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# River Otter Reintroduction in Great Smoky Mountains National Park

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To the Graduate Council:

I am submitting herewith a thesis written by Jane M. Griess entitled "River Otter Reintroduction in Great Smoky Mountains National Park." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Michael R. Pelton, Major Professor

We have read this thesis and recommend its acceptance:

Richard Strange, John C. New

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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# RIVER OTTER REINTRODUCTION IN GREAT SMOKY MOUNTAINS NATIONAL PARK

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Jane M. Griess

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ABSTRACT

Between 26 February and 31 March, 1986, 11 river otter (*Lutra canadensis* were obtained from North Carolina, implanted with radio transmitters, and released on Abrams Creek in Great Smoky Mountains National Park. A total of 635 radio locations were obtained on eight otters.

Male home ranges averaged 14.1 km during the study (March - December) while female home ranges averaged 15.9 km. There were no significant differences in home range length ($p > 0.05$) between sexes.

A total of 75 scats (42 samples) were collected during the study. Food items were calculated on frequency of occurrence. Crayfish occurred in 95% of all samples, followed by fish at 90%. Major fish species eaten were white suckers (57%), stonerollers (50%) and northern hogsuckers (40%). No specific size selection of fish was found. Other food items identified included frogs, turtles, salamanders and insects.

Den sites were identified during the study. Otters used rock crevices/caves 32% of the time, followed by thick vegetation (24%), animal burrows (24%) and vegetative debris (20%).

All but one otter was found to associate with at least one other otter during the study. Ninety-seven percent of the interactions were male/female interactions.

Activity centers (areas where the otter spends 10% or more of its time) were identified for seven of the eight otters. All activity

centers were in remote or inaccessible areas. Activity centers were shared by two otters in three instances.

Only one mortality occurred during the study. A male died two weeks after release. Cause of death was not known, but it is likely the animal starved, due to poor condition of his teeth.

No reproduction was recorded during the study. However, males and females interacted throughout the study. Objectives were met for this study and results indicate that the reintroduction was successful. The only remaining question is whether reproduction occurred; further surveys will have to be conducted to verify this important factor.

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# CHAPTER I

# INTRODUCTION

When Europeans arrived in North America, there were few streams or lakes between the Atlantic and Pacific oceans that did not support river otters (*Lutra canadensis*) (Hall and Kelson 1959). Pelts of the river otter, along with the beaver (*Castor canadensis*), were major reasons for early exploration, settlement and commerce of the United States.

The range of the river otter has drastically decreased during the past 150 years. During the nineteenth century, the animal was a prized furbearer and was intensively trapped, resulting in a severe decline in population throughout its range (Coues 1877 ). Other reasons for the otter's extirpation included diminishing water supplies, destruction of habitat, poisoning from chemicals concentrated in food fishes, and general human disturbances along wetland and stream habitat (VanderWerf 1981, Toweill and Tabor 1982).

Until recently, little was done to improve the status of the river otter in the United States. Limited data are available on the otter's present distribution, density, habitat requirements, social structure, and adaptability to a changing environment. Much of the available information comes from captive studies and trappers' reports of almost a century ago (Caras 1967). There is a growing concern over the status of many endangered and threatened species in North America. Public concern and awareness of these animals has led to legislation and laws at both the state and federal level.

In 1979 the subfamily Lutrine (otters) was added to Appendix II of the Convention on International Trade in Endangered Species (CITES). Seven other species of otters worldwide were already listed as endangered in Appendix I of CITES. As a result, many states found it necessary to evaluate the status of river otter within their borders (Endangered Species Scientific Authority 1978). Due to this evaluation and based on the high value of river otters by both consumptive and non-consumptive users, many states have initiated restoration programs.

Colorado, Oklahoma, Missouri, Arizona, West Virginia, Iowa, Tennessee, Minnesota, Pennsylvania and Kentucky have all recently undertaken otter restoration programs. Until now, results from most of these reintroductions have remained as unpublished file reports, and findings of only a few states have been published. However, most states have been encouraged by early results and have conducted additional restockings (B. Anderson, person. commun.).

River otters historically were inhabitants of the lower elevation streams of what is now Great Smoky Mountains National Park (GSMNP). Due to uncontrolled trapping and habitat destruction, otters were eliminated from from the area that is now GSMNP. The last reported sighting of an otter inside the park was in 1936 (Linzey and Linzey 1968).

Reintroduction of a species is not a new concept for the National Park Service. In 1935, the naturalist technician in charge of fauna research in GSMNP was directed ". . . to determine which species of animals are gone from Great Smoky Mountains National Park and the surrounding region, and which ones advantageously might be reintroduced" (Wright and Thompson 1935). The 1978 National Park Service policy handbook allows for and encourages the reintroduction of native species.

Early in 1984, representatives of four governmental agencies (Tennessee Valley Authority, Tennessee Wildlife Resources Agency, the University of Tennessee and the National Park Service) met to discuss a river otter reintroduction effort in GSMNP. Previously, NPS personnel from Uplands Field Research Lab had conducted a study on beaver reoccupation in the park, and at the same time evaluated potential river otter habitat. They found 144 km of streams in 18 different drainages within the park that could potentially support otters, but suggested that Abrams Creek would be the best site for a reintroduction attempt because it is the longest slow moving stream in the park (Singer et al. 1981). Additionally, fish surveys conducted on Abrams Creek during the previous three years indicated there was ample rough and forage fish available to support a number of otters (S. Moore, pers. commun.) .

Based on findings in cold-water mountain streams in Idaho, of one otter per 3.6 km of waterway (Melquist and Hornocker 1983) it was felt that Abrams Creek could not sustain an otter population (Singer et al.) However, it was felt that this area also could be important in reestablishing otter on a regional basis, due to the protection from trapping and shooting the park provided. Therefore, Abrams Creek was chosen as the release site for the otter reintroduction.

Objectives of this study were:

(1) To delineate the movements, home range, feeding habits and ecology of the introduced river otters in Great Smoky Mountains National Park.

(2) To develop guidelines for the future management of river otters in Great Smoky Mountains National Park and adjacent areas based on findings from this study and other studies.

# CHAPTER II

# STUDY AREA

## Great Smoky Mountains National Park

Great Smoky Mountains National Park was established in 1935 and encompasses 207,301 ha in North Carolina and Tennessee. The Great Smoky Mountains are part of the Unaka Mountain Range of the Blue Ridge Province of the Southern Appalachian Highlands (Fenneman 1938). The topography of the Great Smoky Mountains is made up of steep ridges, dissected by deep narrow valleys, cut by over 1,080 km of fast flowing streams (King and Stupka 1950). The main ridge of the mountain chain runs northeast to southwest and forms the border between Tennessee and North Carolina. Park elevations range from 275.3 m at the confluence of Abrams Creek and the Tennesse River (Chilhowee Lake), to 2,059 m at Clingmans Dome.

The major soil types found in the park are predominant-ly of the Ramsey Association. These soils exhibit low water retention, medium to high acidity and moderate fertility (King et al. 1968).

The climate of the Great Smoky Mountains has been classified as a warm-temperate rain forest (Thornthwaite 1948). Annual precipitation varies with elevation from 140 cm per year to over 200 cm per year (Stephens 1969). Normally, maximum rainfall occurs during July, and minimum rainfall occurs during September or October. Precipitation during 1986 was 37.6 cm below the average annual rainfall (National Weather Service, person. commun.).

Ambient air temperatures also vary with elevation. Temperatures decline approximately 4 C per 1,000 m in elevation. Coldest mean temperatures are usually seen in January or February at 3.3 C, and warmest mean temperatures occur in July or August at 23.9 C (United States Department of Commerce 1972; Stephens 1969).

With the extreme range in elevation, temperatures, topography, aspect and precipitation found in GSMNP, there also occurs a diverse plant and animal life. Prior to the reintroduction of river otters, 59 mammalian species, 130 reptilian species, 200 avian species, 39 amphibian species and 50 fish species were recorded in the national park (King and Stupka 1950). Since the initiation of this reintroduction, one additonal fish species, the yellowfin madtom (*Noturus flavipinnis*) has been reintroduced in Abrams Creek (S. Moore, person. commun.).

Vegetation in GSMNP is diverse. Over 1,300 species of flowering plants, including 131 native trees, and over 2,400 non-flowering plants, including 50 ferns and fern allies, 330 mosses and liverworts, 230 lichens and 1,800 fungi have been documented (King and Stupka 1950).

## Abrams Creek Watershed

Abrams Creek is located in the western portion of GSMNP. The creek flows west passing 10.8 km through Cades Cove, then travelling another 31.7 km before emptying into the Little Tennessee River (Chilhowee Lake), located just outside the park boundary (Figure 1).

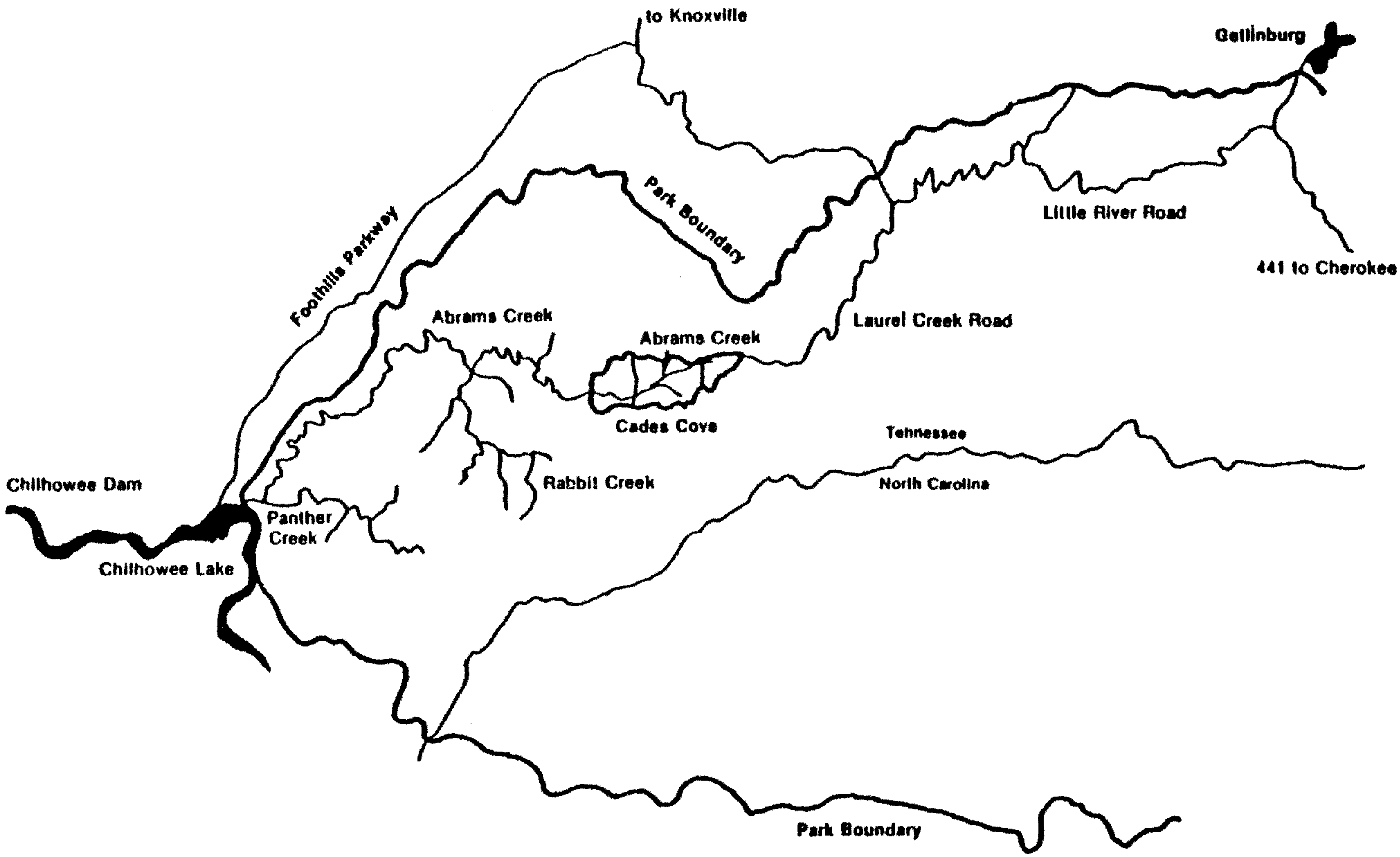


Figure 1. Study area, Great Smoky Mountains National Park, 1986.

Abrams Creek is the longest slow moving creek in the Park. It is a relatively fertile stream since it flows through limestone deposits in Cades Cove, but agricultural practices (cattle, horses and hay leasing) have contributed to some warming and silting in the main stream and its tributaries (Lennon and Parker 1959). Additionally, heavy summer use at the Cades Cove camp ground and picnic area have contributed to some siltation and have lowered the overall water quality of Abrams Creek (Mathews 1978).

Abrams Creek watershed is characterized by low elevation, rolling, broad ridges covered predominantly by oak-pine forest types. The terrain along the creek often is rough. Approximately 5.6 km downstream from Cades Cove is an 8 m waterfall. The stream above the falls is characterized by small cascades, riffle areas and fast flowing water. Below the falls, there are short cascades and long, deep pools. Foot trails follow all but 8.0 km of the creek; however, access by vehicle is limited to only one point, at the Lower Abrams Creek Campground. This area is approximately halfway between the waterfalls and the confluence of Abrams Creek and Chilhowee Lake.

Since 1983, stream surveys have been conducted on Abrams Creek to assess fish populations and water quality. During 1983-1985, surveys were conducted on five different sections, each 200 m long (Figure A-1). The method of fish collection was with backpack electro-shockers. Three passes were made on each section, and all fish were collected, identified, weighed, measured and released . A complete species list for

Abrams Creek was compiled using these data (Table A-1). Additional fish species which were not collected during these surveys were added to this list. These fish were verified to be in Abrams Creek (S. Moore, pers. commun.). Presently, there are six fish families and 25 species present in Abrams Creek.

Water quality parameters also were monitored during the last four years (Table A-2) which included water temperatures, pH, conductivity, flow, alkalinity, average widths and average depths.

## History of Abrams Creek

Prior to the formation of GSMNP, most of the land was owned by large lumber companies. Logging began on a large scale by 1880. Between 1880 and 1900 ,logging practices consisted primarily of selective cutting in easily accesible areas, mainly those lower elevation areas near streams. After 1900, logging practices became mechanized. With the aid of railroads, large tracts which had previously been inaccessible were logged. In addition, clearcutting rather than selective cutting became prevalant throughout the area (Lambert 1958).

The Abrams Creek watershed was never logged to the extent other watersheds. Morton Butler Timber Co. of Chicago owned this land prior to the formation of the park, but decided it was not economically feasible to log the "low-value" timber found there (Lambert 1958). Most of the area remained uncut except for the large flats and coves which were cleared for agricultural purposes.

In 1957, the National Park Service, in conjunction with the U.S. Fish and Wildlife Service, Tennessee Valley Authority and the Tennessee Game and Fish Commission, renovated Abrams Creek. This was done to improve sport fishing on the creek. From Abrams Falls to the Tennessee River, all fish were killed using a chemical fish toxicant. Forty-six species of fish were removed from Abrams Creek, including 16 species which previously had not been recorded in the park (Table A-3) (Lennon and Parker 1959).

Abrams Creek has been one of the park's best trout fishing streams. In 1986, it was estimated through creel data that over 1,028 hours of fishing pressure per year (April through October) were placed on the upper section of Abrams Creek (above the falls), and 365 hours of fishing pressure were placed on the lower section of Abrams Creek. It is generally felt that these figures are low estimates (S. Moore, pers. commun.).

The Great Smoky Mountains National Park annually receives over eight million visitors. Abrams Creek is one of the most visited streams in the park. An estimated 1,436,890 visitors travel through Cades Cove each year. About 20 percent of these people (287,378 visitors) hike all or part of the 4 km (2 1/2 mi) Abrams Falls Trail (R. Yates, pers. commun.). Additionally, Abrams Creek is a popular swimming area during the summer.

# CHAPTER III

## METHODS AND MATERIALS

In 1986, the Tennessee Valley Authority contracted with an experienced fur trapper in North Carolina to provide 10 river otters for the reintroduction effort. River otters were obtained from North Carolina because they could be legally harvested, and the overall cost was less than obtaining them from any other source. Because of North Carolina's trapping regulations, trapping could only occur during the North Carolina statewide trapping season, which ran 15 December through 28 February.

In February, 1986, trapping began in a variety of locations along the North Carolina coast as well as streams and rivers known to contain river otters. Areas known to be actively used by otters were trapped using 1 3/4 double coil steel leg-hold traps. These activity centers were areas such as travel routes, feeding stations or latrine sites. Traps were run at least once every 24 hours. Animals were taken back to temporary holding facilities where they were held before being transported to a holding facility in Knoxville, Tennessee.

All but two animals were transported by plane to Knoxville. The two otters transported by vehicle died from stress-related causes after the vehicle became stuck in a snowstorm.

Upon arrival in Knoxville, each animal was visually examined by personnel from the University of Tennessee, College of Veterinary Medicine. Mortality from stress-related causes occurs frequently in river otters (Hoover et al. 1985, Clark 1984). For this reason, as otters were received they all were held in an enclosure for a week prior to implanting radio transmitters. This holding period allowed the animals adequate time to recover from stress they may have experienced as a result of handling and transport, and allow time necessary to screen for diseases like salmonellosis, which otters could be incubating.

The otters were held together in large covered enclosures measuring 3 x 4 m. Normally, no more than six or seven otters were in captivity at any one time. Enclosures had concrete floors, but were bedded daily with clean, fresh straw. Den boxes and water tanks were also provided.

Originally, the river otters were offered exotic feline diet (Nebraska Brand Chopped Frozen Feline Food, Central Nebraska Packing, Inc., North Platte, NB), a commercially prepared diet consisting of horse meat, bone and fish meal, ground up vegetables and vitamins. This exotic feline diet is reported to be readily consumed by captive river otters (Hoover et al. 1985). However, the wild caught otters in our study refused to eat it. Since they had been fed fresh fish in captivity, while in North Carolina, it was decided to continue feeding fresh fish. Other studies have fed such food items as raw nutria and alligator meat mixed with dry dog food (Hoover et al. 1985). We chose to feed fish supplemented with vitamins.

Otters were fed fresh fish ad libatum. Most fish were obtained by electro-shocking a local reservoir. Major fish species fed included carp (Cyprinus carpio), gizzard shad (Dorosoma cepedianum) and bluegill

(Lepomis macrochirus). Additionally, frozen smelt, obtain from a nearby zoo, were fed when administering oral antibiotic pills. Many of the fish species (e.g. bass, carp and shad) used as otter food contained high levels of thiaminase, an enzyme that destroys the thiamin molecule. A deficiency of thiamin can cause weight loss, diarrhea and even paralysis (Ensminger and Olentine 1978). To prevent this, thiamin was supplemented in the otters' diet at a dose of 20-25 mg daily (Butler Co., Memphis, TN). 1978). Otters were also given daily doses of the antibiotic amoxicillin (Amoxi-tabs Beecham Co., Bristol, Tn), in the food. Injectable antibiotics, benzathine penicillin G and procaine pencillin G (Benza-pen, Beecham Co., Bristol, Tn) were given as intramuscular injections each time the animals were restrained. Animals with severe trap injuries were caught in a squeeze cage and injected daily.

River otters are reported to be susceptible to many diseases. Canine distemper, feline panleukopenia, rabies and parvovirus have all been reported in river otters and mustelids (Hoover et al. 1985). Vaccinations, approved for domestic animals, are commercially available for prevention of these diseases. The decision to give them to otters in a reintroduction may be justified for two reasons. First, vaccinations may offer some protection to the otter while in captivity, and second, vaccinations may provide protection to the animal after release, should the otter come in contact with domestic animals.

An alternative to vaccinations is isolation of the animals while in captivity and before release. We believed the safest way to prevent disease in this study was to prevent the exposure of the otters to any disease-carrying agents. This was accomplished by housing the otters in a holding facility away from the veterinary hospital, and isolated from animals which might transmit diseases. In addition, we limited the number of people who came in contact with the otters.

Because we utilized the isolation procedure, no vaccinations were administered to the otters in this study. We believed the isolation procedure was more effective controlling diseases than vaccinations.

All otters had some injury upon arrival in Knoxville. These injuries occurred when trapped or transported. The major types were foot/leg injuries. Injuries were classified in one of three catagories of severity: 1.) Slight - usually minor lacerations which required little or no medical attention. (e.g. a break in the skin but no muscle or bone exposure). 2.) Moderate - amputation (either by the trap or the veterinarian) of a digit or appendage. 3.) Severe - injuries which required extensive medical and surgical intervention. Of the 14 otters examined (two otters died in transport and were not included) five (36%) had slight injuries, seven (50%) had moderate injuries, and two (14%) had severe injuries.

All otters were held a minimum of 10 days (seven prior to surgery and three post-surgery) regardless of the severity of injuries. If the injury was moderate to severe, animals often were held for additional time until the injury had healed adequately. On the average, otters with slight injuries were held 13 days (from the time of arrival in Knoxville until the time of release). Otters with moderate injuries were held an average of 18 days, and the two otters with severe injuries were held an average of 65 days before their release (Table 1).

Table 1. Summary of translocation - associated river otter injuries.

| Animal No. | Number of days in captivity | Classification of injury | Injury description |
|---|---|---|---|
| M3 | 12 | Slight | Carpal pads of left middle digits excoriated. |
| M4 | 12 | Moderate | Digits II, III and IV of left front foot mutilated. Second phalanx of digits exposed. |
| F5 | 12 | Moderate | Third phalanx of digit II on left front foot missing Third phalanx of digit III of left front foot dis-articulated. |
| F6 | 45 | Severe | Left metacarpal bones exposed medially and laterally. |
| M7 | 85 | Severe | Compound fracture of distal third of right radius and ulna. |
| M8 | 15 | Slight | Left front foot excoriated across digital pad III. Minor cut right front foot. |
| F9 | 17 | Moderate | Digits III and IV of left front foot injured. Distal end of second phalanx of both digits exposed. |
| M10 | 17 | Slight | Cut in area of left metatarsus. |
| M11 | 20 * | Slight | Digits III and IV on right front foot traumatically amputated. |
| M12 | 17 | Moderate | Digits III and IV on left front missing at level of distal end of first phalanx. |

Table 1. (cont.)

| Animal No. | Number of days in | Classification of injury | Injury description |
|---|---|---|---|
| M13 | 28 * | Moderate | Digital pads of II, III, IV and V of left front foot excoriated. |
| M14 | 31 | Moderate | Gash across the dorsal aspect of left carpus at digit 5, tissue mascerated. |
| F15 | 8 | Slight | Laceration on left dorsal tarsus. |
| M16 | 20 * | Moderate | Digit II and IV of left front foot amputated. |

* Surplus animals. The amount of time these animals were in captivity was not necessarily due to their injuries, and were not used when estimating the average time in captivity as a result of injury.

A total of 16 river otters were purchased from North Carolina. Eleven otters were used in the GSMNP reintroduction. Of the remaining five otters, two died from stress in transport as previously mentioned, and three were released at other locations in East Tennessee without transmitters, because they were considered surplus animals. After the otters were held one week, each was transported to the College of Veterinary Medicine to be evaluated. It was found to be less stressful to the otter if a squeeze cage was placed against the entrance hole of the den box; the squeeze cage was covered with a blanket. Normally, an otter was coaxed to enter the darkened squeeze cage and the door lowered. If the otter was not in the den box, then the squeeze cage was placed against the wall of the enclosure, and the animal corraled into it. Often, this process was accomplished by one person; this method proved successful in all instances, and in the author's opinion, was less stressful to the otter than the method described by Shirley et al. (1983).

Once at the UT Veterinary Teaching Hospital, animals were tranquilized using ketamine hydrochloride (Ketaset, Bristol-Meyer Co., Syracuse, NY). A dosage of 22 mg ketamine per kg of body weight was injected intramuscularly.

Rectal swabs for salmonellosis were taken on nine of the 14 otters. Salmonellosis had been reported from river otters used in other reintroduction attempts and held under similar cicumstances in Oklahoma (Hoover et al. 1985). No evidence of salmonellosis was evident based on one culture. Additionally, eight otters were cultured for Campylobacter spp. and since all were negative, the remaining otters were not cultured for this agent.

Blood samples were collected at least once from each otter. These samples were used to check for the presence of microfilaria. Four of the 14 otters were found to have microfilaria (*Dirofilaria lutrae*), however no detectable diseases were observed associated with these microfilaria. Fecal parasite checks were made on all of the otters. This was done using a pooled fecal sample from the otter enclosure. Nine different parasites were identified (Table B-1). Each otter was treated with Ivermectin (Ivomec, MSD Ag Vet, Rahway NJ) to reduce the number of internal parasites. Hemograms and blood chemistries were also completed on each animal (Table B-2, B-3, B-4 and B-5). These were used to assess the general condition of the animals while in captivity, as well as to add to the literature regarding normal volumes for these parameters.

Body measurements (Table 2) and weights (Table 3) were recorded for each otter. On the average, males were larger than females. Mustelids normally exhibit a distinct sexual dimorphism (Stephenson 1977, Powell 1979). Any scars, abnormalities or old injuries also were noted. Animals were further examined to determine approximate age (adult or subadult), and reproductive condition. One female gave birth to four pups while in confinement; however, all four pups died less than two weeks after birth. Therefore, the remaining four females were radiographed to determine if they were pregnant. None of the remaining females exhibited any radiographic signs of pregnancy.

Surgically implantable transmitters (150-151 MHz, Telonics, Inc., Mesa, AZ) were placed in 11 otters: six males and five females. One male

Table 2. Body measurements (cm) of river otters released in Abrams Creek, GSMNP, 1986.

| Animal No. | Sex | Total Length | Tail Length | Hind Foot | Ear | Skull Length | Skull Width |
|---|---|---|---|---|---|---|---|
| 3 | M | 122.0 | 46.0 | 12.9 | 2.4 | 14.1 | 15.4 |
| 4 | M | 126.8 | 52.0 | 12.2 | 2.5 | 14.0 | 12.0 |
| 5 | F | 106.0 | 42.0 | 12.3 | 2.1 | 12.8 | 11.2 |
| 6 | F | 116.5 | 46.0 | 12.8 | 2.0 | 13.5 | 13.0 |
| 8 | M | 127.0 | 51.5 | 14.0 | 2.1 | 15.5 | 14.0 |
| 9 | F | 113.0 | 46.0 | 11.7 | 2.1 | 14.2 | 13.5 |
| 10 | M | 112.5 | 43.5 | 13.0 | 2.3 | 12.5 | 14.8 |
| 12 | M | 124.5 | 51.0 | 14.0 | 2.1 | 14.0 | 14.6 |
| 13 | F | 92.5 | 37.0 | 11.7 | 2.0 | 11.5 | 11.5 |
| 14 | M | 131.0 | 55.0 | 14.4 | 2.5 | 15.0 | 14.5 |
| 15 | F | 105.5 | 42.0 | 12.4 | 1.8 | 13.4 | 12.0 |
| Range | | 92.5 to 127.0 | 37.0 to 55.0 | 11.0 to 14.4 | 1.8 to 2.5 | 11.5 to 15.5 | 11.2 to 15.4 |
| Mean | | 115.11 | 46.3 | 12.6 | 2.2 | 13.9 | 13.1 |

Table 3. Weights (kg) of river otters reintroduced in Abrams Creek, GSMNP, 1986.

| Animal No. | Sex | Weight |
|---|---|---|
| 3 | M | 9.16 |
| 4 | M | 8.45 |
| 5 | F | 5.90 |
| 6 | F | 8.10 |
| 8 | M | 11.70 |
| 9 | F | 7.20 |
| 10 | M | 8.10 |
| 12 | M | 9.80 |
| 13 | F | 3.96 |
| 14 | M | 9.07 |
| 15 | F | 5.02 |

Range 3.96 to 11.7

Female $\bar{X}$ 6.04

Male $\bar{X}$ 9.38

died two weeks after release and his transmitter was removed, sterilized, and placed in another male. Cause of death was uncertain; however, all four of his canine teeth were broken or worn off upon his arrival in Knoxville and it is believed that he starved. Transmitters were inserted through a paralumbar incision, using surgical procedures outlined by Melquist and Hornocker (1979a). All transmitters were checked before and after implantation to insure they were functioning properly.

After transmitter implantation, all animals were returned to their enclosure for three to five days. This recovery time was used for examination and observation. Melquist and Hornocker (1983), and Foy (1984) reported that this type of surgery can be done in the field and animals can be released immediately after waking up from sedation. However, we felt it was important for the safety of these animals to insure full recovery from surgery prior to release. Mortality of river otters during captivity and the first days following release has been high in many states. Colorado experienced 8 pre-release deaths and one otter died shortly after release. Eight of 10 radio transmittered otter in Arizona died within 2 weeks following release, and 4 of 10 otters reintroduced on Oklahoma died within 5 weeks following release (Erickson 1984).

## Radio Telemetry

As soon as otters were judged ready, they were released in groups of two or three at the Abrams Creek Parking Area in Cades Cove. Radio tracking was conducted on a daily basis from the time of the first release, 28 February 1986. Information from radio tracking was used for evaluating dispersal, home range, food habits,and social interactions. Radio transmittered animals were monitored from the ground and using aerial homing techniques (Springer 1979, Melquist and Hornocker 1983). A TS-1 Scanner/Programmer in conjunction with a R-2/150 Receiver (Telonics, Mesa, AZ) equipped with a 2 element H antenna was used for obtaining most locations. A whip antenna was mounted on top of the truck to locate animals near the road.

Triangulation was not used because it was possible to get an accurate location of the animal on the creek. Average distance from the animal to the observer was 100 m or less. Maximum ground-to-ground range of the transmitter varied, but was approximately 0.8 km to 1.2 km. This range varied due to 1) topography, 2) whether or not the animal was in a den, 3) vegetation cover , and 4) whether the animal was in the water or on the stream edge.

A Cessna 172 airplane with H antennas mounted on each wing was used to locate hard to find animals. Maximum air-to-ground range was about 11 km while flying 900 m above ground (Melquist and Hornocker 1983, B. Kindy, pers. commun.).

## Dispersal

The furthest distance travelled was calculated for each otter. This was accomplished by measuring the distance from the release site to the furthest point travelled to by an otter.

## Home Range

Home range length was calculated by measuring the total length of stream and lakeshore travelled by an otter. Home range boundaries were used when an otter used an area on at least two occasions. Single visits to areas outside these boundaries were considered exploritory and not part of the animals home range.

## Daily Movements

Otters were located as close to the same time each day as possible. However, due to the inaccessibility of the area, and given that the otters often moved long distances during a 24 hour period, it was not always possible to locate these animals at exactly the same time each day. When otters were located on consecutive days, the distance from the last location was calculated to produce a rough estimate of distance travelled during a 24 hour period.

## Food Habits

Fresh otter scats were collected during the study to determine feeding habits. River otter scats are easily identified. Most scats are approximately 20 mm in diameter and occur in two,three or four curved segments each about 40-80 mm long (Greer 1955). Often the scats were covered with a thin, greenish mucus. The function of this mucus is to protect the intestinal lining from abrasions by hard, sharp fragments from food items (Lagler and Ostenson 1942). The search routine for scats consisted of going into an area where an otter had been located for at least 2 consecutive days. On many occasions no scats were located, or the underbrush was too thick to effectively search for scats. When scats were located, they were collected, labeled and taken to the laboratory for later analysis. Often, latrine sites (two or more scats together) were located and a total number of scats per pile were estimated. Areas in which scats were collected were described. Scats were washed with warm water and alcohol, air-dried and separated for further analysis.

Scat material was initially spread on paper and carefully sorted to remove potentially diagnostic fish elements. Material discarded at this point consisted mostly of fragments of scales, vertebrae, ribs, pterygiophores (fin supports) and fin rays. These types of elements were usually retained in samples that appeared to contain low numbers of fish bones.

Subsequently, the retained material was once again sorted and carefully screened for elements that were useful in identification to the lowest possible taxon. A high degree of selectivity of diagnostic elements was considered necessary, as it was impractical to attempt identification of as many as possible of the thousands of elements, many of which were fragmentary.

Identification was accomplished by direct comparison of bony elements with comparative skeletal material from the zooarchaeological skeletal collection housed in the Department of Anthropology at the University of Tennessee.

The types of bony elements useful for identification varied, often dependent on the groups of fishes involved, as well as their relative sizes. For example, in the family Cyprinidae (minnows), pharygeal bones and their teeth were often important diagnostic features.

Besides dental formulae, the shape of the teeth (which are subject to constant wear and replacement), as well as the shape and thickness of the pharyngeal bone itself, were sometimes useful in identification of individuals to species.

Although the pharyngeals were less important in the identification of catostomid (sucker) remains, a greater diversity of element types was utilized for comparison. Some of the more frequently used bones were the maxillary, dentary, hyomandibular, and bones of the hyoid and opercular series, although many other bony elements were utilized, as well. In general, elements of the cranium were used in all the different groups of fish identification (Figure C-1). Occasionally, axial skeletal bones (e.g. vertebrae) were of importance in fish identification (e.g. the highly unmodified fenestrate vertebrae of Salmo gairdneri, the rainbow trout).

Minimum number of individuals (MNI) of a taxon was determined by adding all elements of that taxon that clearly were representative of different specimens. Usually, the type of element (e.g. dentary) from one side (left or right) found to be in greatest quantity was utilized, as well as size differences, in determining MNI for a given taxon. For example, if there were more maxillary bones (e.g. nine) representative of a taxon than any other type of bone in the sample, and five of the bones were from one side, then the MNI for that taxon was calculated as five, unless one or more of the elements from the opposite side were clearly different in size from all those from the left side.

Size estimation of specimens represented by the elements used in MNI determination was accomplished by direct comparison of each element with the same bones from comparative skeletal material with known standard length measurements (standard length being the straightline measurement from the anterior part of the fish to the end of the vertebral column at the base of the caudal fin). This method is based upon the general assumption of the existence of a linear proportional relationship between bone dimensions and fish size (Casteel 1976). Thus, if a bone (or fragment of a bone) appeared to be approximately 3/4 as large (in one or more dimensions) as the bone from a comparative specimen with a known standard length of 160 mm, the estimated standard length of the bone from the scat sample was determined to be about 120 mm. Unfortunately, the large number of elements and their often highly fragmentary nature rendered precise proportional determination by measurement (as suggested by Casteel, 1976) impossible. However, estimates of original fish size obtained by the more subjective visual comparison method used in this study are considered here to be reasonably accurate and useful, at least for lumping identified fish taxa into fairly distinct size classes (e.g. 50-100 mm minnows as distinct from 150-300 mm minnows),

Food items were calculated on the basis of percentage of occurrence by dividing the number of scats into the number of occurrences of a food category. For example, if one scat was found to contain mostly crayfish and a small number of fish bones, each was considered as occurring only once (Wilson 1954; Ryder 1955; Grenfell 1974; Holcombe 1980; Chabreck et al. 1982). The author chose to use percentage of occurrence for several reasons. Erlinge (1968b) studied captive European river otters in South Sweden found that scat analysis calculated by frequency of occurrence, gives a true picture of the relative importance of the different food items eaten. Additionally, all other food studies done has been based on frequency of occurrence, and by doing this study the same it lends itself well for comparison. Volume measurements were not considered to be feasible due to the large amount of crayfish exoskeleton which passes through the otter's digestive tract compared to remains of fish which originally made up a larger volume of food (Pierce 1979).

It is important to note that scat analysis has limitations when determining actual feeding habits. Lagler and Ostenson (1942) pointed out that digestible material is largely absorbed and is not present in the scat. Therefore, animals with few hard body parts are not adequately represented in the scat. Additionally, exposure to the elements may alter scat contents. Of more importance, the food items with many hard body parts (e.g. crayfish) contribute more volume than do fleshier prey such as fish (Pierce 1979).

## Den and Resting Sites

Den sites were actively sought when an otter had been located in the same area on more than one occasion. When a den or resting site was located, it was examined and described.

## Social Interaction

Interaction between otters was recorded. When an otter was located within 300 m of another otter, they were considered in association with one another. Percentage of time alone and in association with another otter was calculated for each otter. Additionally, time of day and season when animals were found in association were recorded.

## Data Analysis

Differences in distances travelled in a 24 hour period, and home range sizes between sexes were investigated using Student's t-test. Frequency of movements for sexes was also investigated using analysis of variance procedures (Snedcor and Cochran 1967).

CHAPTER IV

# RESULTS AND DISCUSSION

## Post Release Movements

Otter movements varied after release. All males (n=5) moved downstream at least 4.0 km ($\overline{x}$ = 5.1 km) within the first 48 hours after release. All females (n = 5) stayed within 1.6 km of the release site the first 3 days, and in 2 instances (F15 and F9), for 12 and 14 days, respectively. Females moved away from the release site ($\overline{X}$ = 4.0 km) after an average of 3 days (r = 2 and 5 days), with the exception of F15 who remained stationary for six days. By approximately one month after release, all animals appeared to have established a home range.

Erickson (1984 p 6) found that animals released at the same location were "able to space themselves appropriately in relation to the resources of their new environment and maximize their post-release interactions, and minimize total movement from the release site." Results of the present study indicated this was true in GSMNP. The reintroduced otters spaced themselves relatively evenly along Abrams Creek, and frequently interacted.

Normally all routes of dispersal followed Abrams Creek (Figure 2). All but one otter dispersed downstream from the release site. However, one female (F15) dispersed upstream into Cades Cove, where she remained for three weeks. Contact was lost with her on 30 April 1986; she was not located again until 16 June 1986, when she was found in the Laurel Creek

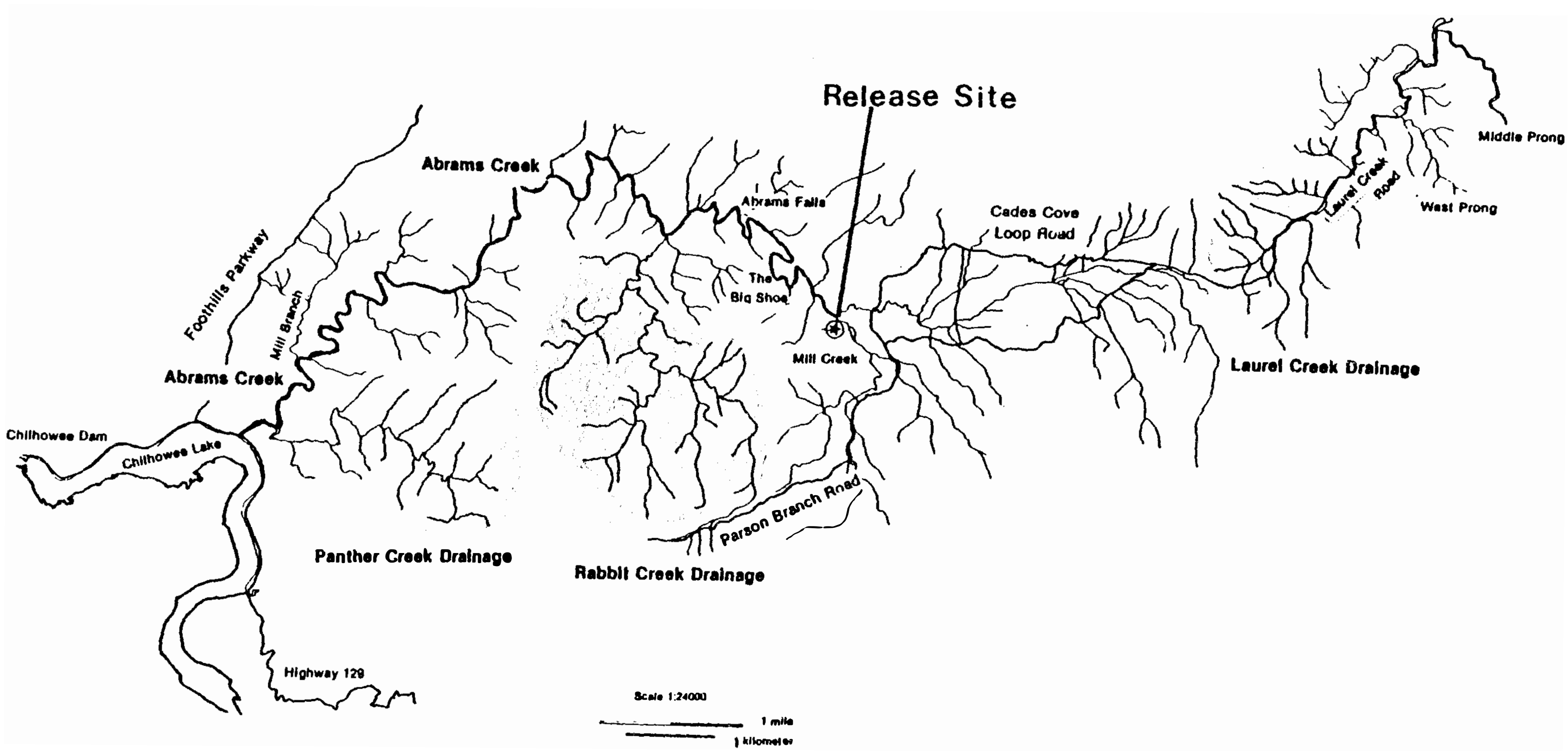


Figure 2. Abrams Creek drainage, GSMNP.

drainage (Figure 3). To reach the Laurel Creek drainage, this animal likely crossed Crib Gap, the main entrance to Cades Cove from the East, and traversed a minimum distance of 2.4 km overland.

Overland travel is not unknown for river otters. River otters in Idaho were recorded travelling overland up to 3 km (Melquist and Hornocker 1983). Liers (1951) documented one of his otters travelling 9.6 km overland before being trapped in a farm yard. Dispersal of juveniles appears to be the primary reason for overland travel in native river otters (Melquist and Hornocker 1983).

The furthest distance travelled from the release site by an otter in this study was 39.2 km by M8, followed closely by F15 who travelled 36.5 km. On the average, females travelled 21.3 km from the release site (r = 8.4 to 36.5 km), while males travelled an average of 27.6 km (r = 16.0 to 39.2 km) (Table 4). Each otter apparently explored large sections of Abrams Creek before establishing a home range. On the average, males had larger exploratory movements ($\overline{x}$ = 28.0 km), than females ($\overline{x}$ = 22.8 km). There was no significant difference in dispersal ($p$ = 0.28) between sexes. However, there was considerable variation among individuals.

## Radio Telemetry

Eight of 11 otters (four males and four females) were monitored for 309 days, during which time 635 radio locations ($\overline{x}$ = 79.4 locations per otter) were recorded (Table 5). The study was designed so that the otters would be monitored through the end of 1986, however sporadic

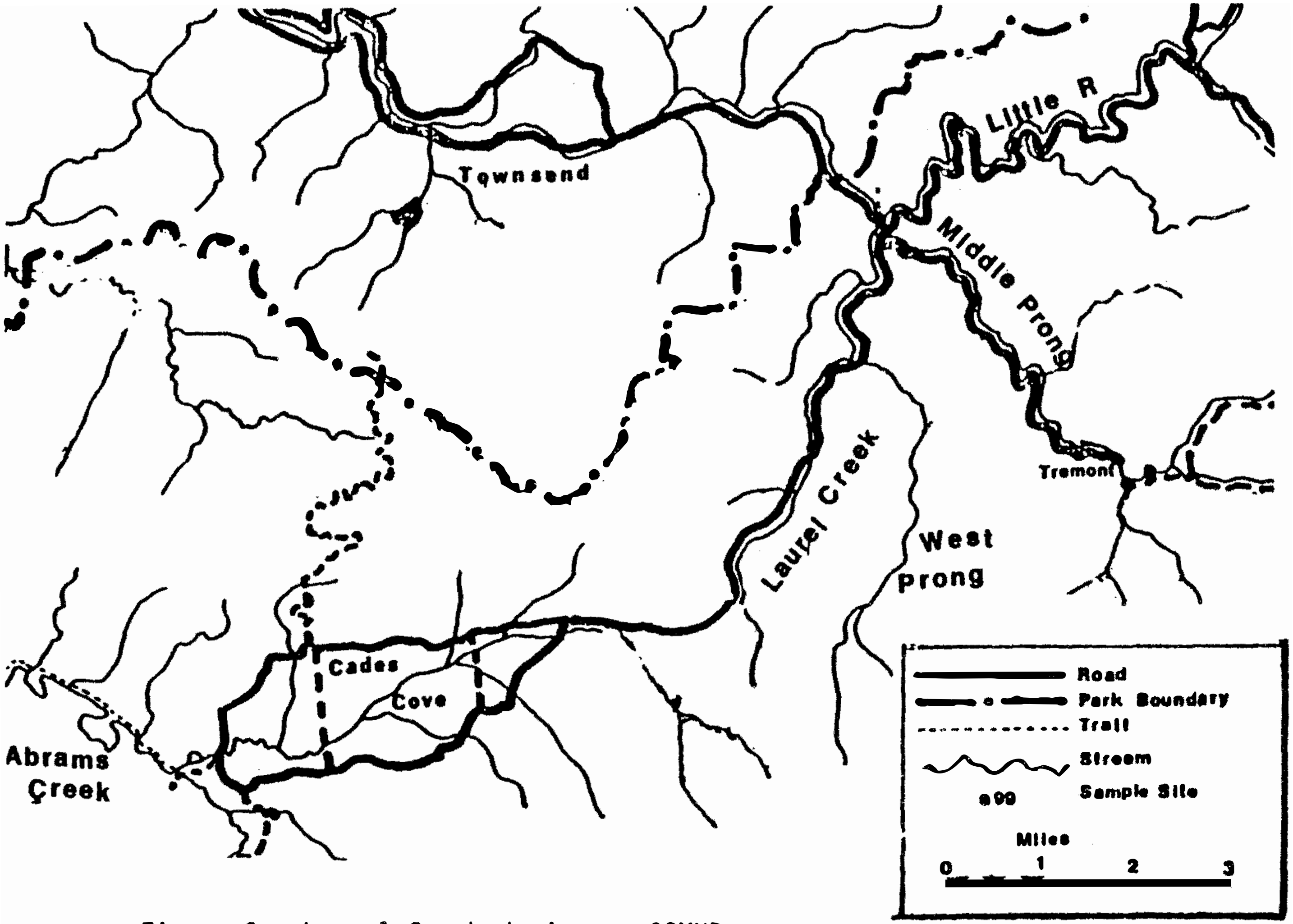


Figure 3. Laurel Creek drainage, GSMNP.

Table 4. Furthest distance travelled from the release site by river otter reintroduced on Abrams Creek, GSMNP, 1986.

| Otter No. | Distance (km) |
|---|---|
| F5 | 16.5 |
| F6 | 30.1 |
| F9 | 8.4 |
| F15 | 36.5 |
| M8 | 39.2 |
| M10 | 24.8 |
| M12 | 16.0 |
| M14 | 32.3 |

Table 5. Summary of telemetry locations on river otters released on Abrams Creek in GSMNP between 26 February and 31 December 1986.

| Animal No. | Sex | No. of Locations | Date Released | Date of Last Location |
|---|---|---|---|---|
| 5 | F | 105 | 26 February | 13 January 1987 |
| 6 | F | 59 | 31 March | 9 February 1987 |
| 8 | M | 95 | 21 March | 9 February 1987 |
| 9 | F | 74 | 17 March | 8 August 1986 |
| 10 | M | 73 | 2 March | 15 August 1986 |
| 12 | M | 120 | 17 March | 1 January 1987 |
| 14 | M | 45 | 31 March | 1 January 1987 |
| 15 | F | 62 | 24 March | 16 November 1986 |

locations were made after 31 December 1987, till all transmitters quit. Because one otter died early (13 days post-release) and two other animals apparently had premature transmitter failure, these three otters were not used in the data analysis.

The radio transmitters used in this study were advertised as having a life of 12 to 14 months. However, the author believes that two transmitters malfunctioned less than one week following release. Possibly the two otters may have moved out of the study area, however this is unlikely since two thorough aerial searches (one the day after release of one of the otters) failed to turn up the otters. Other studies have experienced similar problems with their radio transmitters (Serfass 1984, Erickson 1984).

In summary, of the 11 otters released, three signals were "lost" within two weeks, three transmitters apparently quit operating on or about 8 August, 15 August and 16 November, and five animals were monitored through 31 December 1986 (Figure 4).

## Home Range

Six of the eight otters (M10, M12, M14, F5, F6, F9) established home ranges along Abrams Creek. One female (F15) established a home range in Laurel Creek drainage. A male (M8) established his home range in Tellico Reservoir (Figure 5).

The average home range length for all otters in this study, was 15.0 km (r = 8.8 to 23.5 km) (Table 6); the mean home range length for females averaged 15.9 km (r = 9.2 to 23.5 km) and males averaged 14.1 km

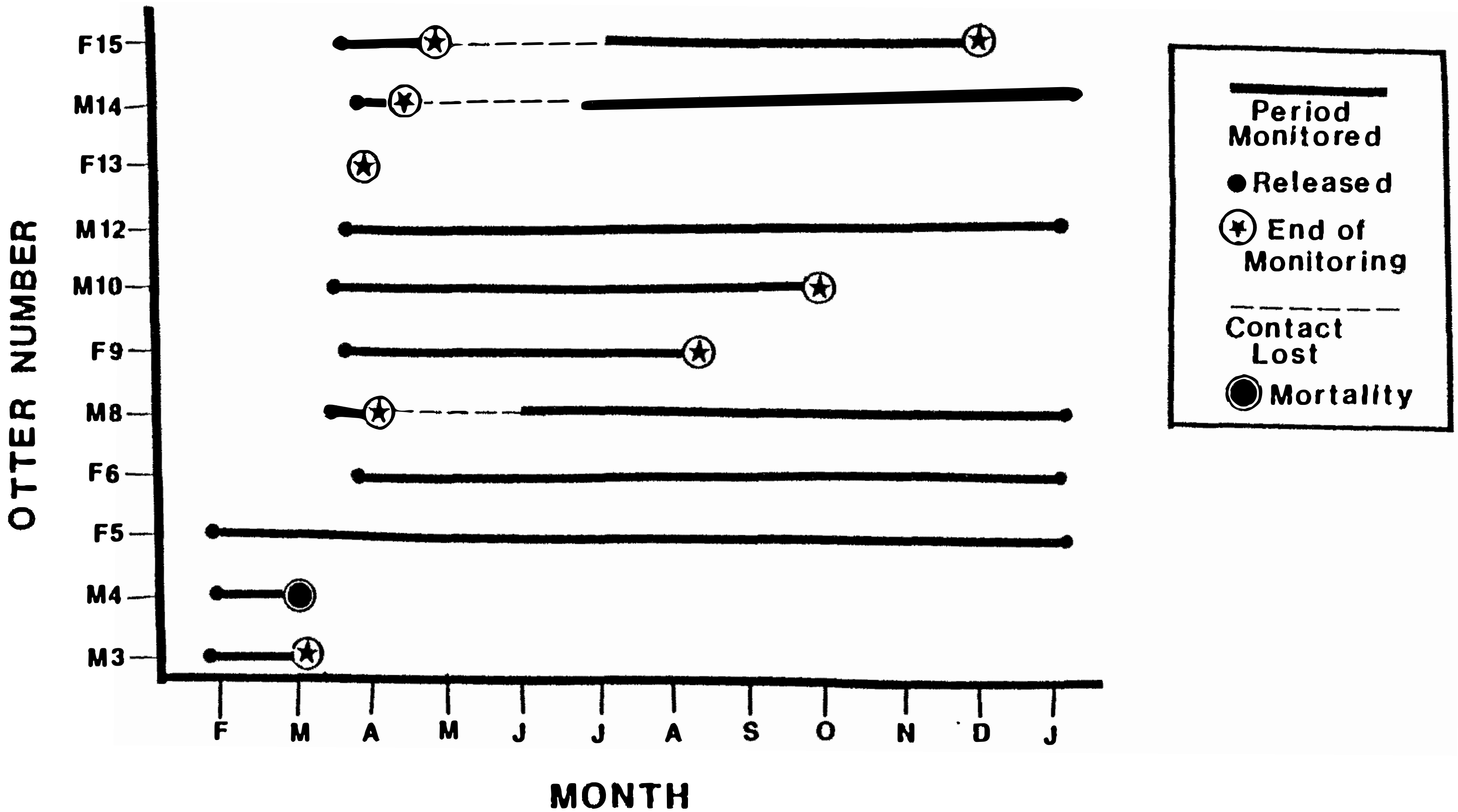


Figure 4. Summary of radio tracking of river otters in Abrams Creek, Feb. 1986 to Jan. 1987.

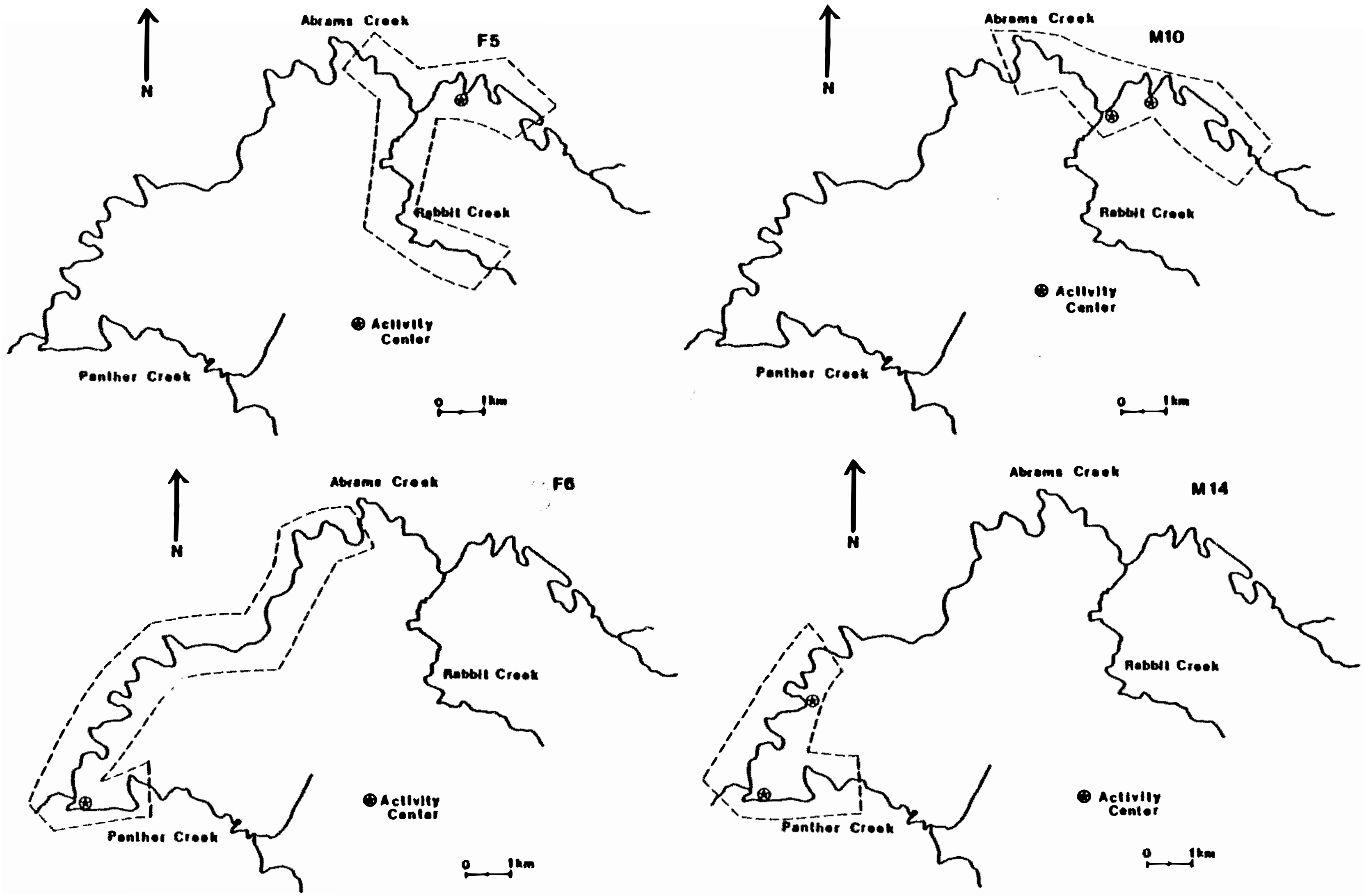


Figure 5. Home range maps of river otters reintroduced in Abrams Creek, GSMNP, 1986.

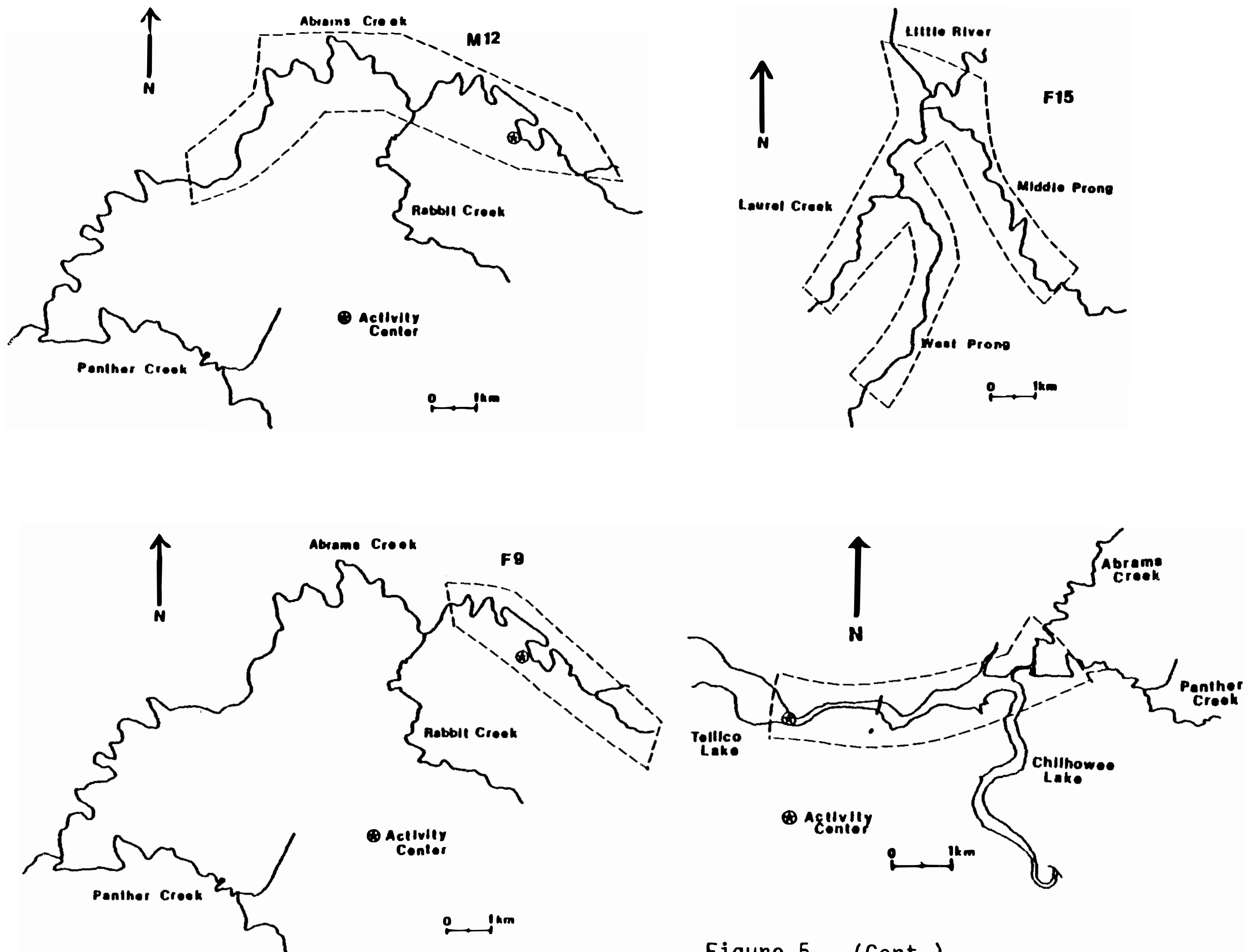


Figure 5. (Cont.)

Table 6. Lengths of home ranges for river otters released in Abrams Creek, GSMNP, 1986-1987.

| Animal No. | Home range length |
|---|---|
| F5 | 9.2 km |
| F6 | 17.9 km |
| F9 | 13.1 km |
| F15 | 23.5 km |
| M8 | 12.2 km |
| M10 | 17.7 km |
| M12 | 17.6 km |
| M14 | 8.8 km |

Average Home Range length . . . 14.9 km

Average Home Range Females . . 15.9 km

Average Home Range Males . . . 14.1 km

($r = 8.8$ to 17.7 km). There were no significant differences in home range length between sexes ($p > 0.05$); however, differences between individuals were considerable. These findings are in contrast with other river otter studies since the home ranges are smaller in this study. Home range length of native river otter in Idaho varied depending on the season and among animals of the same age and social status. However, the average adult male exhibited a home range of 50 km while the adult female home range was only 44.3 km (Melquist and Hornocker 1983). Male European river otter (Lutra lutra) were found to have larger home ranges than females, at 15.3 km and 11 km, respectively (Erlinge 1967a). River otters reintroduced in a riverine system in Missouri also had significantly different home range lengths; males averaged 40.3, km while females averaged 24.0 km (Erickson 1984)

Otter home ranges are usually oriented along water courses and are linear in shape (Powell 1979). Food availability, habitat quality, season, weather conditions and interaction with other otters could influence the size and shape of an otter's home range (Hornocker et al. 1983).

River otters home range length/size depends on the habitat however,(e.g. mountain stream, marsh, reservoir) in which the animal is found, and the resources available in that habitat. Melquist and Hornocker (1983) determined that otters in Idaho develop a strong site attachment. A strong site attachment influences an animal to remain in the same area, thus creating a home range. These site attachments are for food resources, shelter, and social interactions with other otters.

The minimum annual home range for otter in Idaho was 31 km (Melquist and Hornocker 1983). The average home range length for otters reintroduced into a riverine system in Missouri was 32.2 km (Erickson 1984). While mean home range size for otters reintroduced in a lake habitat in Missouri were 9.1 km (Erickson 1984). Perhaps, habitat quality in Abrams Creek is superior to that of Idaho and Missouri study sites. If this is true, it may help explain the small home ranges exhibited by otters in this study. Otters living in different habitat types other than riverine, exhibit a different home range pattern. Female otters in a Texas marsh were found to utilize 295 ha as a home range, while males utilized 400 ha (Foy 1984).

Of the 8 otters monitored longer than one month, seven established home ranges that overlapped a portion of at least one other otter's home range (Figure 6). Overlap occurred near the edge of the animals' home range. However, otters travelled through large sections of adjoining otters' home ranges. Home range overlap occurs depending again on habitat type, otter density and the time of year. Native otters in Idaho had extensive home range overlap. In all study areas male/male, male/female and female/female overlaps occurred (Melquist and Hornocker 1983). Reintroduced otters in Missouri exhibited home range overlap intra- and intersexually as well (Erickson 1984).

## Daily Movements

A mean daily distance travelled was calculated for each animal (Table 7). The maximum distance travelled during a 24 hour period ranged

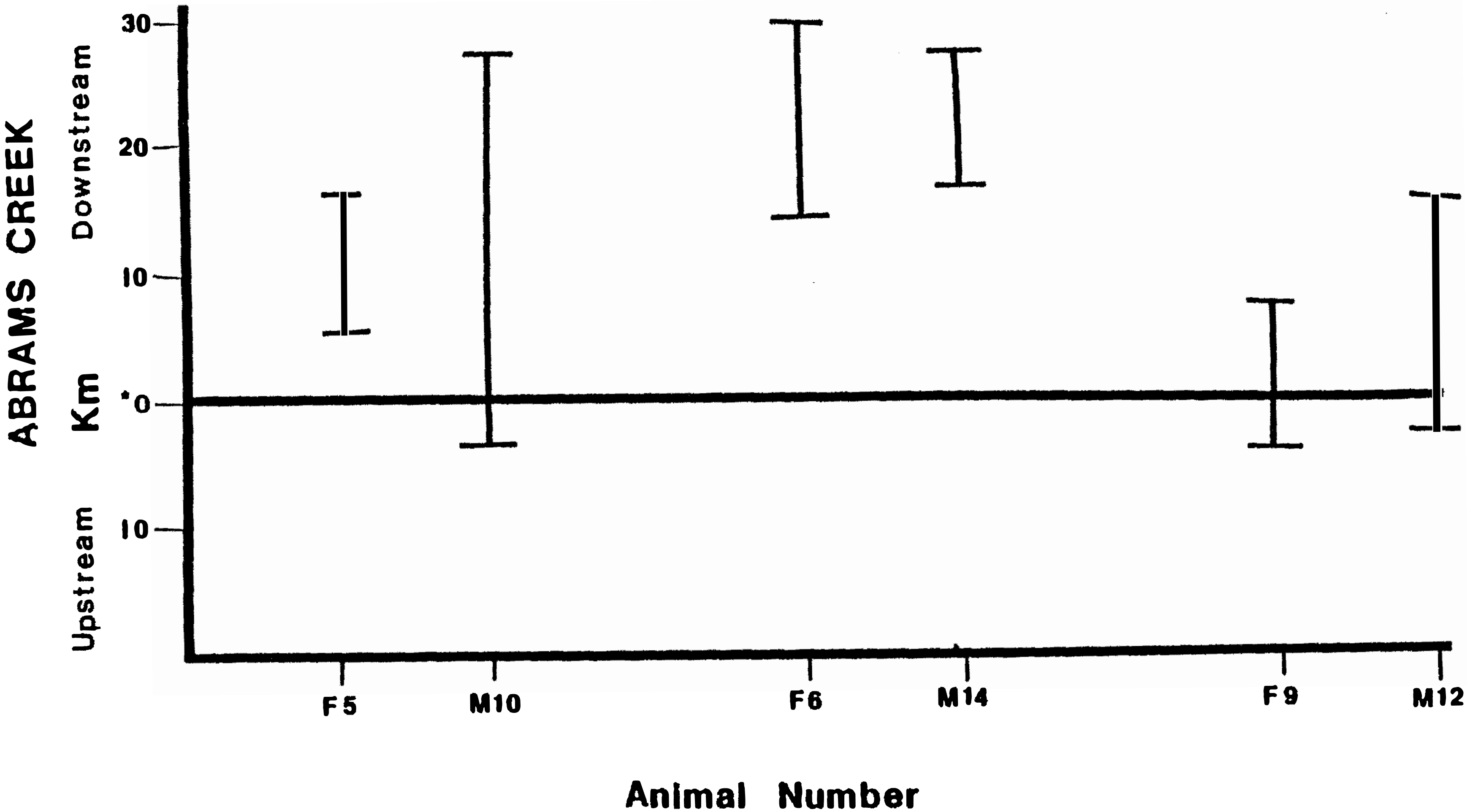


Figure 6. Home range overlap of river otters reintroduced in Abrams Creek. GSMNP, 1986.

*Release site

Table 7. Mean distance travelled in a 24 hour period by 8 river otters released in Abrams CreeK, GSMNP, 1986.

| Animal Number | sex | Mean Distance Travelled km | mi | n * | Range Min. | Max. |
|---|---|---|---|---|---|---|
| 6 | F | 1.81 | 1.0 | 8 | 0 | 6.4 |
| 9 | F | 2.60 | 1.6 | 30 | 0 | 7.7 |
| 5 | F | 1.55 | 0.9 | 30 | 0 | 5.6 |
| 15 | F | 2.50 | 1.6 | 16 | 0 | 9.2 |
| 8 | M | 2.14 | 1.2 | 35 | 0 | 10.6 |
| 14 | M | 1.45 | 0.8 | 4 | 1 | 3.5 |
| 12 | M | 2.55 | 1.4 | 45 | 0 | 6.3 |
| 10 | M | 2.30 | 1.4 | 27 | 0 | 9.8 |
| Average | | 2.11 | 1.2 | | 0.13 | 7.4 |

* n equals the number of 24 hour observations.

from 1.5 km to 2.6 km. If the animal was found in the same location the following day, a distance of 0 km was recorded. Distances moved during a 24 hour period ranged from 0 to 10.6 km. The mean 24 hour distance moved was the same for males and females (2.1 km). These results are similar to 24 hour movements exhibited by otters in a Texas marsh (Foy 1984); average 24 hour movements were 3.6 km. The maximum movement recorded for a 24 hour period was 7.3 km (Foy 1984). In Idaho, a dispersing young male otter moved 42 km in 24 hours. However, the average distance moved in 24 hours was found to be 4 km (Melquist and Hornocker 1983). Native otters in Sweden travelled an average of 1 to 5 km per 24 hours depending on the season (Erlinge 1967a). The extent of daily movements may reflect two possibilities. Erlinge (1967a) found otters in Sweden made two types of movements: travel and foraging. Foraging movements often were slower and in a zig-zag pattern. While travel movements were always faster and more direct. Travel movements were exhibited more by males. Erlinge concluded that male otters were "patroling" the boundaries of their ranges and reinforcing their scent markings.

## Food Habits

A total of 42 samples consisting of 75 scats were collected during the study. All scats were collected from moss-covered creek banks, except one that was collected from a large rock in the middle of Rabbit Creek. Tumlison (1984) found 54% of river otter scats collected in Arkansas on moss or leaf covered creek banks. In several instances, two or more scats were deposited in the same area, possibly indicating a scent post. Scent marking is probably the most important means of communication between river otters (Toweill and Tabor 1982, Melquist and Hornocker 1983). Normally otters scent mark by repeatedly defecating in the same area. Usually prominent areas such as on the bank or large rocks.

The majority of the otter scats (84%) were collected within 4.5 km above Abrams Falls, 5.3% were collected approximately 1.6 km below Abrams Falls, 6.6% were collected along Little Bottoms area of Abrams Creek (lower Abrams), and 4.0% were found on Rabbit Creek (Figure 7).

Crayfish represented the most frequently occurring food item (Table 8). Crayfish remains were found in 95% of the 42 scats and latrine samples. Additionally, crayfish were an important food item during every month of the study. This finding is consistent with Grenfell (1974) and Pierce (1979). Other studies have found crayfish second to fish in frequency of occurrence (Sheldon and Toll 1964, Toweill 1974, Lauhachinda 1978).

Fish remains occurred in 90% of all scats. Five fish families and 11 species were represented (Table 9). White suckers (Catostomus commersoni) made up 57% by number of fish eaten, followed by stonerollers (Campostoma anomalum) (50%). Other fish occurring frequently were northern hog suckers (Hypentilium nigricans) (40%), and creek chub (Semotilus atromaculatus) (33%). Only two species of game fish, rainbow trout (Salmo gairdneri) and rockbass (Ambloplites rupestris), were identified in scats at 14.0% and 2.3% respectively. It

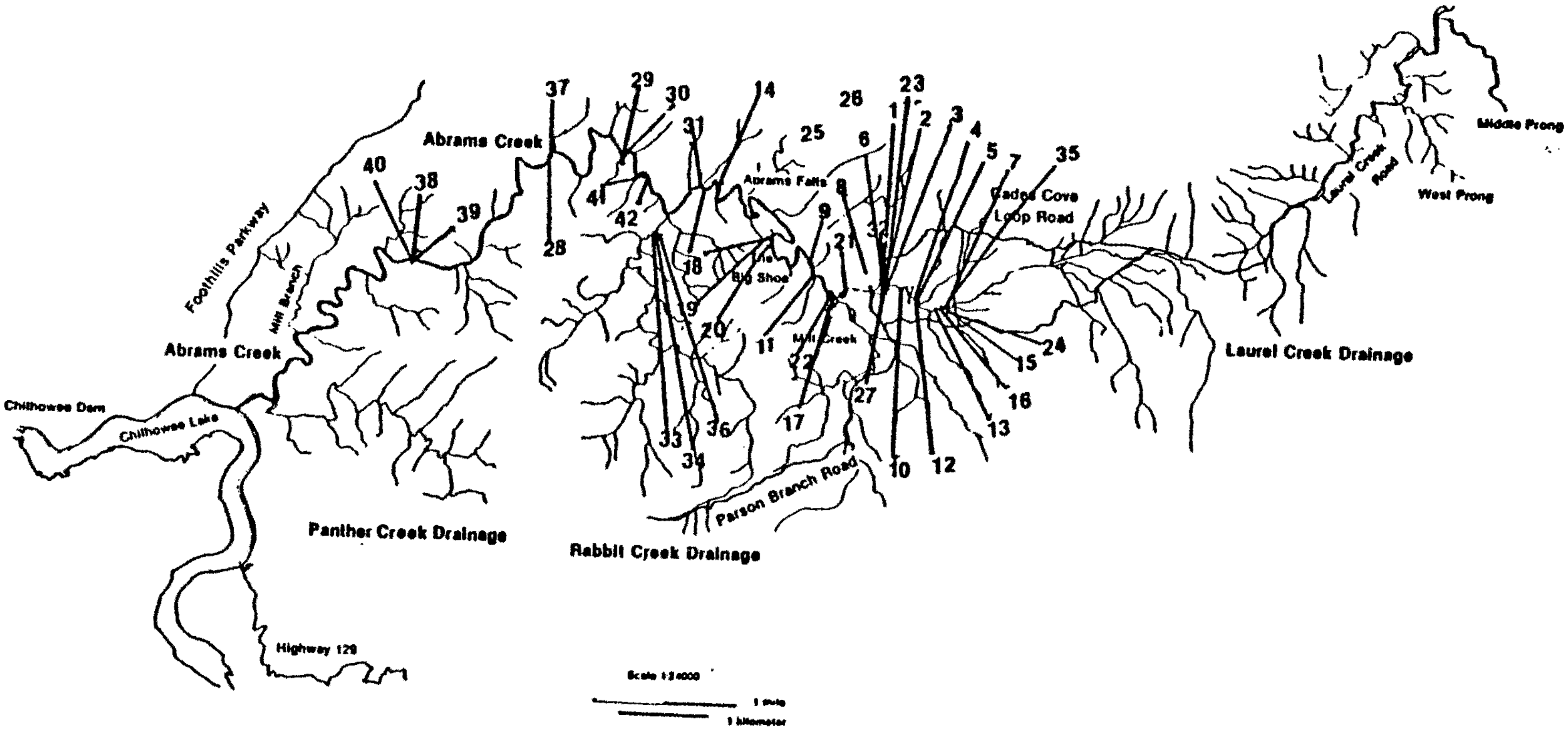


Figure 7. Locations of 42 scat and latrine sites collected between 9 April 1986 and 28 September 1986, in Great Smoky Mountains National Park.

Table 8. Non-fish food items identified in river otter scats collected between 9 April, 1986 and 28 September, 1986.

| | No. of occurrence | Frequency of occurrence |
|---|---|---|
| Crayfish | 40 | 95.0% |
| Turtles | 8 | 19.0% |
| Frogs | 9 | 21.0% |
| Salamanders | 2 | 4.7% |
| Insects | 2 | 4.7% |

Table 9. Fish species identified in river otter scats collected between 9 April, 1986 and 28 September, 1986.

| | No. of occurrence | Frequency of occurrence |
|---|---|---|
| FISH | 36 | 90% |
| Salmonidae | 6 | 14.3% |
| *Salmo gairdneri* | 6 | 14.3% |
| Cyprinidae | 29 | 69.0% |
| *Campostoma anomalum* | 21 | 50.0% |
| *Nocomis micropogon* | 1 | 2.3% |
| *Notropis* sp. | 1 | 2.3% |
| *Rhinichthys atraulus* | 6 | 14.0% |
| *Semotilus atromaculatus* | 14 | 33.0% |
| Catostomidae | 28 | 67.0% |
| *Catostomus commersoni* | 24 | 57.0% |
| *Hypentilium nigricans* | 17 | 40.0% |
| *Moxostoma erythrurum* | 1 | 2.3% |
| Centrarchidae | 1 | 2.3% |
| *Ambloplites rupestris* | 1 | 2.3% |
| Percidae | 1 | 2.3% |
| *Etheostoma* sp. | 1 | 2.3% |

is important to note that 5 of the 6 rainbow trout were in the 50-100 mm size range; this is considered fingerling size.

Crayfish are obviously an important food item for river otters. Their productivity (Pennak 1978, Arrington 1981), size, speed and propensity for shallow water (Pennak 1978) make them easily accessible to river otters. When a food source is available such as crayfish, river otters will exploit it, given this species' opportunistic tendancies (Chanin 1985).

Raccoons (Procyon lotor) and mink (Mustela vison) also consume crayfish. However, it is not a major portion of these animals diets (Toweill and Tabor 1982) and thus competition likely is minimal.

Trout regularly consume crayfish; however, rainbow and brown trout feed primarily on aquatic insects, terrestrial insects, snails and small fishes (Pflieger 1975). In a food study of rainbow and brook trout in GSMNP, Habera (1987) found that 13 % (by occurrence) of rainbow trout and 29% of brook trout contained crayfish. However, none of the crayfish measured greater than 3.8 cm (Habera 1987). Brook trout apparently consume more crayfish than rainbow trout but brook trout only occur in the upper watersheds of GSMNP above 15% slope (Singer et al. 1981). This type of situation is unattractive to river otter because the streams are smaller and food resources are limited. Because of the small number and size of crayfish eaten by trout, it is unlikely river otters will affect trout populations with their consumption of crayfish.

Crayfish remain in burrows during winter months making them inaccessible to otters (Pennak 1978). Thus river otters must shift their diets to include more fish and fewer, if any crayfish (Ryder 1955, Sheldon and Toll 1961, Toweill 1974).

Though previous food studies seldom identified fish to the species taxonomic level, they did group fishes by families such as Cyprinidae (forage-minnows), Centrarchidae (pan-sunfish) and Catostomidae (rough-suckers) (Lagler and Ostenson 1942, McDanial 1963, Lauhachinda 1978). Results of the present study compare similarly to other studies. The most frequently occurring families in the present study were Cyprinidae and Catostomidae. Additionally, non-fish food items were similar when compared to other studies (Table D-1).

Lengths were calculated for all fish identified in the scat analysis (Figure 8). Overall 88% of all fish were in the 50 to 256 mm (2 in to 10 in) range. Fifty fish (28%) were in the 50 to 100 mm (2 in to 4 in) range, 22% in the 101 to 152 mm (4 in to 6in) range, 22% in the 153 to 204 mm (6 in to 8 in) range, and 16% in the 205 to 256 mm (8 in to 10 in) range. There appeared to have been no specific size selection in fishes that were 256 mm (10 in) or less. The remaining 12% of fish identified in the scats were those fish which were greater than 256 mm. These results compare similarly to findings of size of fish eaten by European river otter. Wise (1980) found little evidence of otters selecting fish of a particular size, but rather that otters took different sizes of fish in proportion to their abundance.

Since scats were collected from April through September 1986, there were not enough data to support any specific annual feeding patterns. However, specific food items were selected during certain months of the

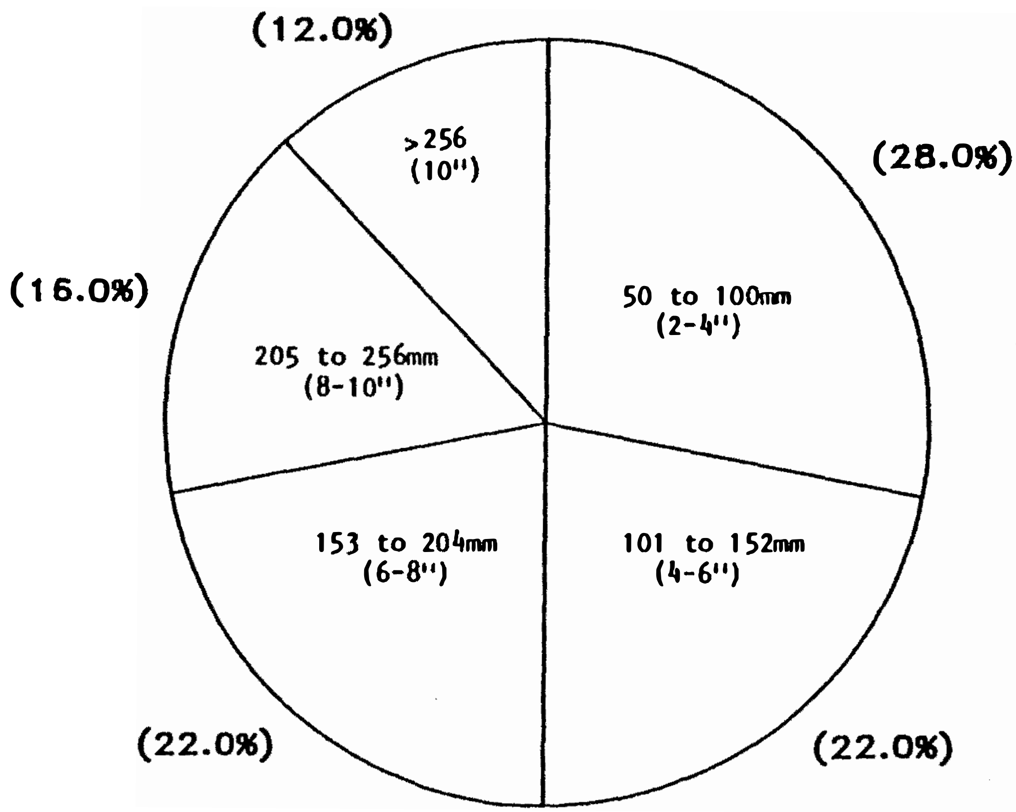


Figure 8. Percent distribution of sizes of fish identified in river otter scats.

study (Table D-2). Amphibians (frogs, toads, and salamanders) were found to occur in scats collected during April and May; this was similar to findings in the Great Dismal Swamp (Pierce 1979). Since this is the breeding season, amphibians are more active and vulnerable to predation (Mount 1975). In addition 67% of the turtle remains identified in the scats were found during April; this is the time of year turtles emerge from the water to lay their eggs, thus making them easy prey for the otters (Mount 1975).

No seasonal pattern occurred for crayfish or fish, indicating they were available throughout the study. However, crayfish have been shown to be seasonally available, and noticeably absent during the winter months (Sheldon and Toll 1964, Toweill 1974).

Otters catch fish in an inverse proportion to their swimming ability, that is, the slower swimming fish are the first to be eaten (Ryder 1955). The rough and forage fishes in the present study were eaten 81% of the time and these are the slower swimming species found in Abrams Creek. Ryder (1955) concluded that otters capture fish species in direct proportion to their abundance. However, this conclusion contrasts with the findings of the present study. Based on stream surveys, rainbow trout were the most abundant fish species in Abrams Creek (S. Moore unpubl. data, Porter and Turner 1985). However, only six rainbow trout were identified in scats. More than just abundance of a fish population regulates which fish species will be captured most. Not only is vulnerability of a fish species determined by population size, but also their habitat, their mobility, body size and behavior (with regard to shelter) (Erlinge 1967). Otters may actually benefit trout populations by removing competitive fish from trout waters (Ryder 1955). However, with an approximate density of one otter every 4.8 km of Abrams Creek, it is unlikely that these otters will impact the food resources (fish, crayfish, amphibians) directly ot indirectly. Based on stream surveys conducted in 1983-85, an abundant fish population thrives on Abrams Creek (Table D-3). It would appear that food is not a limiting factor for the otters in this study.

## Den and Resting Sites

On 25 occasions, otter dens/resting sites were identified. In all instances these areas were within 5 m of the water. On 8 occasions (32%), rock crevices/caves were identified as dens. In all cases the entrances of these dens were above the normal waterline. Upon examination of dens, it was found that they all extended into the rocks and seemed to provide excellent protection from the weather. On six occasions (24%), resting areas were found in thick vegetation. These areas were used for diurnal resting and possibly nocturnal resting; however no radio locations were recorded at night. Major species of vegetation present at rest sites were rhododendron (*Rhododedron maximum*), mt laurel (*Kalmia latifolia*) and thick patches of blackberry bushes (*Rubus* sp.). Twice otters were accidentally flushed out of their resting areas. Because of flooding of bank dens in spring, otters in Idaho used thick riparian vegetation (Melquist and Hornocker 1983).

Dens and holes excavated by groundhogs (*Marmota monax*) and muskrats (*Ondatra zibethicus*) accounted for 24% of the dens in the present study (n=6). Groundhog burrows were used by otters frequenting Cades Cove (n=4). Otters using muskrat dens (n=2) were located just outside the park along the shoreline of Chilhowee Lake.

Vegetative debris accounted for an additional 20% (n=5) of the dens. This included logjams and treefalls along Abrams Creek (Table 10).

Den sites were not lacking along Abrams Creek drainage. In 24 cases (96%), dens were located at least 0.8 km away from the hiking trail. In one instance, a groundhog burrow less than 100 m from Cades Cove loop road was used . These results possibly indicate that otters selected dens based on seclusion and lack of human disturbances, because there was no lack of adequate den sites anywhere along the stream. The same dens were used by more than one otter. Early in the study, a groundhog burrow was used by three different otters (F15, M12, and F9) on three different occasions. Also, a rock slide along lower Abrams Creek was used by two different otters (F5 and M10).

Normally river otters do not excavate their own dens, but instead, utilize dens dug by other animals or natural shelters (Toweill and Tabor 1982). Yeager (1938) described otters denning in the hollow trunks of large cypress trees, and even abandoned duck blinds have been used (Toweill and Tabor 1982).

Table 10 . Summary of identified den and resting sites used by reintroduced river otter in GSMNP, 1986.

| Location | Percent Used | No. of times Located there |
|---|---|---|
| Rock crevices/slides | 32% | 8 |
| Riparian vegetation | 24% | 6 |
| Animal Burrows | 24% | 6 |
| Logjams/undercut banks | 20% | 5 |

## Social Interaction

Seven otters were located with another otter on at least one occasion, three otters were located with two additional animals on at least one occasion, and one otter (F15) was never located in association with other otters (Table 11).

On 97% of the occasions, recorded interactions occurred between males and females. There appeared to be an obvious lack of same sex interaction. Two males were found together only twice. Melquist and Hornocker (1983) found that only young male otters associated with females during the non-breeding season and adult males remained solitary.

The basic social group in river otters is the family group (female and her offspring) (Liers 1951, Erlinge 1968a, Melquist and Hornocker 1983). Occasionally a juvenile (male or female) will join a family group. Most non-family group associations (lone juveniles, yearlings or females without young) last only a short period (Melquist and Hornocker 1983). In some instances groups of otter may remain together for longer periods of time such as a group of six otters in Wisconsin. During the period that they were regularly seen together, waterways were frozen (Beckel-Kratz 1977).

River otters in streams and river systems exhibit more rigid social structure. Otters reintroduced in Missouri remained solitary 81% of the time. Females were solitary except during the late winter and early spring. Only one female/female association was ever recorded (Erickson

Table 11. Summary of social interaction between river otter reintroduced in Abrams Creek, GSMNP, 1986.

| Otter No. | In assoc. with | No. of times together | Percent of time located together | Total no. of locations |
|---|---|---|---|---|
| F5 | M10 | 14 | 13.3% | 105 |
| F6 | M14 | 10 | 17.0% | 59 |
| M8 | F6, M14 | 1 | 1.6% | 95 |
| F9 | M12 | 15 | 1.5% | 74 |
| M10 | F9, M12 | 2,2 | 2.7%, 2.7% | 73 |
| M12 | F9, F5 | 15,2 | 12.5%, 1.7% | 120 |
| M14 | F6 | 10 | 22.2% | 45 |
| F15 | ---- | ---- | ----- | 62 |

1984). Males were more social than females and did appear to exhibit group attachment (Erickson 1984). The behavior of the reintroduced otters in Missouri appeared similar to behavior of otters reported for native populations elsewhere (Melquist and Hornocker 1983, Foy 1984).

River otters tend to be more social than other mustelids (Liers 1951, Best 1962, Beckell-Katz 1977, Hornocker et al. 1983). Otters from this reintroduction often were solitary; however, they were located together during every month of the study, which would enable necessary reproductive encounters.

Otters in this study also exhibited intrasexual territoriality (Figure 6); this is typical of most mustelids (Powell 1979). Powell (1979, p 154) defines territory as "an area of exclusive use; this implies priority access to resources and may imply defense (by aggression or by marking)". Otters in our area were known to utilize scent markings through latrine sites. These scent markings may have been responsible for the avoidance of certain areas by other otters.

Scent markings possibly provide information to other otters in the same area. This information may include the otter's identity, who produced the scat, its age, sex, breeding condition and status (Chanin 1985). Scent markings may promote avoidance of the dominant by the subordinate otters in an area of overlap. Melquist and Hornocker (1983) suggested that individual otters might settle in one activity center for a period of time and prevent other otters from entering their "personal space" by scent marking extensively in that area. Regardless of the reason, scent marking is obviously a necessary part of the river otter's life based on the time spent depositing and checking scent posts (Chanin 1985).

The above results are consistent with how otters behaved when reintroduced into a riverine system in Missouri (Erickson 1984). Erickson (1984) stated that resource allocation (food, shelter) may determine the type of social organization among river otters in riverine systems. In Idaho, otters were evenly distributed where prey was also relatively evenly distributed (Hornocker et al. 1983). Also, male otters in Missouri tended to be more social than females (Erickson 1984). The above results are similar to the findings of the present study.

The one instance of an otter not being found in association with another otter in this study was female F15. This animal left the Abrams Creek watershed altogether.

## Activity Centers

Throughout the study, otters used certain areas more frequently than others within their home ranges. These "preferred" areas were considered activity centers, and often varied in number among individual otters (Figure 9) (r = 0 to 2). These activity centers were never located in any one area of the otter's home range (i.e. in the center or on the edge). However, all activity centers (n=9) identified had characteristics in common. All activity centers were located near long, deep pools. These deep pools likely provided abundant and easily

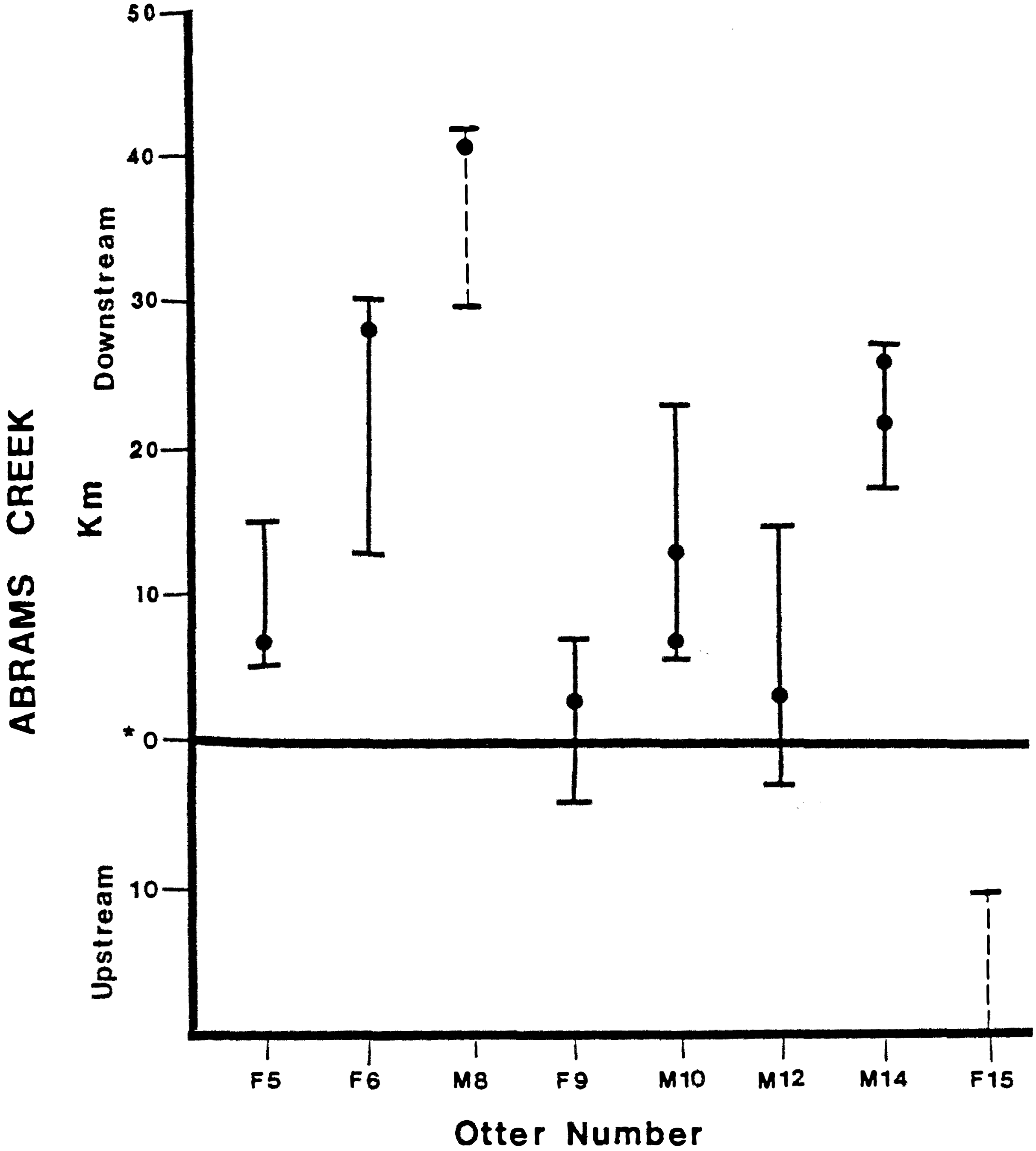


Figure 9. Location of activity centers within the home range of river otters reintroduced in Abrams Creek, GSMNP, 1986.

*Release site, ----Outside Abrams Creek.

accessible food for the otters when the activity center was used. Also, all activity centers were located near appropriate den sites. In all instances activity centers were located at least 1.5 km from the hiking trail which follows the creek for approximately 17 km, and all were in rugged areas. A combination of abundant food, adequate shelter and minimal human disturbance was common at all activity centers.

With the exception of F15, all reintroduced otters established activity centers. Two otters utilized two separate activity centers each, while the remaining five otters established only one area as an activity center (Figure 9).

Often two otters used the same activity centers (Table 12). For example, F9 and M12 used the same activity center together on 9 occasions. Each was located there alone 20 and 51 times, respectively. M14 and F6 used the same activity center together on 3 occasions. However, M14 was located there alone on 13 occasions while F6 was found using the area on 18 occasions alone. M10 and F5 also shared an activity center; they were located 12 times together using this area, and each was located alone 23 and 31 times, respectively. These findings are similar to those of native river otters in Idaho who frequented the same activity centers concurrently, although they each had independent activity centers as well (Melquist and Hornocker 1983).

Seasonal changes in activity centers were not observed in the present study. In Idaho, otters tended to shift activity centers during Kokonee salmon spawning runs (Melquist and Hornocker 1983). At these times, otters congregated in spawning areas to feed, until spawning was

Table 12. Summary of time river otters were in association with other otters at activity centers, and number of times otters were located there alone.

| Otter no. | Number of times together | Number of times alone |
|---|---|---|
| F5 + M10 | 12 | 31 , 23 |
| F6 + M14 | 3 | 18 , 13 |
| F9 + M12 | 10 | 20 , 51 |

complete. There are no fish species in GSMNP that exhibit distinct seasonal movement patterns (migrations) as Kokonee salmon, though redhorses (Moxostoma spp.) do school to spawn in shallow areas of Abrams Creek, probably making them more accessible to the otters (Pflieger 1975).

## Mortality

The carcass of an older male otter was recovered two weeks after release 5.5 km downstream from the release site. Prior to release it was observed that all four canines were broken and/or worn to the gum line. Although cause of death could not be determined, due to the advanced state of decomposition when found, it is believed that he starved due to the condition of his teeth, as well as the fact that certain prey items such as crayfish and amphibians were not readily available (Pennak 1978).

No other mortalities were reported during the study (February through December 1986). However, in March 1987, M12 was accidentally trapped in a fish hoop net set in a cove on Chilhowee Lake. This animal was returned to the University of Tennessee where he was weighed, measured and evaluated by personnel of the College of Veterinary Medicine. This animal had gained more than 1.4 kg and had grown an additional 8.6 cm. He appeared to be in excellent condition. No abdominal adhesions were present as a result of the implanted transmitter, and no other adverse effects from the transmitter were noted. It appeared that this animal had done exceptionally well since its release in March 1986, a length of 360 days.

Accidental trapping of otters in fish, crab and lobster traps has long been a problem for otters. Ganier (1928) reported river otters being trapped in fish traps in Reelfoot Lake. European river otters also have been accidentally drowned in traps meant for fish and crabs; 84 otters were accidentally drowned between 1975 and 1983. In 18 months, 23 of these otters were drowned in Fyke nets set for eel in fresh water lochs, and 22 in lobster pots in England (Chanin 1985).

No other documented mortalities occurred during the present study. Causes of mortality of river otters from other studies have been starvation (Britt et al. 1984), roadkills (Melquist and Hornocker 1983) and accidental trapping in beaver sets (Tabor 1974, Erickson 1984).

## Reproduction

Signs of reproduction were not observed during this study. However, telemetry locations indicated that males and females were together (n = 7) during what is normally considered the breeding season (December through March) (Toweill and Tabor 1982). Due to the short life of the transmitters, (estimated by the manufacturer to be 12 to 14 months) it will be difficult to determine if any reproduction occurs in 1987.

Unfortunately, all transmitters had ceased functioning by March 1987. Prior to March, only one female demonstrated any localized movements; her movements were restricted to her activity center for three consecutive weeks. However, her last location (9 February 1987) was over 5 km away from her previous center of activity.

Females with transmitter implants are presumed to have no difficulty reproducing (Reid et al.1986). A study of the effects of intraperitoneal transmitter implants on reproduction of seven instrumented adult female river otters in western North America found that all stages of the breeding cycle proceeded successfully (Reid et al. 1986).

North American river otters normally reach sexual maturity at two years of age (Liers 1951). Females can successfully breed at two years; however, male river otters are seldom successful breeders until five to seven years old (Liers 1951). All of the river otters reintroduced in this study were considered adults; however, exact ages were not known. Therefore, the possibility exists that some of the reintroduced otters will not reproduce successfully for two years (a year before they are bred and another year for delayed implantation and gestation).

CHAPTER V

# SUMMARY AND CONCLUSIONS

A total of 11 river otters were released in Abrams Creek in Great Smoky Mountains National Park between 26 February and 31 March 1986. Data obtained through radio telemetry and scat analysis indicated that otters successfully fed, located other otters and established home ranges in and around Abrams Creek. These otters from a warm coastal salt marsh environment appeared to adapt well to a cold mountain stream habitat.

No differences were found between the sexes in distances travelled within 24 hours, although there were considerable differences among individuals. The average distance travelled during a 24 hour period was 2.1 km.

No differences were found between sexes in home range size, although again there were considerable differences among individuals. Average home range length for all otters was 15.0 km.

Otters appeared to adapt well to the available food resource in Abrams Creek. Crayfish were found to occur most frequently in scats, followed closely by fish. Fish probably play the most important role in the otters diet because fish are available throughout the year and are available in greater volume. Fish most often identified in the scats were white suckers, northern hogsuckers, stonerollers and creek chubs.

Based on scat analysis and size classification of fish eaten, it was evident that otters do not select for a specific size of fish but rather on the availability and ease of capture of fish. The four major fish species eaten were the slower swimming fish.

Otters utilized available dens and resting sites along Abrams Creek. Den and resting sites appeared to be used primarily in areas of little human disturbance. Those den sites which were identified were always located in areas with abundant food supply (long, deep pools). Otters used dens that were natural formations and dens built by other animals (muskrat and groundhog).

The majority of the time, the otters remained solitary. However, seven of eight otters were located with at least one other otter during the study. Not surprising was the fact that 97% of these associations were male/female interactions. Three females overlapped the majority of their home range with three males. No female/female home range overlap occurred.

Seven of the eight river otters established at least one activity center. These activity centers always were located in areas of abundant food supply (deep pools) . Also a den site was always in or near an activity center. Activity centers were always located a minimum of 1.5 km from the hiking trail. Three pairs of otters (male/female) were located together using the same activity center. However, these animals also were located in these activity centers alone.

The success of any reintroduction is usually evaluated on the reproductive success of the animals released. However, because of the late age of sexual maturity and because of the long reproductive cycle of river otters (approximately 10 months delayed implantation, and

63 days gestation), it will be impossible to determine if reproduction has occurred in this study. Therefore, other criteria will have to be used to evaluate whether reproduction occurred.

Results of this study compare favorably to other reintroductions, as well as native populations of river otters. Daily movements of otters in this study, were similar to movements of otters reintroduced in Missouri, as well as native otters in Texas. Food habits were similar in this study, to reintroduced otters in Missouri and native otters in Idaho, Louisiana, Michigan, Virginia and many other native populations. Social interaction for the reintroduced otters compared favorably to reintroduced otters in Missouri, as well as to native populations of otters in Idaho and Sweden. Similar dens were used by reintroduced otters in this study and by otters found throughout North America and Europe. Scent markings were used by otters in this study as they were in many native populations of otters.

The only aspect of this project that was not similar to other studies was the size of the animals home ranges. In this study , the females had larger home ranges than the males. In native populations of river otters, the males normally have a larger home range. Also river otters reintroduced in Missouri river otters had a larger home range. Possibly,if this study had continued for a year or more, results may have been different.

Based on the findings in this study, and comparing them to other river otters studied (both native and reintroduced populations), the author feels that this was a successful reintroduction effort.

Verification if whether reproduction takes place would offer additional evidence to the projects success. Continued study of the river otters' ecology is important (Appendix E).

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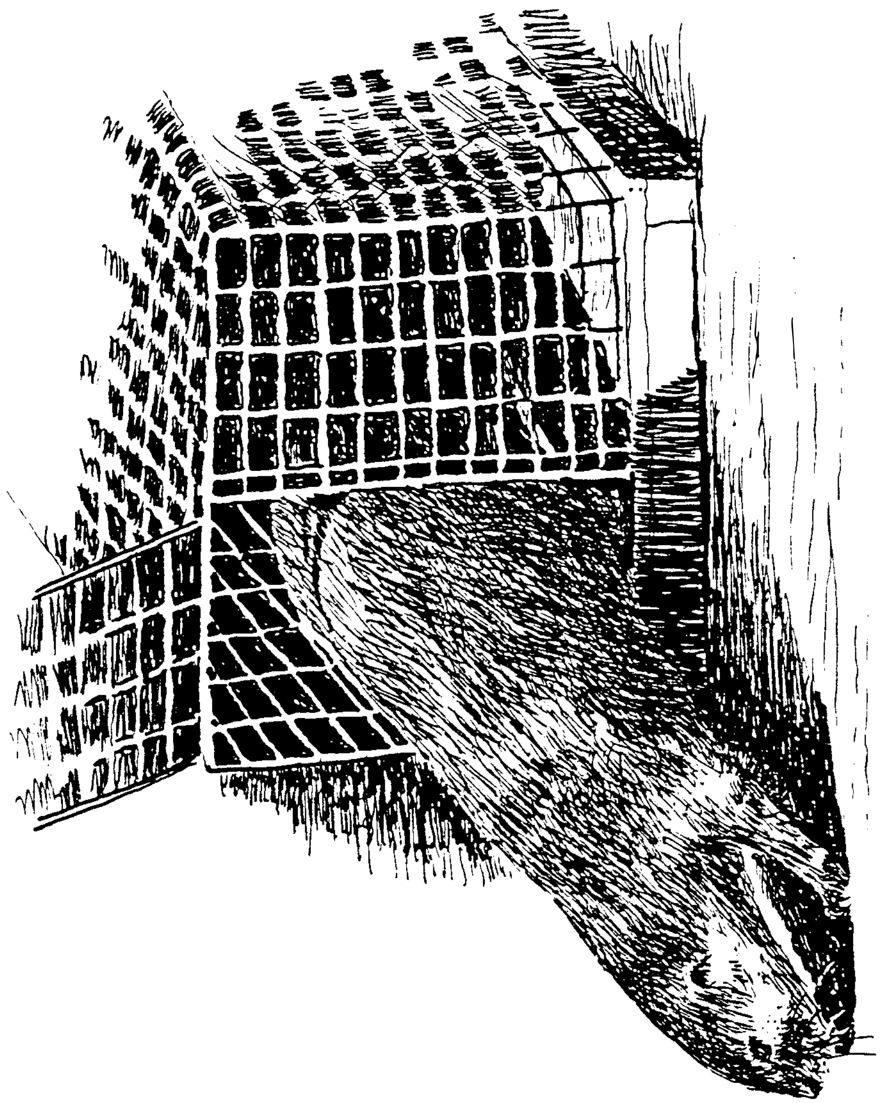
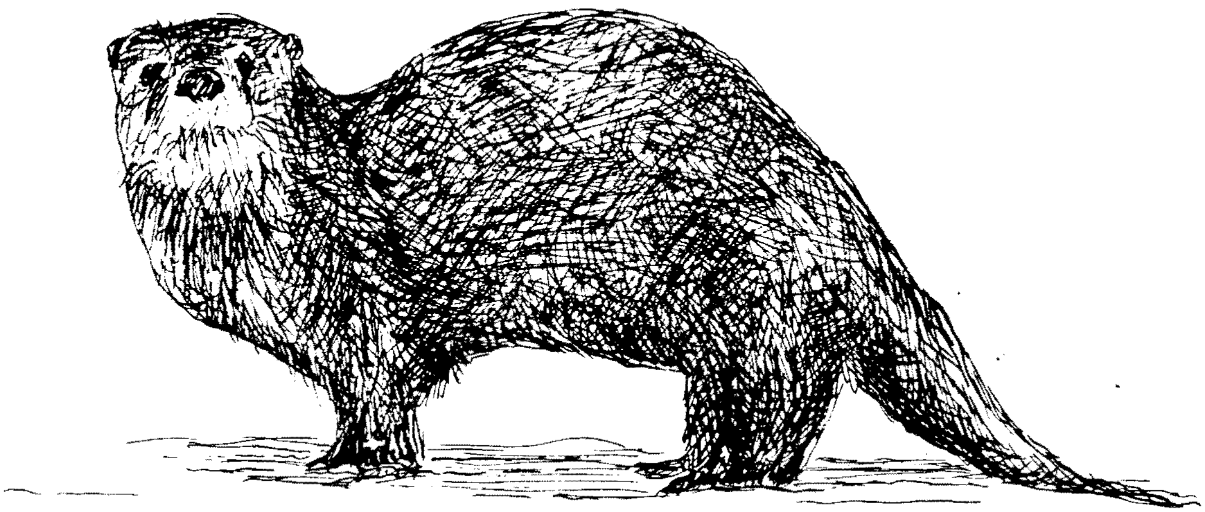




# APPENDICES

# APPENDIX A

# FISH AND WATER QUALITY INFORMATION

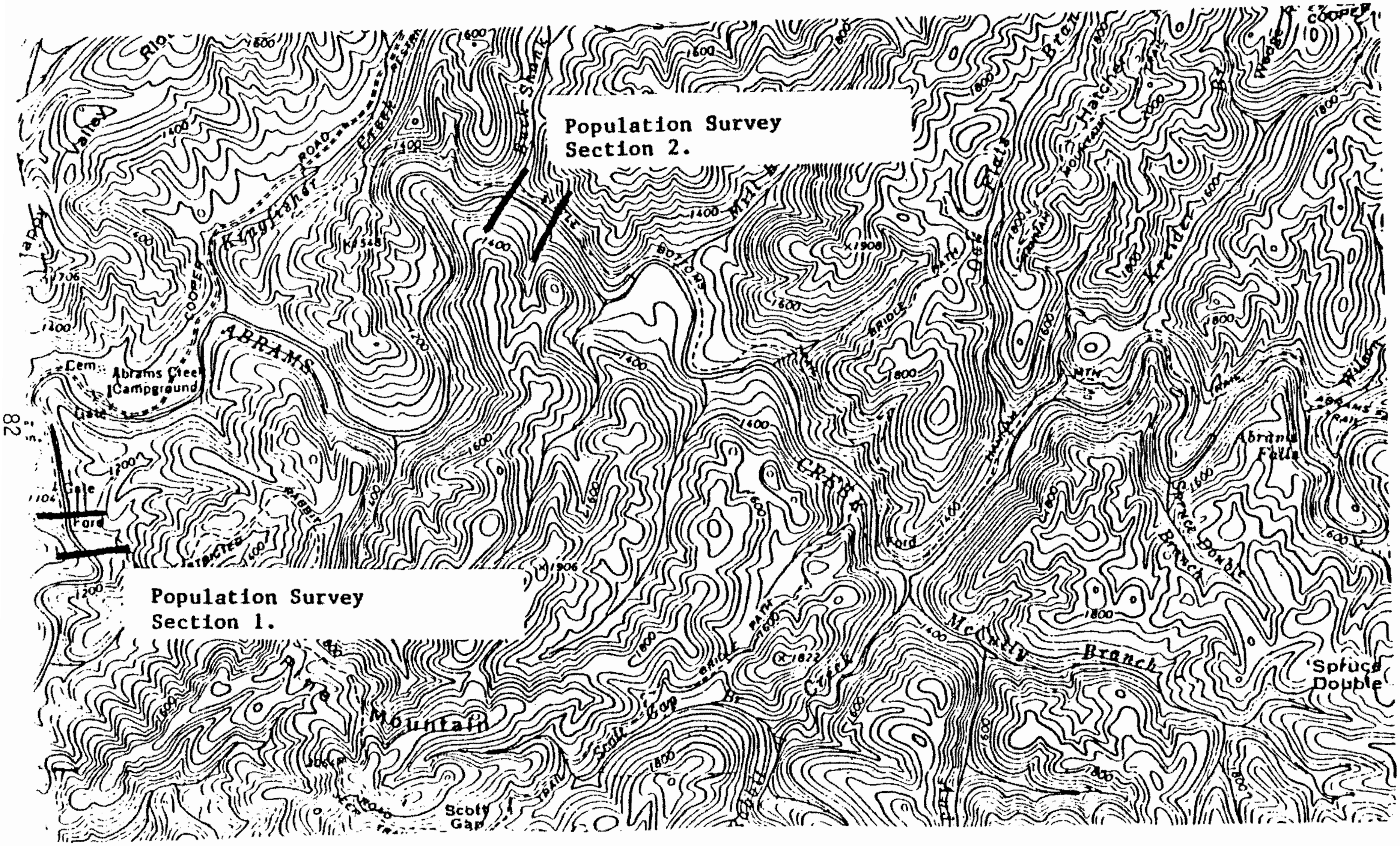



Figure A-1. Abrams Creek and population survey sections, 1983-1984.

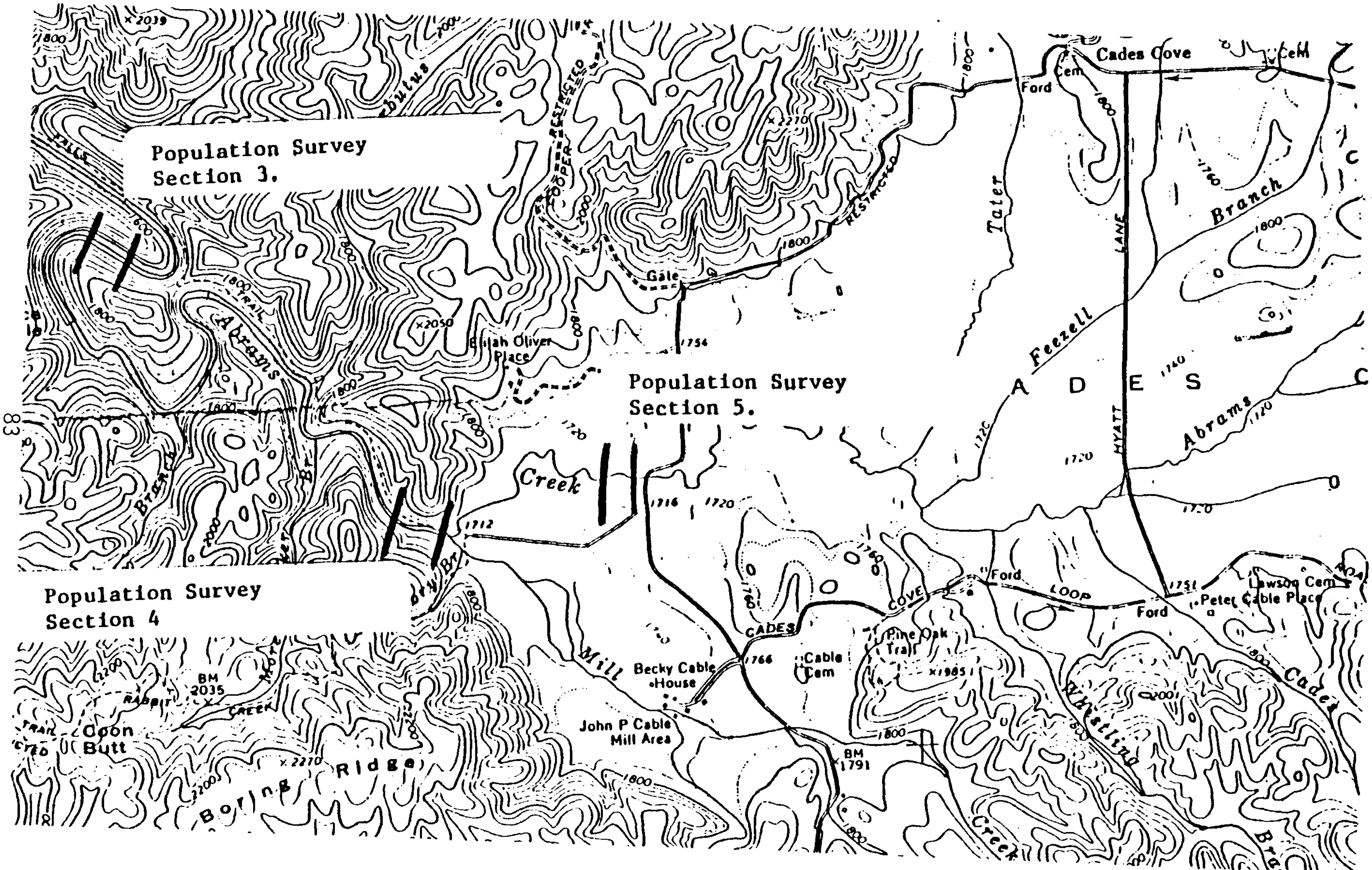



Figure A-1. (cont.)

Table A-1. Species List of Fish Found in Abrams Creek in Great Smoky Mountains National Park.

| Scientific Name | Common Name |
|---|---|
| Salmonidae | |
| *Salmo gairdneri* | Rainbow trout |
| *Salmo trutta* | Brown trout |
| Cyprinidae | |
| *Campostoma anomalum* | Stoneroller |
| *Hybopsis amblops* | Bigeye chub |
| *Nocomis micropogon* | River chub |
| *Notropis coccogenis* | War paint shiner |
| *Notropis galacturus* | Whitetail shiner |
| *Notropis leuciodes* | Tennessee shiner |
| *Notropis telescopus* | Telescope shiner |
| *Cyprinus carpio* | Common carp* |
| *Pimephales promelas* | Fathead minnow |
| *Rhynichthys atratulus* | Blacknose dace |
| *Semotilus atromaculatus* | Creek chub |
| Catostomidae | |
| *Hypentilium nigricans* | Northern hog sucker |
| *Moxostoma carinatum* | River red horse |
| *Moxostoma duguesnei* | Black red horse |
| *Catostomus commersoni* | White sucker |
| Centrachidae | |
| *Ambloplites rupestris* | Rock bass |
| *Micropterus dolomieui* | Smallmouth bass |
| Percidae | |
| *Etheostoma chlorobranchium* | Greenfin darter |
| *Etheostoma rufilineatum* | Redline darter |
| *Etheostoma simoterum* | Tennessee snubnose darter |
| *Etheostoma zonale* | Banded darter |
| *Percina evides* | Gilt darter |
| Ictaluridae | |
| *Noturus flavipinnes* | Yellowfin madtom |

*Not collected in stream survey but verified in Abrams Creek.

Table A-2. Water Quality Parameters for Five Sections of Abrams Creek, Collected Between 1983 and 1985.

| | 1983 | | 1984 | | 1985 | | | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Sect. 4 | Sect. 3 | Sect. 2 | Sect. 5 | Sect. 1 | Sect. 3 | Sect. 5 | Sect. 4 |
| Date | 9/29 | 9/26 | 9/24 | 9/25 | 10/26 | 11/16 | 11/7 | 11/25 |
| Water Temp. (C) | 13 | 14 | 14 | 14 | 15 | 14.1 | 14.0 | 13.5 |
| pH | 7.6 | 6.7 | 7.0 | 7.2 | 7.1 | 7.3 | 7.3 | 7.3 |
| Conductivity mic/cm | 101 | 92.5 | 65 | 135 | 360* | - | - | - |
| Flow (cfs) | 8.9 | 9.2 | 9.9 | 9.9 | 9.0 | 12.0 | 8.0 | 9.0 |
| Alkalinity (mg/l) | 55 | 50 | - | - | 41 | 41 | 75 | 82 |
| Average Width (m) | 17.4 | 20.3 | 20.0 | 10.0 | 16.5 | 210.5 | 8.5 | 18.1 |
| Average Depth (m) | .205 | .339 | .230 | .430 | .252 | .348 | .214 | .193 |

*Possible error.

Table A-3. Fishes Collected During the Reclamation of Lower Abrams Creek and Tributaries in June 1957. Those Species Denoted by an Asterisk Are New Records for Great Smoky Mountains National Park.

| Scientific Name | Common Name |
|---|---|
| Salmonidae | |
| *Salmo gairdneri* | Rainbow trout |
| *Salvelinus fontinalis* | Eastern brook trout |
| Cyprinidae | |
| *Cyprinus carpio* | Carp* |
| *Campostoma anomalum* | Stoneroller |
| *Hybopsis micropogon* | River chub |
| *Hybopsis amblops* | Bigeye chub |
| *Notropis ariommus telescopus* | Popeye shiner |
| *Notropis atherinoides dilectus* | Southern emerald shiner* |
| *Notropis coccogenis* | Warpaint shiner |
| *Notropis cornutus chrysocephalus* | Central common shiner |
| *Notropis galacturus* | Whitetailed shiner |
| *Notropis leuciodus* | Tennessee shiner |
| *Notropis spilopterus* | Spotfin shiner |
| *Notropis stigmaturus* | Blacktail shiner* |
| *Phenacobius catostomus* | Suckermouth minnow |
| *Rhinichthys atratulus obtusus* | Blacknose dace |
| *Semotilus a. atromaculatus* | Creek chub |
| Catostomidae | |
| *Hypentelium nigricans* | Hogsucker |
| *Catostomus c. commersoni* | White sucker |
| *Moxostoma duquesnei alleghaniensis* | Black redhorse sucker |
| *Moxostoma erythrurum* | Golden redhorse sucker |
| Centrarchidae | |
| *Micropterus d. dolomieui* | Smallmouth bass |
| Chaenobryttus *coronarius* | Warmouth* |
| *Ambloplites r. rupestris* | Rock bass |
| *Lepomis auritis* | Yellowbelly sunfish* (Redbreast sunfish) |
| *Lepomis humilis* | Orangespotted sunfish* |
| *Lepomis m. megalotis* | Longear sunfish |
| *Lepomis m. macrochirus* | Bluegill |
| Percidae | |
| Stizostedion *canadense* | Sauger |
| *Percina c. caprodes* | Logperch* |
| *Etheostoma blennioides* | Greenside darter |
| *Etheostoma camurum* | Bluebreast darter |
| *Etheostoma albellare* | Fantail darter |
| *Etheostoma rufilineatum* | Redlined darter |

Table A-3. (Continued)

| Scientific Name | Common Name |
|---|---|
| Ictaluridae | |
| Ictalurus punctatus | Channel catfish* |
| Ictalurus furcatus | Blue catfish* |
| Ameiurus natalis | Yellow bullhead* |
| Ameiurus melas | Black bullhead* |
| Noturus flavus | Stonecat* |
| Schilbeodes miurus | Brindled madtom* |
| Petromyzontidae | |
| Ichthyomyzon castaneus | Chestnut lamprey* |
| Lampetra lamottei | American brook lamprey |
| Clupeidae | |
| Dorosoma cepedianum | Gizzard shad* |
| Cyprinodontidae | |
| Fundulus catenatus | Studfish |
| Sciaenidae | |
| Aplodinotus grunniens | Freshwater drum* |
| Cottidae | |
| Cottus carolinae | Freshwater sculpin |

Adapted from Lennon and Parker, 1959.

# APPENDIX B

## RESULTS OF MEDICAL

## EVALUATIONS AND SCREENING TESTS

Table B -1. Helminth parasites and parasite products identified from river otter from North Carolina. and released in GSMNP, 1986.

| Parasite | Body Location |
|---|---|
| Cestoda | |
| Pseudophyllidean eggs | Small Intestine |
| Trematoda | |
| Digenea eggs | |
| Paragonimus spp. eggs | Lung |
| Nematoda | |
| Strongyloides lutrae eggs | Small Intestine |
| Aelurostrogylus pridhami larvae | Lungs |
| Dracunculuslus spp. adult | Subcutaneous Tissue |
| Dirofilaria lutrae microfilaria | Subcutaneous Tissue |
| Strongylida type eggs | Intestine |

Table B-2. Total Differential Leukocyte Value for River Otters from North Carolina.

| Animal No. | WBC (μ/l) | SEG | | Lymph | | Mono | | Eos | | Injuries* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Rel. % | Count | Rel. % | Count | Rel. % | Count | Rel. % | Count | |
| M3 | 17,400 | 84 | 14,616 | 10 | 1,740 | 3 | 522 | 2 | 348 | Slight |
| M4 | 9,400 | 88 | 8,272 | 6 | 564 | 1 | 94 | 5 | 470 | Moderate |
| F5 | 10,600 | 59 | 6,254 | 22 | 2,332 | 4 | 424 | 15 | 1,590 | Moderate |
| M8 | 8,400 | 70 | 5,880 | 25 | 2,100 | - | - | 5 | 420 | Slight |
| F9 | 11,000 | 60 | 6,600 | 28 | 3,080 | 4 | 440 | 7 | 770 | Moderate |
| M10 | 5,400 | 47 | 2,538 | 31 | 1,674 | 4 | 216 | 18 | 972 | Slight |
| M11 | 14,100 | 70 | 9,870 | 22 | 3,102 | 5 | 705 | 2 | 282 | Slight |
| M12 | 7,000 | 42 | 2,940 | 41 | 2,870 | 1 | 70 | 16 | 1,120 | Moderate |
| M13 | 6,800 | 67 | 4,556 | 20 | 1,360 | 7 | 476 | 6 | 408 | Moderate |
| M14 | 9,300 | 77 | 7,161 | 16 | 1,488 | 4 | 372 | 3 | 299 | Moderate |
| F15 | 6,700 | 38 | 2,546 | 61 | 4,087 | 1 | 67 | - | - | Slight |
| M16 | 7,900 | 85 | 6,715 | 3 | 237 | 10 | 790 | 2 | 158 | Moderate |
| F6 (2/24) | | 53 | 3,657 | 27 | 1,863 | 3 | 207 | 17 | 1,173 | Severe |
| (3/10) | | 48 | 3,408 | 26 | 1,846 | 3 | 213 | 23 | 1,633 | |
| (3/21) | | 52 | 4,992 | 25 | 2,400 | 5 | 480 | 18 | 1,728 | |
| M7 (3/10) | | 66 | 4,554 | 22 | 1,518 | 10 | 690 | 2 | 138 | Severe |
| (3/12) | | 68 | 6,460 | 24 | 2,280 | 4 | 380 | 4 | 380 | |
| (3/14) | | 77 | 12,089 | 17 | 2,669 | 2 | 314 | 1 | 157 | |
| (3/18) | | 39 | 3,978 | 27 | 2,754 | 4 | 408 | 22 | 2,244 | |
| (3/23) | | 45 | 4,050 | 23 | 2,070 | - | - | 32 | 2,880 | |
| (4/8) | | 67 | 7,504 | 16 | 1,792 | 1 | 112 | 15 | 1,680 | |
| (4/21) | | 61 | 5,124 | 8 | 672 | 2 | 168 | 29 | 2,436 | |
| (4 ) | | 78 | 7,888 | 16 | 1,536 | 5 | 480 | 1 | 96 | |

WBC = White blood cell; SEG = Segmented neutrophils; Lymph = Lymphocytes; Mono = Monocytes; Eos = Eosinophils.

*Complete description of injuries can be found on pages 15 and 16.

Table B-3. Hematology Parameters of River Otter from North Carolina.

| Animal No. | RBC ($10^6$/ml) | Hb (g/dl) | PCV (%) | Injuries* |
|---|---|---|---|---|
| M3 | 9.05 | 14.5 | 41.5 | Slight |
| M4 | 8.37 | 12.0 | 34.8 | Moderate |
| F5 | 8.70 | 13.2 | 38.8 | Moderate |
| M8 | 7.78 | 9.9 | 28.8 | Slight |
| F9 | 7.78 | 10.7 | 35.6 | Moderate |
| M10 | 8.87 | 12.8 | 36.8 | Slight |
| M11 | 8.81 | 14.4 | 43.3 | Slight |
| M12 | 8.36 | 13.0 | 39.3 | Moderate |
| M13 | 6.46 | 9.1 | 27.5 | Moderate |
| M14 | 9.35 | 14.9 | 44.0 | Moderate |
| F15 | 8.35 | 11.9 | 34.0 | Slight |
| M16 | 11.24 | 17.1 | 49.2 | Moderate |
| F6 (2/24) | 7.39 | 10.6 | 31.7 | Severe |
| (3/10) | 8.17 | 12.0 | 34.7 | |
| (3/21) | 8.70 | 13.1 | 38.6 | |
| M7 (3/10) | 3.94 | 5.3 | 16.4 | Severe |
| (3/12) | 5.34 | 8.1 | 22.6 | |
| (3/14) | 5.65 | 7.7 | 23.5 | |
| (3/18) | 5.92 | 8.2 | 26.0 | |
| (3/23) | 6.52 | 8.7 | 30.6 | |
| (4/8) | 6.26 | 8.1 | 25.6 | |
| (4/21) | 7.89 | 9.7 | 33.0 | |
| (4/ ) | 8.18 | 10.5 | 32.1 | |

RBC = Red blood cell, Hb = Hemoglobin, PCV = Packed cell volume.

*Complete description of injuries can be found on pages 15 and 16.

Table B-4. Serum Biochemistry Parameters for River Otters from North Carolina.

| Animal No. | Ca (mg/dl) | P (mg/dl) | AP (mg/dl) | ALT (μ/l) | AST (μ/l) | Injuries* |
|---|---|---|---|---|---|---|
| M3 | 8.7 | 5.0 | 90 | 329 | 53 | Slight |
| M4 | 8.3 | 6.1 | 70 | 211 | 53 | Moderate |
| F5 | 8.0 | 6.3 | 73 | 57 | 58 | Moderate |
| F6 | 8.0 | 7.5 | 89 | 84 | 82 | Severe |
| M8 | 8.2 | 7.1 | 96 | 112 | 49 | Slight |
| F9 | 8.7 | 6.9 | 59 | 46 | 31 | Moderate |
| M10 | 9.6 | 6.1 | 143 | 133 | 57 | Slight |
| M11 | 9.3 | 5.0 | 85 | 80 | 41 | Slight |
| M12 | 9.4 | 6.1 | 106 | 93 | 41 | Moderate |
| M13 | 7.7 | 6.5 | 104 | 114 | 68 | Moderate |
| M14 | 8.6 | 4.5 | 94 | 66 | 52 | Moderate |
| F15 | 8.6 | 5.2 | 226 | 88 | 80 | Slight |
| M16 | 8.2 | 4.6 | 110 | 65 | 39 | Moderate |
| M7 (3/10) | 6.5 | 9.2 | 99 | 64 | 55 | Severe |
| (3/12) | 8.5 | 7.6 | 145 | 96 | 82 | |
| (3/23) | 7.8 | 8.4 | 85 | 139 | 118 | |
| (4/8) | 9.1 | 6.2 | 111 | 139 | 112 | |

Ca = Calcium, P = Phosphorus, AP = Alkaline phosphatase, ALT = Alanine aminotransferase, AST = Aspartate aminotransferase.

*Complete description of injuries can be found on pages 15 and 16.

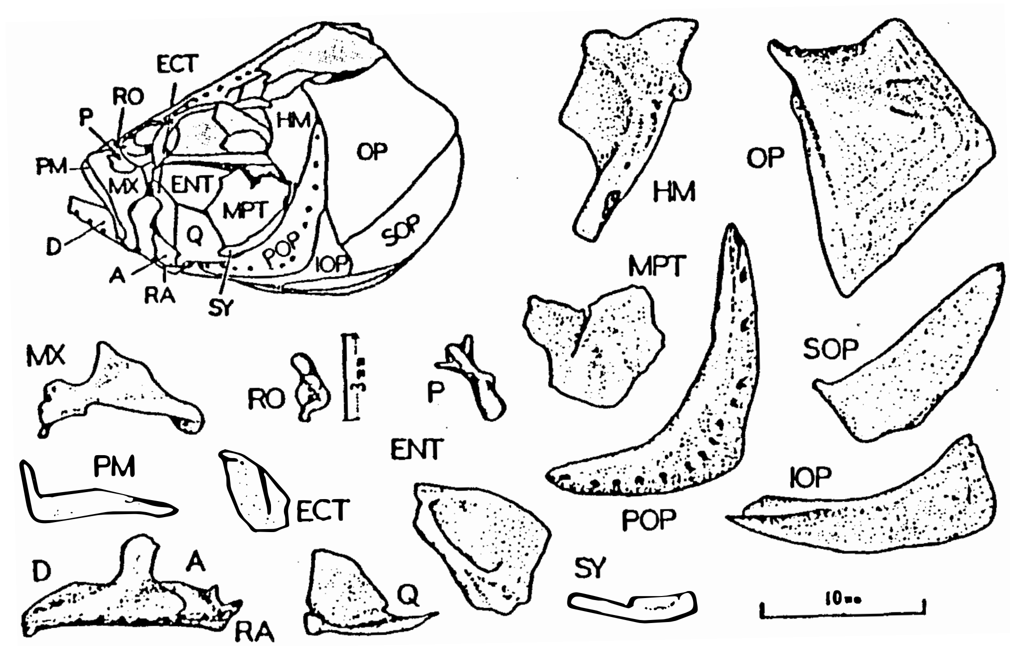
Table B-5. Serum Biochemistry Parameters for River Otters from North Carolina.

| Animal No. | Glucose (mg/l) | Creatinine (mg/l) | Urea N (mg/dl) | Total Protain (g/dl) | Albumin (g/dl) | Injuries* |
|---|---|---|---|---|---|---|
| M3 | 121 | 0.2 | 26 | 7.6 | 3.1 | Slight |
| M4 | 164 | 0.3 | 43 | 6.5 | 2.5 | Moderate |
| F5 | 105 | 0.2 | 17 | 5.8 | 2.6 | Moderate |
| F6 | 103 | 0.3 | 43 | 6.8 | 2.4 | Severe |
| M8 | 175 | 0.7 | 41 | 6.2 | 2.8 | Slight |
| F9 | 132 | 0.7 | 34 | 7.4 | 3.1 | Moderate |
| M10 | 113 | 0.8 | 35 | 7.2 | 3.4 | Slight |
| M11 | 112 | 0.5 | 24 | 6.9 | 3.0 | Slight |
| M12 | 106 | 0.6 | 30 | 7.8 | 3.1 | Moderate |
| M13 | 121 | 0.3 | 34 | 6.1 | 2.3 | Moderate |
| M14 | 136 | 0.4 | 26 | 6.6 | 2.8 | Moderate |
| F15 | 89 | 0.2 | 26 | 6.1 | 2.8 | Slight |
| M16 | 107 | 0.3 | 34 | 8.2 | 3.0 | Moderate |
| M7 (3/10) | 93 | 0.3 | 39 | 6.2 | 2.5 | Severe |
| (3/12) | 103 | 0.3 | 46 | 6.8 | 3.1 | |
| (3/23) | 79 | 0.3 | 26 | 7.4 | 2.7 | |
| (4/8) | 114 | 0.3 | 34 | 8.6 | 3.3 | |

*Complete description of injuries can be found on pages 15 and 16.

# APPENDIX C

# BONES USED IN FISH IDENTIFICATION




| | | | |
|---|---|---|---|
| MX | Maxillary | HM | Hyomandibular |
| PM | Premaxillary | MPT | Metapterygoid |
| D | Dentary | POP | Preopercle |
| A | Angular | SY | Symplectic |
| RA | Retroarticular | OP | Opercle |
| RO | Rostral | SOP | Subopercle |
| ECT | Ectopterygoid | IOP | Interopercle |
| Q | Quadrate | ENT | Endopterygoid |
| P | Autopalatine | | |

Figure C-1. Cranial bones often used to identify fish species

# APPENDIX D

# FOOD HABITS STUDY INFORMATION

Table D-1. Summary of River Otter Food Habit Studies Conducted Between 1942-1983, in North America.

| Year | Authority | Location | Type of Sample | Results |
|---|---|---|---|---|
| 1942 | Lagler & Ostenson | Michigan | Stomach intestine | 52.0% Fish, 4.7% Amph., 16.0% Crustaceans, 25% other verts., 0.8% insects. |
| 1954 1959 | Wilson | North Carolina | Scats digestive tracts | Primarily fish (carp, catfish, suckers and sunfish). Also blue crab shrimp, water beetles, clams and decapods. |
| 1955 | Ryder | Michigan | Stomachs | Fish, crayfish and amphibians. |
| 1955 | Greer | Montana | Scats | 98.2% fish, 41.2% invert., 18.4% amphibians, 6.1% mammals, 5.2% birds, 0.4% reptiles. |
| 1961 | Hamilton | New York | Stomachs | 70.0% fish, 34.7% crayfish, 25.8% amphibians, 13.5% insects. |
| 1963 | McDaniel | Florida | Stomachs | Rough fish-suckers, bowfin and catfish 54.3%, crayfish were found more often than game fish. |
| 1964 | Sheldon & Toll | Mass. | Scats | Fish remains occurred most freq. centrarchidae 54%, yellow perch, white sucker and Golden shiner. |
| 1968 | Knudsen & Hale | Michigan Minn. Wisc. | Digestive tracts scats | Fish (non-game), crayfish, frogs and aquatic insects were also important foods. |
| 1974 | Grenfell | Cal. | Scats | Crayfish were most important food item occurring 95% followed by water fowl fish ranked third. |
| 1974 | Toweill | Oregon | Stomachs | Fish in 80% of digestive tracts, followed by crustaceans, amphibians and birds (33%, 12%, 8%). |
| 1978 | Lauhachinda | Ala. | Digestive tracts | Fish-sunfish, suckers, and catfish in 83.2% of digestive tracts. |
| 1979 | Pierce | Virginia | Scats | Crayfish 82%, fish 62%, amphibians in April collection. |
| 1980 | Holcombe* | Louisiana | Digestive tracts | 83.3% fish, 19.8% crabs, 1.6% crayfish. |
| | | | | 81.1% fish, 2.7% crabs, 40.5% crayfish, 7.0% mammals. |
| 1980 | Modafferi & Yocum | Cal. | Scats | 70% fish, 51% crabs, 6% birds, 9% dragon flies, 12% ostracods, 4% snails. |
| 1982 | Loranger | Mass. | Stomachs | Fish were principal foods--brown bullheads, sunfish, white suckers. Bullfrogs, crayfish were infreq. |
| 1983 | Melquist & Hornocker | Idaho | Scats | Fish occurred 93-100% of all scats. Other foods were inverts. birds, mammals and reptiles. |

Table D-1. (Continued)

| Year | Authority | Location | Type of Sample | Results |
|---|---|---|---|---|
| 1982 | Chabreck et al.* | Louisiana | Digestive tracts | 83.3% fish, 19.8% crabs, 1.6% crayfish, 7.9% mammals, 2.4% birds, 1.6% shrimp, 1.6% mollusks. |
| | | | | 83.0% fish, 3.8% crabs, 34.0% crayfish, 7.5% mammals, 5.7% snakes, 3.8% mollusks. |
| 1984 | Stenson et al.* | British Columbia | Scats stomachs | 99.4% fish, 7.2% crustaceans, 4.2% birds. |
| | | | | 86.9% fish, 13% birds, 2.9% crustaceans. |

*Studies were conducted in fresh and salt or brakish water. First set of data is for salt/brakish, second set is for fresh water.

Table D-2. Summary of Food Items Identified from River Otter Scats Collected Between 9 April 1986 and 30 September 1986, Abrams Creek, Great Smoky Mountains National Park.

| No. | Date | Rainbow trout | Stone roller | River chub | Notropis Sp. | Blacknose Dace | White Sucker | Northern hoasucker | Golden red horse | Rock Bass | Etheostoma Sp. | Creek Chub | Frog (Ranidae) | Crayfish | Salamander | Ag. Insects | Turtle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4-09-86 | X | | | | | | | | | | X | | | | | |
| 2 | 4-13-86 | | | | | X | | | | | | | X | X | | | |
| 3 | 4-13-86 | | X | | | | X | | | | | | X | X | | | X |
| 4 | 4-13-86 | | X | | | | X | X | | | | | X | X | | | X |
| 5 | 4-15-86 | | | | | | X | | | | | | X | X | | | |
| 6 | 4-15-86 | | X | | | | X | | | | | | | X | | | |
| 7 | 4-21-86 | | X | | | | X | | | | | X | | X | | | X |
| 8 | 4-21-86 | | X | | | X | X | X | | | | X | | X | | | |
| 9 | 4-21-86 | | | | | | X | X | | | | | | X | | | X |
| 10 | 4-21-86 | | X | | | | X | | | | | X | | X | | | |
| 11 | 4-21-86 | | | | | | X | X | | | | X | X | X | | | X |
| 12 | 4-27-86 | | X | | | | | X | | | | X | X | X | | | |
| 13 | 4-27-86 | | X | | | | X | X | | | | X | X | X | | | X |
| 14 | 4-29-86 | | | | | | | | | | | | | X | | | |
| 15 | 4-30-86 | | | | | | | | | | | | | X | | | |
| 16 | 5-02-86 | | | | | | X | | | | | | | X | | | |
| 17 | 5-02-86 | | X | | | | X | | | | | | | X | | | |
| 18 | 5-05-86 | | X | | X | | X | X | | | | | | X | | | |
| 19 | 5-05-86 | | X | | | | X | X | | | | | | X | | | |
| 20 | 5-05-86 | | X | | | | X | X | | | | X | | X | | | |
| 21 | 5-09-86 | | X | | | X | X | X | | | | X | | X | | | |
| 22 | 5-18-86 | X | X | | | | | | | | | | | X | | | |
| 23 | 5-18-86 | | X | | | | | | | | | | | X | | | |
| 24 | 6-02-82 | | | | | | X | | | | | X | | X | | | |
| 25 | 6-02-86 | | | | | X | | | | | | | | X | | X | |
| 26 | 6-02-86 | X | X | | | | X | | | | | X | X | X | | | |
| 27 | 6-02-86 | | | | | | | | | | | X | | X | | | |
| 28 | 6-09-86 | | X | | | X | X | X | | | | X | | X | | | X |
| 29 | 6-27-86 | | | | | | | X | | | | | | X | | | |
| 30 | 6-27-86 | | | | | | | | | | | | | X | | | |
| 31 | 7-01-86 | | | | | | | | | | | | | X | | | |
| 32 | 7-04-86 | | X | | | | X | X | | | | | | X | | | |
| 33 | 7-07-86 | | X | | | | X | | | | | | | X | | | |
| 34 | 7-14-86 | | | | | | | | | | | X | | X | | | |
| 35 | 7-14-86 | X | | | | | X | X | | | | | | X | X | | |
| 36 | 7-22-86 | | | | | | X | | | | | | | X | X | X | |
| 37 | 8-28-86 | X | X | X | | | X | X | | | | | X | X | | | |
| 38 | 8/28/86 | X | X | | | X | | X | | | X | | | X | | | |
| 39 | 9-30-86 | | | | | | | X | | X | | | | X | | | |
| 40 | 9-30-86 | | | | | | | | X | | | | | | | | |
| 41 | 9-30-86 | | | | | | | | | | | | | X | | | |
| 42 | 9-30-86 | | | | | | | | | | | | | X | | | |

Table D-3. Fishes Collected During Stream Surveys on Five Sections of Abrams Creek During 1983, 1984 and 1985. Method of Sampling Was Backpack Electroschockers.

| Fish Species | 1983 Sect. 3 # | 1983 Sect. 3 Range mm | 1983 Sect. 4 # | 1983 Sect. 4 Range mm | 1984 Sect. 2 # | 1984 Sect. 2 Range mm | 1984 Sect. 5 # | 1984 Sect. 5 Range mm | 1985 Sect. 1 # | 1985 Sect. 1 Range mm | 1985 Sect. 3 # | 1985 Sect. 3 Range mm | 1985 Sect. 5 # | 1985 Sect. 5 Range mm | 1985 Sect. 4 # | 1985 Sect. 4 Range mm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainbow Trout | 445 | (78-280) | 640 | (70-291) | 15 | (160-328) | 53 | (670-710) | 4 | (227-307) | 160 | (82-331) | 156 | (57-340) | 669 | (55-330) |
| Brown Trout | 4 | (120-572) | 1 | (119) | | | 2 | (50-348) | | | 2 | (148-325) | 1 | (482) | 2 | (90-116) |
| River Chub | 642 | (40-266) | 174 | (58-225) | 85 | (40-220) | 54 | (54-176) | 82 | (46-221) | 628 | (29-202) | 1 | (117) | 97 | (42-194) |
| Warpaint Shiner | 99 | (36-116) | 6 | (50-105) | 135 | | | | 104 | (38-116) | 196 | (35-113) | | | 9 | (82-95) |
| Tennessee Shiner | 40 | (38-72) | | | | | | | 170 | (36-79) | 90 | (27-78) | | | | |
| Blacknose Dace | 77 | (53-109) | 423 | (43-134) | | | 143 | (30-82) | | | 69 | (41-103) | 323 | (30-95) | 324 | (32-95) |
| N. Hog Sucker | 41 | (59-259) | 127 | (47-333) | 37 | (50-310) | 16 | (112-225) | 67 | (53-324) | 61 | (51-352) | 29 | (87-259) | 78 | (68-342) |
| Stoneroller | 842 | (51-191) | 721 | (36-280) | 175 | (30-120) | 16 | (55-188) | 834 | (43-207) | 400 | (40-203) | 121 | (32-190) | 396 | (44-174) |
| White Sucker | 15 | (220-353) | 164 | (97-350) | | | 104 | (50-360) | | | 89 | (72-377) | 141 | (68-355) | 215 | (70-385) |
| Rock Bass | | | | | 28 | (155-289) | | | 48 | (70-235) | | | | | | |
| Small Mouth Bass | | | | | 13 | (52-242) | | | 14 | (57-270) | | | | | | |
| Black Redhorse | | | | | 4 | | | | 8 | (66-82) | | | | | | |
| Tenn. Snudnose Darter | | | | | | | 1 | | 52 | (36-65) | 51 | (38-76) | 22 | (46-68) | 8 | (52-70) |
| Rosyside Dace | | | | | | | 3 | | | | | | 6 | (47-55) | 3 | (47-67) |
| Fathead Minnow | | | | | | | 19 | (40-60) | | | | | | | | |
| River Redhorse | | | | | | | | | 2 | (70-78) | | | | | | |
| Telescope Shiner | | | | | | | | | 311 | (34-85) | | | | | | |
| Whitetail Shiner | | | | | | | | | 39 | (31-125) | 2 | (59-82) | | | | |
| Big Eye Chub | | | | | | | | | 35 | (51-88) | | | | | | |
| Redline Darter | | | | | | | | | 103 | (33-72) | | | | | | |
| Banded Darter | | | | | | | | | 9 | (45-60) | | | | | | |
| Gilt Darter | | | | | | | | | 4 | (55-58) | | | | | | |
| Greenfin Darter | | | | | | | | | 14 | (58-95) | | | | | | |
| Creek Chub | | | | | | | | | | | 1 | (36) | 60 | (21-172) | 8 | (41-98) |

# APPENDIX E

# RECOMMENDATIONS

# RECOMMENDATIONS

## Recommendations Directly Relating to This Study.

1.) Additional stocking of river otters should be considered for Abrams Creek drainage. Similar streams in Idaho support one otter for every 3.6 km of stream. Theoretically, Abrams Creek alone (without Panther Creek or Rabbit Creek) could support 10 otters. The release of additional animals at the initial release site would help to insure an adequate number of animals to sufficiently repopulate this drainage. Otters have dispersed along the Abrams Creek drainage making it evident that these animals are capable of dispersal. In fact, two otters dispersed far enough to possibly prevent them from being of benefit to the repopulation of otters in this area. Also, one male was accidentally killed, removing him from the reproductive stock.

2.) Monitoring of otters should continue even though radio transmitters have ceased to function. This can be accomplished by periodically walking stretches of the stream to search for otter sign such as scats, tracks and feeding sites. Additionally, reported sightings of the otters should be recorded by agencies involved in this project. The exact location, the animal's activity, and the date of the sighting should be recorded.

If additional animals are to be released in Great Smoky Mountains National Park, they should be equipped with radio transmitter implants. Further study of the river otters' ecology is needed in order to better manage this animal.

3.) A continuing information/education program can be a beneficial aspect of this reintroduction project. It is often important to have the public's support as well as the support of the agencies involved. All of the agencies involved can promote this project by taking every opportunity to discuss it with civic organizations; a project of this type should reflect well on the agencies and can be beneficial for support of future projects. Additionally, an on-going education program, aids in dispelling misconceptions that might arise concerning the otters (e.g. their primary food items ).

4.) Law enforcement is an important aspect of a project of this type. Continued enforcement will be necessary to insure that these animals are protected enough to be allowed to maintain their numbers and repopulate the area to carrying capacity. Efforts should be made to monitor the occupied areas as frequently as possible.

## General Recommendations for a River Otter Reintroduction

1.) When obtaining otters for reintroduction, the time of year for release must be considered. Otters often are trapped in late winter (January-March) and this is usually the time of year that females are likely to give birth. By trapping in late winter, it may be possible to catch a female that soon will give birth, or already has, thus possibly causing her to lose her pups.

Additionally, when otters are released in late winter, prey are at their lowest numbers. It is essential for reintroduced otters to forage effectively from the time they are released. The deaths of eight out of 10 otters in Arizona were attributed to prey biomass being at its lowest point when otters were released, causing the otters not to be able to forage effectively (Britt et al. 1984).

Ideally, restockings should occur in late summer or early fall. By this time of year, pups are weaned and able to forage on their own (Park 1971). Also, food availability is high and easily accessible (Pennak 1978). By releasing otters in late summer or fall, otters can explore their new environment and establish a range before winter when prey become less available.

2.) Trapping methods for obtaining otters should be specified prior to onset of trapping. Trap injuries can be a major problem . Live traps such as padded leg-hold traps and modified No. 11 Victor double long spring leg-hold traps are recommended (Shirley et al. 1983, R. Watson person. commun.) Some injuries still occur with both recommended traps; however, they are not as severe as injuries received from unmodified steel leg-hold traps.

Specifications should be made on the type of trap to be used as well as the condition of the animals. Financially, it is more expensive to accept injured animals because there is the possibility of losing that animal to infection and/or stress. Also, the medical costs involved in treating animals can outweigh any money saved by accepting an injured animal.

3.) Solid wooden box cages with small air holes should be used to transport river otters. Otters can damage their teeth by chewing on wire cages. Canines and incisors can become broken and damaged. When this happens, an otter can not effectively forage and catch prey and may starve. Additionally, by being in a dark box the animal is calmer and stress is reduced.

Care should be taken that all boxes have adequate air holes and be bedded with straw or shredded paper to absorb any urine or feces. The amount of time an animal is in a box should be limited as much as possible. Special attention should be paid to transport during extremes of weather (e.g. severe heat and cold).

4.) Captive otters should always be provided fresh water, fresh food and clean bedding. To prevent spoilage, food should never be left in the enclosure for more than six hours (four hours in hot weather). Antibiotics and vitamins should be administered daily by placement in food. Clean bedding is always important because otters must groom (roll and rub on vegetation) to maintain the oil coating in their fur. A loss of this oil waterproofing could mean hypothermia, pneumonia and death. An example of the necessity of grooming is found in post-mortem reports of 88 otters of various species which died in zoos in North America. Thirty-five percent had pneumonia, which was believed to be the result of poor coat condition, leading to increased susceptibility to infection (Duplaix-Hall 1975).

5.) Holding facilities for the otters should be carefully considered. As much room as possible should be allowed for the animals. Ideally, covered enclosures with concrete floors and wire or metal sides should be used because otters may chew or climb out. Otters can quickly chew thru wood. In each enclosure there should be a den box for each animal. This is important since the otter may feel "safe" in these boxes, plus it allows someone in the enclosure to clean without disturbing the animals. When it comes time to transport the animals they are confined to a small area and can be transferred into their boxes or transported in the den boxes if the boxes are equipped with doors that latch. It is important not to stress these animals any more than absolutely necessary since stress is a major contributing factor to death of captive river otters (Erickson 1984, Hoover et al. 1985).

Several otters should be kept together when possible. Besides the additional warmth generated from sharing the same den box (reduces hypothermia), these otters provide company and in this study, groomed each other, which may have reduced stress.

When otters are translocated over a considerable distance, or are held for some time such as by a trapper waiting to collect a number of otters before transport, otters should be held for a period of time prior to release. This helps ensure recovery from any stress they may have experienced during transport and handling. This also allows time for evaluation and observation of animals, and any necessary treatment of injuries.

River otters should be handled as little as possible, and when necessary should be handled by as few people as possible to reduce the chance of exposing the otters to diseases (Hoover et al. 1985).

6.) Release sites must be carefully considered. Abundant prey items should be available, as well as a diversity of food items. Water supplies must be available throughout the year, free of pollution, and not frozen throughout the winter. These areas also should be relatively free of human disturbances.

There are many areas where otters once occurred but no longer do. In many instances, otters could be returned to these areas. Habitats need to be evaluated, and marginal habitats improved. Habitats can be improved in many ways, such as improving water quality, manipulating vegetative cover or reintroducing other animals such as the beaver. Beavers tend to alter the environment and provide prey habitat, thus increasing prey biomass (Tumlison et al. 1984).

7.) Finally, a study on safe and effective trapping methods is needed. There are many otters being trapped for reintroduction purposes that are dying as a result of severe trap injuries. In 1983-84, the Tennessee Wildlife Resources Agency had nine consecutive otters die as a result of stress and trap injuries (B. Anderson, Person. commun.). Investigating this problem could be beneficial to a number of state and federal agencies.

VITA

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