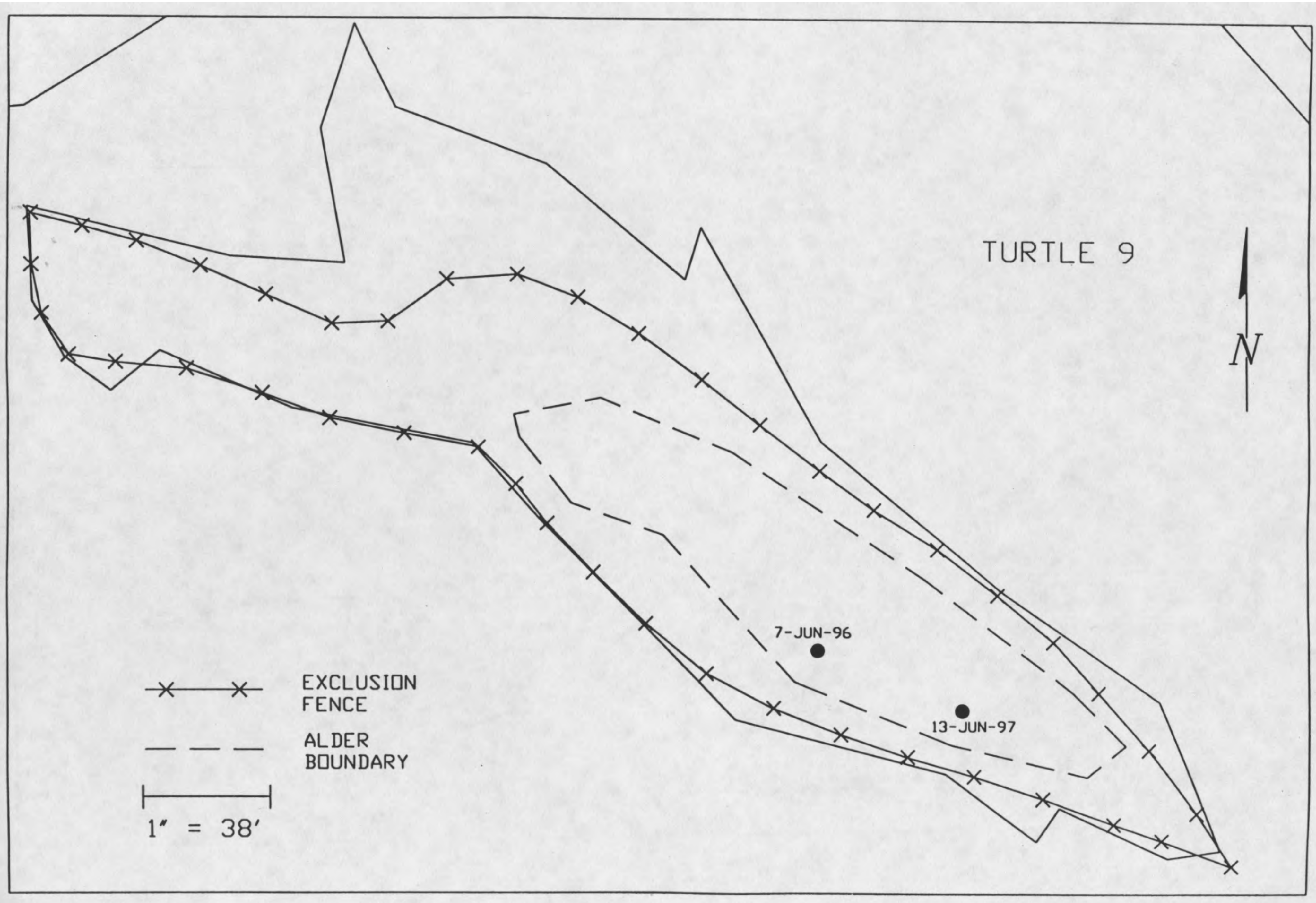


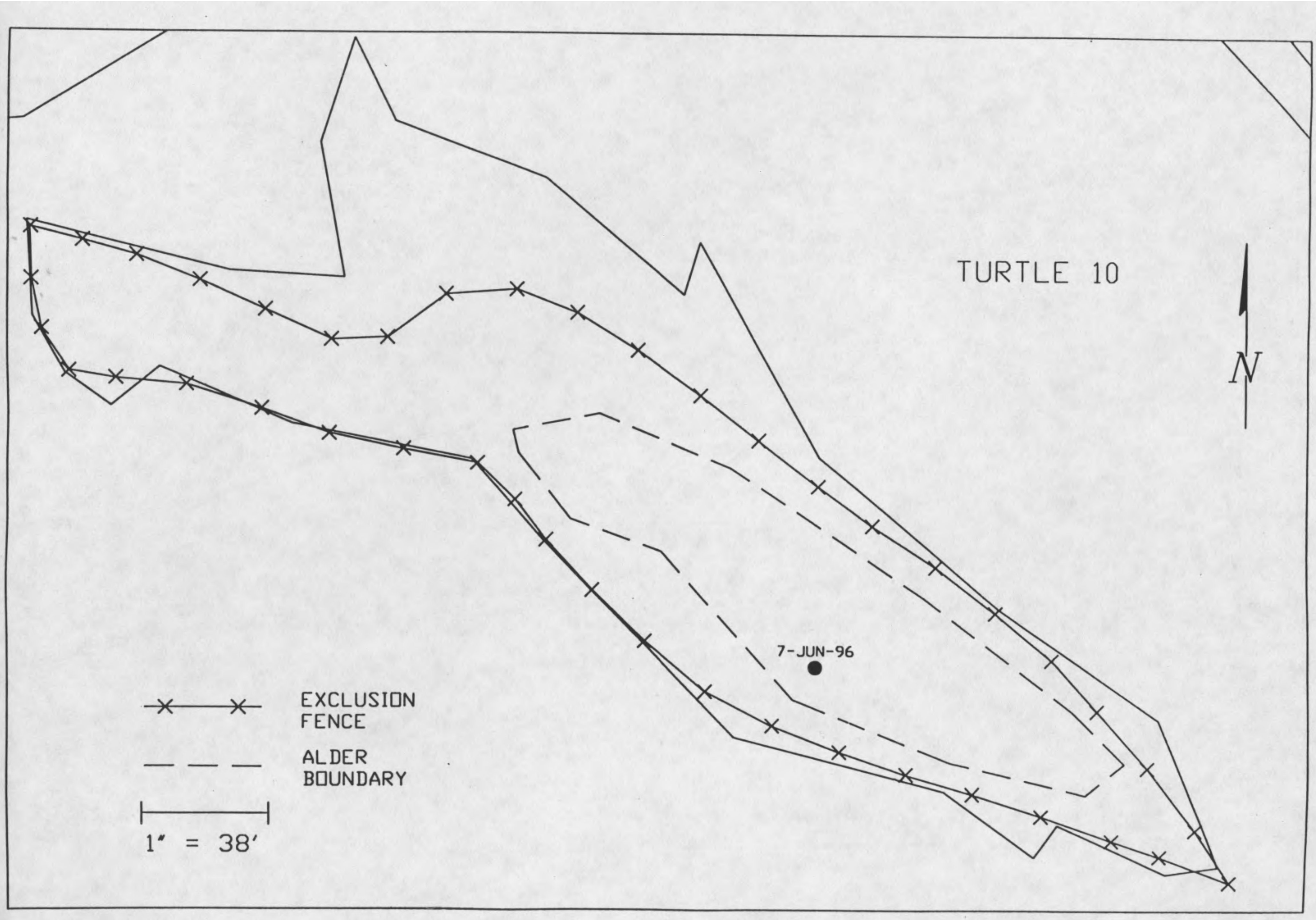
9-AUG-95
19-JUL-96
29-SEP-95
5-OCT-96
21-OCT-96
1-SEP-95
12-JUN-97
11-SEP-95
25-MAY-96
21-MAY-98
30-MAY-96
4-AUG-95
14-JUL-95
13-JUN-96
23-JAN-96
10-NOV-95 THRU 3-DEC-95
20-OCT-95
27-JUN-95
18-MAY-96
8-SEP-95
6-SEP-96
22-JUN-95
22-MAY-96
19-MAY-98
10-JUL-95 B
10-JUL-95A
12-JUL-95
FP1
FP43
FP30
FP23
17-AUG-95
18-JUL-95
18-AUG-95
12-AUG-95
22-JUL-95
7-SEP-95
8-JUL-95
7-JUN-95
22-JUL-96
3-JUL-96
8-JUL-96
5-JUL-95
21-APR-95
3-JUN-96
28-AUG-95
6-MAY-96
24-MAY-96
19-APR-95
30-MAY-98
21-JUN-95
10-JUN-96
12-JUN-96
21-JUN-95
25-MAY-97
28-JUN-95
16-JUN-95
CREEK
N
DITCH ALDER
TURTLE 5
24-AUG-96
OUTSIDE SOURWOOD
ENTRANCE MAPLE
ROADSIDE ROCKS
BIG PINE
ROADSIDE SOURWOOD
PINE #2
CROOKED SOURWOOD
BIG POPLAR
FORKED MAPLE
LOWEST MAPLE
CATTLE CROSSING
EXCLUSION FENCE
ALDER BOUNDARY
1" = 110'

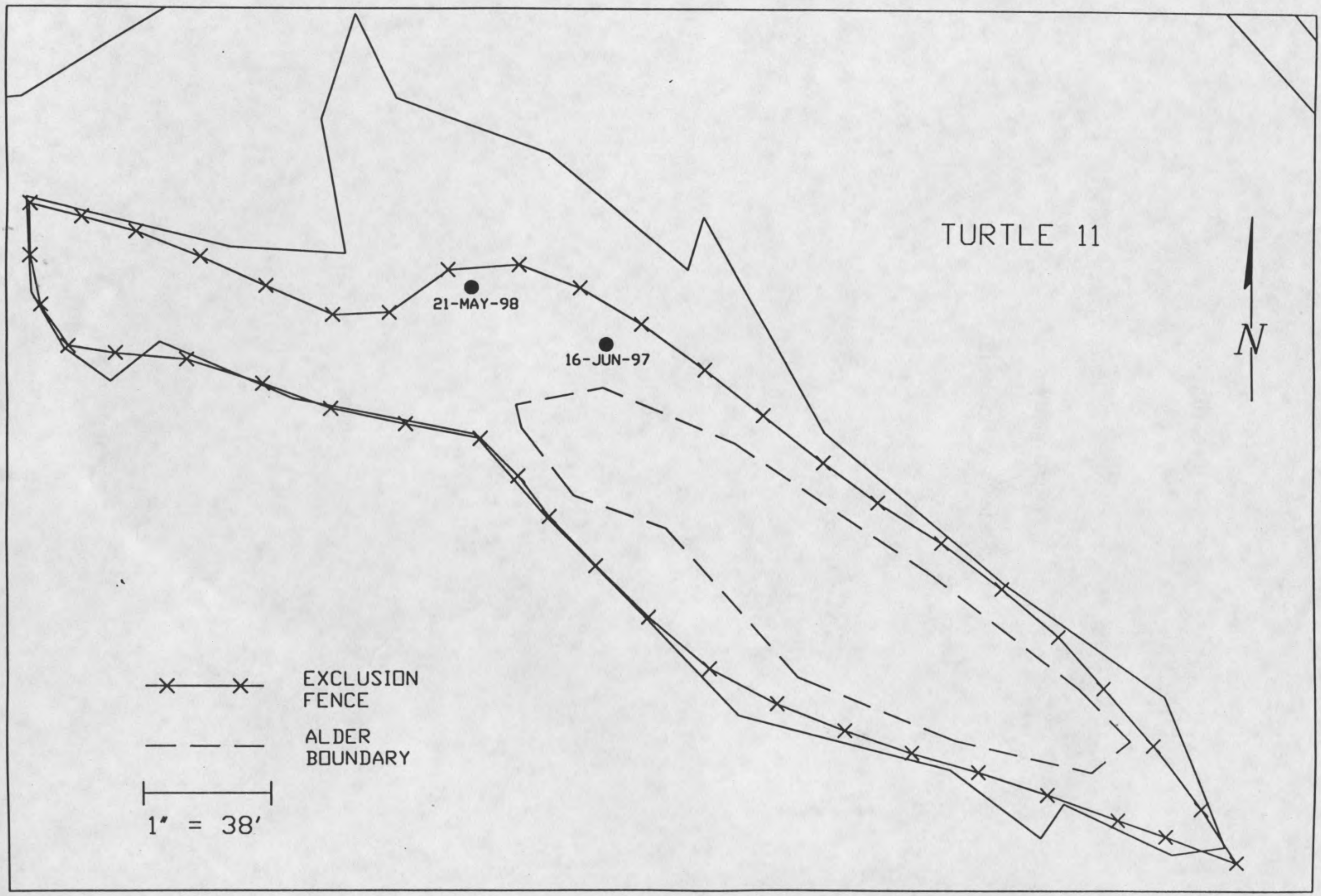

TURTLE 6
N
4-JUN-98
19-JUL-96
5-SEP-95
3-JUL-96
22-JUL-96
28-JUN-97
8-JUL-96
3-SEP-94
25-MAY-97
13-JUN-96
12-JUN-96
24-JUN-96
6-JUN-98
EXCLUSION FENCE
ALDER BOUNDARY
1" = 38'


TURTLE 7
N
25-JUN-95
6-MAY-97
28-JUN-97
10-MAY-95
5-JUN-95
EXCLUSION FENCE
ALDER BOUNDARY
1" = 38'


TURTLE 8
N
17-SEP-95
EXCLUSION FENCE
ALDER BOUNDARY
1" = 38'


TURTLE 9
N
7-JUN-96
13-JUN-97
EXCLUSION
FENCE
ALDER
BOUNDARY
1" = 38'


TURTLE 10
N
7-JUN-96
EXCLUSION FENCE
ALDER BOUNDARY
1" = 38'



TURTLE 11
N
21-MAY-98
16-JUN-97
EXCLUSION FENCE
ALDER BOUNDARY
1" = 38'

Appendix V

Plant Species List for Research Site "A"

provided by

Kenneth A. Bridle, Ph.D.

PLANT SPECIES LIST
Research Site "A" Bog Complex
Compiled by Kenneth A. Bridle, **Ph.** D.

Community Types/Locations:
H= Hayfield, **R=** Riparian (along creek), Open canopy area, Closed canopy area

PLANTS

Canopy:	*Salix nigra*	black willow	R,C
	Liquidambar styraciflua	sweet gum	R,C
	Betula nigra	river birch	R,C,H
	Acer rubrum	red maple	R,C,H
	Acer negundo	box elder	R,C,H
	Fraxinus pennsylvanica	green ash	R,C
	Fraxinus americana	American ash	C
	Nyssa sylvatica	black gum	R,C,H
	Fagus grandifolia	American beech	R,C
	Carya alba	mockernut hickory	R,C
	Pinus virginiana	Virginia pine	R,C
	Liriodendron tulipifera	tulip tree	R,C,H
	Platanus occidentalis	sycamore	R,C
Subcanopy:	*Alnus serrulata*	tag alder	O,C,H,R
	Carpinus caroliniana	ironwood	R,C,H
	Cornus florida	flowering dogwood	R,C
	Asimina triloba	pawpaw	R
	Cersis canadensis	redbud	C,R,H
	Magnolia acuminata	cucumbertree	C,R
	Oxdendrum arboreum	sourwood	H,R,C
	Juniperus virginiana	red cedar	H,R,C
	Prunus serotina	black cherry	H,R,C
	Diosryros virginiana	persimmon	H,R,C
Shrubs:	*Cephalanthus occidentalis*	buttonbush	H,R
	Rosa palustris	swamp rose	O,H,R
	Rosa multiflora	multiflora rose	O,C,H,R
	Cornus amomum	silky or swamp dogwood	O,C,R,H
	Kalmea latifolia	mountain laurel	C,R
	Alnus serrulata	tag alder	O,H,C,R
	Ligustrum sinensis	Chinese privet	H,R,C
	Euonymus americana	strawberry bush	C,R
	Viburnum prunifolium	black haw	H, R, C
	Xanthorhiza simplicissima	yellowroot	R, C
	Sambucus canadensis	elder berry	O,R,H,C
	Arundinaria gigantica	cane	R
	Callicarpa americana	beauty berry	C, R
	Chioanthus virginicus	fringe tree	C,
	Clethra accuminata	mountain sweet pepperbush	H,C,R
	Rhododendron periclymenoides	wild azalea	C,R
	Toxicodendron vernix	poison sumac	C,
	Vaccinium staminium	deerberry	C,R
	Viburnum cassinoides	northern wild raisin	C

Herbs:	*Atherium felix-femina*	northern lady fern	C,R
	Polystichum agrostichoides	Christmas fern	C,R
	Thelypteris novoboracensis	New York fern	C,R
	Thelypteris hexagonpteris	broad beech fern	C,R
	Tiarella americana	foam flower	C,R
	Iris sp.	iris	C,R
	Mitchella repens	partridge berry	C
	Hexastylis sp.	wild ginger	C,R
	Chimaphila maculata	pipsissewa	C,R
	Desmodium nudiflorium	ticktreefoil	C,R,H
	Juncus sp.	lamp rush	O,C,R,H
	Carex lurida	a sedge	O,H
	Carex spp.	other sedges	O,H
	Rhynchospora sp.	beakrush	O,H
	Eleocharis sp.	spikerush	O
	Polygonum sagittatum	tearthumb	O,H
	Polygonum punctatum	a knotweed	O,H
	Sagittaria sp.	an arrowhead	C,H(?)
	Scutellaria latiflora	a skullcap	O,R
	Scutellaria serrata	a skullcap	O
	Lemna spp.	duckweeds	O,H
	Hibiscus moscheutos	swamp rose mallow	H,O
	Rubis sp.	blackberry	H,R,O,C
	Impatiens capensis	orange jewelweed	H,R,O,C
	Boehmaria cylindrica	false nettle	H,R,C
	Solidago rugosa	rough-stemmed goldenrod	H,R,O
	Citcuta maculata	water hemlock	H,O
	Agrimona parviflora	agrimony	H,R,O
	Rhexia virginica	Virginia meadow beauty	H,O
	Helenium autumnale	sneezeweed	H,O
	Lobelia cardenalis	cardinal flower	H,C,R
	Mimulus ringens	monkey flower	H,O
	Trifolium spp.	clovers	H,O
	Agrostis alba	redtop grass	H,R
	Festuca spp.	tall (?) fescue	H,R
	Phalaris sp.	a canarygrass	H
	Andropogon sp.	a bluestem	H,O
	Panicum virgatum	switchgrass	H,R,O
	Aletris farnosa	white colicroot	R,C
	Galium sp.	bedstraw	H,R,C,O
	Hypericum sp.	St. John's wort	H,O
	Habenaria (=Plantathera) sp.	an orchid	O,C
	Veronica arvensis	speedwell	O
	Symplocarpus foetidus	skunk cabbage	C
Vines:	*Toxicodendron radicans*	poison ivy	R,
	Smilax spp.	greenbriars	R,C,
	Vitus sp.	wild grape	R,C,H
	Dioscorea batatas	cinnamon vine	R,H
	Aniostichus nudiflorium	cross vine	R,C
	Lonicera japonica	Japanese honeysuckle	R,C,H
	Clematis virginiana	virgins' bower	R,C
	Parthenocissus quinquefolia	Virginia creeper	R,C
Nonvasculars:	several moss and algae species in the wet areas and smaller ditches		
	Sphagnum, Grimmna		O,C,H