The Effect of Human Activities on the Distribution and Abundance of the Jordan Lake - Falls Lake Bald Eagles

by

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(ABSTRACT)

I studied the effect of human activities on bald eagle (*Haliaeetus leucocephalus*) distribution and abundance at Jordan Lake and Falls Lake, North Carolina in 1986 and 1987. Eagles used most of the area available on Jordan Lake, but 63% of the use occurred in the northern 25% of the lake. Eagle use at Falls Lake was restricted to a few areas in the northern section of the lake. Jordan Lake had 7.2 times as many eagle observations as did Falls Lake. Data from radio-tagged eagles and timing of population fluctuations suggest that eagle populations at Jordan and Falls Lakes were principally migrating eagles from southern states. The peak in eagle numbers in May 1987 may have represented a migratory wave, whereas the decrease in June and July may have been the result of some eagles continuing northward. Eagles returning south from the Chesapeake Bay and other northern areas may account for the slight increase observed in August. Two eagle roosts were located and monitored throughout the study at Jordan Lake. Human activities at both lakes peaked during summer months. Boating was the predominant activity during summer. Sixty-three intentional disturbances by motor boats produced a mean eagle flush distance of 137.2 m. Only 8% of the eagles flushed when the approaching boat was > 250 m from shore. Loglinear analysis revealed that human use of the shoreline and eagle use of the shoreline were related. Shoreline segments (250 m) used by humans were used less frequently by eagles than would be expected under a model of complete independence. I saw more eagles and fewer humans on weekdays than on weekends during boat surveys of selected Jordan Lake sections, suggesting that human use in certain sections on weekends displaced eagles. The lake section north of the Farrington Bridge showed the largest difference between eagle numbers on weekdays versus weekends. I developed a regression model that predicted the threshold density of disturbance within this section to be 0.5 boats/km^2. On

most days during the summer, this threshold level of boating traffic is surpassed in lake sections south of the Farrington Bridge. Primary management objectives should be to reduce human activities within high eagle use areas, specifically the northern end of Jordan Lake, and to promote the bald eagle as a recreational benefit rather than a management problem.

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INTRODUCTION

Historical Overview

On June 20, 1782, the bald eagle (*Haliaeetus leucocephalus*) was adopted as our national emblem (Bent 1961). At that time, the bald eagle ranged throughout much of North America, its population limited only by the availability of suitable habitat. As our country's population grew and expanded, contact between humans and bald eagles increased. Over a period of time, this contact began to adversely effect the bald eagle. Researchers first reported a decline in bald eagle populations in the early 1900's (Maxon 1903, Cameron 1907, Sage et al. 1913, Roberts 1932, Howell 1937), and attributed this mainly to shooting and habitat destruction. Broley (1958) suggested later that the decline in reproductive success during the 1940's and 1950's may have resulted from pesticide induced sterility. Research to date has found DDE, a metabolite of the organochlorine pesticide DDT, to be an important cause of eagle reproductive failures (Hickey and Anderson 1968, Krantz et al. 1970, Wiemeyer et al. 1972, Wiemeyer et al. 1984). The Environmental Protection Agency's ban of DDT for crop use in 1972 (E.P.A. 1975) has lead to increased bald eagle reproduction rates in many areas in recent years and some populations have increased (Nash et al. 1980, Abbot 1981, Fraser 1981, Grier 1982).

Although this is encouraging, bald eagle populations were declining well before the introduction of DDT into the environment (Howell 1937). This pre-DDT decline was of great enough concern to pass the Bald Eagle Protection Act of 1940 (16 United States Code 668). This act protected the eagle from direct persecution, but it did not prohibit habitat destruction.

In 1978, the bald eagle was officially listed as "endangered" under the Endangered Species Act of 1973 and is currently listed as "endangered" in 43 states and as "threatened" in 5 states. This piece of legislation provides for the identification of critical habitat for the preservation and enhancement of endangered species.

Despite the Endangered Species Act, the Bald Eagle Protection Act, and the strong positive feeling of many people towards the bald eagle (Kellert and Berry 1980), direct persecution, habitat destruction, and other forms of human disturbance continue. Presently, indiscriminant shooting, trapping, electrocution, entanglement with fishing gear, collisions with powerlines, vehicles, and other manmade objects and poisoning by pesticides, ingested lead shot and other contaminants contribute directly to eagle mortality (Fraser 1983). Habitat losses resulting from forestry practices, housing, recreational, and industrial developments, including cutting of nest trees and destruction of perch and roost sites, may indirectly effect eagle mortality by lowering the amount of quality eagle habitat available for breeding, summering and wintering populations (Stalmaster 1976, Fraser 1983).

The Bald Eagle in North Carolina

History and Present Status

Early records indicate that throughout the late nineteenth century until the early 1940's, the bald eagle was distributed throughout the entire state of North Carolina, but was much more common along the coast where it was a frequent breeder in suitable habitat (Pearson et al. 1942). Like other eagle populations, the eagles of North Carolina were victims of DDT and its metabolites. Reproductive success and eagle numbers decreased and by 1974 there were no active eagle nests in the state. In 1984, the first confirmed successful eagle nest in 10 years was found. In 1986, an additional active nest was found and in 1988 there were 3 active bald eagle nests in North Carolina (Tom Henson, pers. comm.). All nests were located along the North Carolina coast. Efforts to increase bald eagle numbers in the state include a hacking project at Lake Mattamuskeet National Wildlife Refuge (Welton 1984).

In 1985, twenty bald eagles (8 adults, 12 immatures) were recorded in North Carolina during the National Wildife Federation's midwinter count. Only 3 immature eagles were observed during the 1986 count, but 23 (7 adults, 13 immatures, 3 unknowns) were seen during the 1987 count. The inconsistency of these counts can be attributed to variable survey effort. It appears that as the bald eagle population as a whole continues to increase, recolonization of suitable habitat within the state of North Carolina is taking place.

Bald Eagles at Jordan and Falls Lakes

During the summer of 1985, large numbers of bald eagles were observed on Jordan Lake and Falls Lake, North Carolina. Presence of this endangered species places clear responsibilities on the U.S. Army Corps of Engineers (COE), constructers of these lakes, under the U.S. Endangered Species Act. The Act states (section 7) that "All...federal agencies shall...utilize their authorities in furtherance of the purposes of this act, by carrying out programs for the conservation of endangered species..." and that "Each federal agency shall...insure that any action authorized, funded, or carried out by such agency...is not likely to jeopardize the continued existence of any endangered species...". The COE planned to complete constructing or upgrading 7 recreational facilities and a state maintenance center by March 1989 on Jordan Lake (U.S. Fish and Wildl. Serv. 1987). These developments were expected to increase boat traffic and other potential eagle disturbances on Jordan Lake.

Because these reservoirs and eagle populations are new, little detailed information exists about eagle or human use of these areas. Eagle responses to human activities may vary geographically (Stalmaster and Newman 1978, Fraser et. al. 1985) and it is difficult to predict the impact current or proposed recreational developments will have on the Jordan-Falls Lake bald eagles. Recreational boating has been reported to be very disturbing to eagles perched along the shoreline (Ingram 1965, Steenhof 1976, Stalmaster 1976, Wallin and Byrd 1984) and human presence at campgrounds has caused eagles to move to less disturbed areas (Steenhof 1976). Site specific knowledge of local eagle ecology and responses to human activities is essential in producing reliable information to be used in formulating an effective eagle management plan for these lakes.

The goal of this study was to provide the necessary information needed to produce an eagle management plan that will protect the bald eagle, while minimizing the loss of potential recreational benefits to the surrounding residents. We believe that if this problem is adequately resolved, the bald eagle's presence will increase the overall recreational value of the whole Jordan-Falls Lake project.

Specific objectives were to

1. determine seasonal bald eagle distrubution and abundance on the two areas, including location of roosts, feeding areas, and other use areas;
2. determine the number of bald eagles at each roost site;
3. quantitatively describe summer recreational use patterns of the reservoirs;
4. assess the impacts of human activities on the Jordan-Falls Lake eagles;
5. assess the potential impacts of proposed developments on the reservoirs;
6. develop management recommendations and guidelines for the eagle population on the reservoirs.

STUDY AREA

The study area consists of B. Everett Jordan Lake, Falls Lake and the surrounding lands. These areas are managed primarily by the U.S. Army Corps of Engineers (COE) and the North Carolina Department of Natural Resources. The lakes are adjacent to the Raleigh-Durham metropolitan areas in central North Carolina (Fig. 1). The study area is in the piedmont plateau physiographic province and the southeastern mixed forest ecoregion.

Both lakes are COE impoundments established for flood control, water supply, water quality control, recreation, and fish and wildlife conservation. Construction of Jordan Lake was begun in 1967 by the COE and was completed in 1973. Permanent impoundment was completed in October 1982. The project encompasses 18,927 ha of which 5,625 ha are permanently flooded. The remaining 13,302 ha are being managed for recreation and wildlife. At normal pool stage Jordan Lake is approximately 27.4 km long with 241 km of shoreline (Corps of Engineers 1983a). The Falls Lake project was begun in 1978 by the COE and the impoundment was completed in 1982. The project encompasses 15,378 ha of which 5,055 ha are permanently flooded. The remaining 10,324 ha will be preserved for recreation, wildlife, and environmental use around the reservoir. The lake is approximately 35.4 km long with 370 km of shoreline (Corps of Engineers 1983b).

Management plans for both lakes call for extensive recreational use and developments, such as boat launching areas, picnic and camping areas, and beaches (Stephen Brown, U.S. Army Corps of Engineers, Falls Lake, North Carolina, pers. comm.). Some of these developments currently are in use, others are in various stages of planning and construction.

METHODS

Monitoring Bald Eagles and People

Shoreline Surveys

We surveyed shorelines at Jordan Lake, Falls Lake, and portions of associated streams using Cessna 152, Cessna 172, and Piper Supercub fixed-wing aircraft. These surveys were conducted approximately 30 m above the water and 15-30 m from the shoreline trees, at air speeds between 110-150 km/hr (60-80 knots), consistent with safety and FAA regulations. Initially, the FAA was reluctant to issue us a low altitude permit, which delayed our survey work. We conducted low altitude surveys on weekdays only.

We flew aerial surveys from July 1986 through December 1987. We attempted to survey both lakes twice weekly during spring and summer, twice monthly during fall, and monthly during winter. Unavailability of pilots or aircraft and inclement weather (visibility < 5 km, ceiling < 305 m (1000 ft), wind > 50 km/hr) reduced the number of surveys we could conduct. When possible, canceled flights were rescheduled. Only complete lake surveys were analyzed.

When feasible, both lakes were surveyed on the same day. We alternated the order in which the lakes were surveyed to minimize temporal biases. We usually began surveys during early morning hours, but some afternoon surveys were flown for comparison with morning flights. Morning surveys were paired with the nearest afternoon surveys (within 10 days) and a signed rank test was used to determine if eagle or people numbers differed between survey times. Morning surveys started prior to 1100 EST (range 0658-1055) and afternoon flights started at or after 1100 (range 1100-1610). The time required to survey each lake was approximately 2 hours.

During surveys, we plotted the locations of all humans and eagles observed at Jordan Lake on 1:1320 aerial photographs. We plotted eagle and people locations at Falls Lake on recreational contour maps of the lake. The aerial photos and maps were overlayed with clear acetate and observations were plotted with fine-tipped marking pens. On completion of each flight, we transferred the data from the acetate overlay to topographic maps to determine UTM coordinates for each observation.

In addition to the location of each eagle, we recorded on the aerial photograph an estimate of the bird's age (adult, subadult, immature, or juvenile) using plumage characteristics/age relationships described by Southern (1964) and Clark (1983) and behavior (perched or flying). We noted on the photographs the number, location, and activities of people observed. Boats were recorded as one observation, regardless of the number of people on board. When there were too many people or boats to accurately plot from the aircraft, we counted their numbers and estimated their locations in specific areas of the study lakes. We divided both lakes into sections according to physiographic features, such as creeks and bridges, to allow analyses of activities in areas of moderate size and geographic coherence (Fig. 2 and 3).

During aerial surveys, we searched shorelines for eagle nests and monitored frequencies of birds radio-tagged in connection with bald eagle studies on the Chesapeake Bay and in central Florida.

Roost Counts

We counted eagles at roosts (Fig. 4) approximately weekly during spring and summer and biweekly or monthly during fall and winter. Eagles were counted as they entered the roosts. Observers were stationed in permanent blinds or vehicles during the counts. Vandals in the Mason Point Roost repeatedly destroyed our blinds, making counts from vehicles more practical there. We conducted the counts in the evening from approximately 2 hours before dark until light conditions prevented further observation. We recorded the age class of the bird, the time of arrival at the roost and the location of individual roost trees for each bird, when possible.

During eagle counts at Mason Point, we recorded human activities taking place near the roost and any responses by the eagles. We used a highway traffic counter to monitor the amount of vehicle traffic on the dirt road that passes through the Mason Point Roost at Jordan Lake (state route 1728). We checked and reset the counter each time we counted eagles at the Mason Point Roost and at other times when we were in the area. The counter tallied the number of axles that crossed it. The road was a dead end and all vehicles that entered the roost must have departed on the same road. Thus, the total reading on the counter was divided by 4 to determine the number of vehicles using the road. The number was then divided by the number of days since the last tally to calculate the mean number of vehicles per day. Counting periods were of uneven length because vandals frequently deactivated the counting device.

Weekday/Weekend Boat Surveys

Because recreational lake use was much higher on weekends, we compared eagle shoreline use on weekends with use on weekdays to determine if people were affecting eagle distribution or abundance. We surveyed four sections of Jordan Lake (Fig. 5) twice weekly from 30 August-19 October, 1986 and from 1 May-2 September, 1987. These lake sections were selected because we often saw eagles there during aerial surveys. We did not conduct surveys on Falls Lake because of the low number of eagles using the area.

Each week, we surveyed the sections once on a weekday and once on a weekend, pairing days by similar weather patterns. Surveys were conducted with motor boats by 1-2 observers traveling 50-200 m from the shoreline, depending on water depth. We used binoculars and spotting scopes to scan for people and eagles. We plotted the positions of eagles and humans on topographic maps. We also recorded the recreational use type (boating, fishing, etc.), time of observation, eagle age class, eagle behavior, and eagle reaction to the survey boat or other potential disturbances. Surveys started at approximately 1100 EST and ended at approximately 1600 EST. We used signed rank tests (Conover 1971) to determine if people and eagle numbers were similar on weekdays and weekends within the 4 lake sections.

The north of Farrington Bridge lake section was further divided into 2 subsections (Fig. 2), the predominantly shallow water area north of the tip of Mason Point (8.1 km^2 with 28 km of shoreline),and the deeper water area south of Mason Point to the Farrington Bridge (4.1 km^2 with 8.25 km of shoreline). Human observations were placed in one of two recreational use classes: boats or people on shore. We tested for similar numbers of these two uses on weekdays and weekends within the 2 subsections. We compared densities of eagles, boats, and people on shore between the northern and southern sections using signed rank tests to determine if these densities were similar on weekdays and weekends.

Experimental Eagle Disturbances

We approached eagles from boats and on foot and measured distances between the observer and the flushing eagle. We collected these data during weekly boat surveys from 6 June 1987 to 8 August 1987. Each week the entire shoreline was surveyed using two power boats. Surveys began at approximately 0730 EST and ended at approximately 1700 EST. The start-

-ing point was alternated between the Farrington boat launch and the Ebeneezer boat launch to prevent temporal data biases. Survey boats traveled in opposite directions around the lake and the survey was completed when the 2 boats met approximately 9.5 hours later. Surveys were conducted approximately 200 m from shore and eagles were located by scanning the shoreline trees with binoculars. When a bird was located, the boat was positioned perpendicular to it and, when possible, approximately 400 m from shore. In narrow parts of the lake, it was impossible to start our approach from 400 m. In these cases, we attempted to position ourselves as far away from the eagle as possible (at least 200 m). We then approached the bird at approximately 4 km/hr until it flushed. When the flush occurred, a numbered buoy was anchored to mark the boat's position. We then marked the perch tree with a color coded sign and the location was recorded on a topographic map. The time of the flush and age class of the eagle also were recorded. We noted the direction that the eagle flushed and where it landed to prevent flushing the same bird repeatedly. The following day, we returned to the area and measured the distance from the buoy to the perch tree using a 200 m braided nylon rope marked in 1 m increments. We tied the rope to the marked tree, and using the boat, the line was spooled out until the buoy was reached. The distance was read off the rope and recorded.

Walking approaches were conducted similar to Fraser et al.'s (1985) protocol. Only eagles that had an unobstructed view of the approaching observer for approximately 400 m were subjected to this type of disturbance. We stood in the open for five minutes, then walked towards the eagle stopping for 1 minute every 10 m. When the eagle flushed, we marked our location with a stake. The perch tree was marked with a color coded sign and its location was recorded on a topographic map. We measured the distance using the same technique as employed for the boat disturbances.

On three occasions, we tested the reactions of roosting eagles to gunshots near the Mason Point Roost. One observer was hidden in an elevated blind to record when eagles flushed and 2-3 people shot firearms at varying distances from roosting eagles. We began shooting at approximately 1200 m from the roost (near the Mason Farm House) at sunset. We moved closer to the roost at 200 m intervals along state route 1728 and spaced each volley of shots at 5 minute intervals. At each 200 m interval, 6 12-gauge shotgun shots and 10 .22-caliber rifle shots were fired. The last series of shots was fired 200 m from the roost. Shooters remained hidden from roosting eagles throughout each test.

In addition to recording flushing eagles, the observer in the blind counted the number of eagles present at the end of the experiment. We counted eagles in the roost on the evenings before and after each experiment.

Human Use in Relation to Eagle Use

To examine the relationship between eagle distribution and human distribution, we divided each lake shoreline into 250 m segments and used aerial survey data to characterize each segment as to its use by eagles and people. We developed a computer program to calculate euclidean distances between eagle and human observations and each shoreline segment. We cross-classified 961 shoreline segments on Jordan Lake and 1124 segments on Falls Lake by lake section, season, eagle presence or absence within 50 m of a segment during any aerial survey, and human presence or absence within 200 m of a segment on any aerial survey. We fit a log-linear model (Fienberg 1985) to the Jordan Lake data using forward and backward model selection procedures. There were too few segments used by eagles on Falls lake to properly conduct these analyses.

RESULTS

Eagle Distribution and Abundance

Annual Cycle

Jordan Lake

We observed 778 eagles during 58 aerial surveys of Jordan Lake in 1986-87 (range 1-31 eagles per flight, Table 1). Monthly means ranged from 2.0 to 25.0 eagles per survey (Table 2). The Jordan Lake eagle population peaked in May 1987 with lows in January and February 1987 (Fig. 6). We found no significant difference in eagle numbers during morning and afternoon flights (Table 3).

We observed immature birds throughout the year with a high during summer and a gradual decrease through fall and winter. Adult birds were observed infrequently during winter and early spring and increased abruptly from 0.0 adults per flight in March 1987 to 5.7 in April and to 11.0 in May 1987 (Table 4, Fig. 6). The numbers of adults remained relatively constant during the summer and then dropped 84% between August and September 1987 (Table 4).

One to three radio-tagged immature eagles were monitored during aerial surveys from 22 May 1987 to 29 September 1987 (Table 5). All locations of radioed birds were north of Farrington Bridge.

Falls Lake

We observed 108 eagles during 43 low altitude surveys of Falls lake (range 0-8 eagles per flight, Table 1). Monthly means ranged from 0.0 to 6.7 eagles/survey with a peak in August 1986 and 1987 and lows in January, February, March and May of 1987 (Table 2). Most of the eagles observed on Falls Lake (63%) were adults. The pattern of adult arrival and departure was similar to that observed on Jordan Lake (Table 6, Fig. 7). Eagle numbers were similar during morning and afternoon flights (Table 3).

Distribution

Jordan Lake

Although eagles used all sections of Jordan Lake, aerial surveys showed that much use was concentrated in relatively small sections of the lake. Of 778 eagle observations on Jordan Lake, 63.3% were north of the Farrington bridge, 16.2% were between the Farrington Bridge and the US 64 Bridge, 13.1% were in the US 64 Bridge to New Hope River section, and 7.4% were in the New Hope and Haw River sections. (Fig. 8). When controlled for lake section sizes, the area north of Farrington bridge received much more eagle use per km^2 than did the other sections, which all received approximately the same amount of use (Fig. 9). We also calculated eagles per km of shoreline and found similar results (Fig. 10).

Falls Lake

Of 108 eagle observations on Falls lake, 31.5% were in the lake section north of Cheek Road Bridge, 60.2% were between Cheek Road Bridge and Highway 50 Bridge, 7.4% were between Highway 50 Bridge and NC 98 Bridge, and 0.9% were between NC 98 Bridge and the Falls Dam (Fig. 11). Eagle density was highest north of Cheek Road Bridge and between Cheek Road Bridge and Highway 50 Bridge and was lowest in the other two lake sections (Fig. 12 and 13). Eagles on Falls lake concentrated use in the northern part of the lake in relatively small areas.

Roost Use

Jordan Lake

Eagle use of roosts was greatest during summer and declined in winter. Overall, more eagles used the Mason Point roost than the Morgan Creek roost. However, the drop in use during the winter was less dramatic at Morgan Creek than at Mason Point where use was near zero from November to March 1987 (Table 7, Figs. 14 and 15).

We occasionally saw eagles using the Mason Point roost during the day; however eagles began entering roosts at an accelerated rate approximately one hour prior to local sunset (Fig. 16). Eagles were difficult to see 30 minutes after sunset and all of the eagles we observed at the Mason Point roost entered prior to 45 minutes after sunset.

Falls Lake

During August 1986, we observed four eagles roosting near the Rolling View Recreation Area (Fig 17). We observed this area several other times in October and November, but saw no eagles. In 1987, we were unable to locate a consistently used roost area at Falls Lake. However, during 1987 early morning aerial flights, we consistently observed eagles perched along the shoreline northwest of the Rolling View Recreation Area.

Falls Lake Nest Site

We found a nest during the 30 July 1986 aerial survey of Falls Lake. During December 1986 we climbed into the nest and examined it. The large size of the nest, its shape, branches used for construction, prey remains in the nest, and its location in areas used by eagles (Fig. 17) indicated that it probably was constructed by eagles. It had been recently refurbished with green plant materials and we observed eagles perched near and in the nest. We found a pair of great-horned owls (*Bubo virginianus*) using the nest in early February 1987. It is not unusual for great-horned owls to use eagle nests (Broley 1947, Fraser 1981).

Human Distribution and Abundance

Dynamics

Jordan Lake

Human activity on Jordan Lake was greatest during summer months and peaked in July 1987 (Fig. 18, Table 8). We observed 1425 incidences of human activity on 58 low altitude aerial surveys in 1986-87 (range 1-71 per flight, Table 9). Human activity declined after August, but the 1987 surveys showed a marked increase in November. We saw significantly more humans during afternoon than during morning aerial surveys (Table 10).

Falls Lake

Human activity on Falls Lake also was greatest during summer months with high numbers in May 1987 and August 1987 (Fig. 19, Table 8). We observed 1216 incidences of human activity on 43 low altitude aerial surveys ranged from 0 to 146 per flight (Table 9). People numbers remained high during the summer and decreased throughout the fall and winter with a low in February. An exception was November 1987. We observed an increase in human activity similar to that seen at Jordan Lake. We saw significantly more humans on afternoon flights than on morning flights (Table 10).

Distribution

Jordan Lake

Of 1425 observations of humans on Jordan Lake, 10.2% were North of Farrington Bridge, 38.4% were between the Farrington Bridge and the US 64 Bridge, 31.8% were in the US 64 Bridge to New Hope River section, and 19.6% were in the New Hope and Haw River sections (Fig. 20). When controlled for lake section sizes, the section North of Farrington bridge received the lowest use and the Farrington Bridge to US 64 Bridge section received highest use (Fig. 21). During summer and early fall, most human activity was related to boating, while during winter most activity was related to shore use (Fig. 18, Table 11).

Falls Lake

Of 1216 human observations on Falls lake, 11.4% were in the lake section north of Cheek Road Bridge, 27.6% were between Cheek Road Bridge and Highway 50 Bridge, 27.5% were between Highway 50 Bridge and NC 98 Bridge, and 33.5% were between NC 98 Bridge and the Falls Dam (Fig. 22). Human density was lowest north of Cheek Road Bridge and similar among other lake sections (Fig. 23). Boating was the predominant human activity throughout the year at Falls Lake (Fig. 19, Table 12).

Roost Use at Jordan Lake

Vehicle traffic in the Mason Point roost area was relatively high throughout the year (range 1.0 - 7.3 vehicles/day), but peaked during August and September (Table 13). We observed no apparent effect of vehicle traffic on the number or behavior of eagles in the roost. We observed humans within 500 m of roost trees during 64.3% of 56 eagle counts the Mason Point roost. Most people at the Mason Point roost remained close to their vehicles and appeared to cause no disturbance to roosting eagles. However, on 3 occasions we observed pedestrians walk away from their vehicles and directly approach roosting eagles, causing them to flush and leave the roost area. In contrast, we saw humans near the Morgan Creek roost on only 12.2% of 41 counts.

Weekday/Weekend Comparisons

We saw more eagles and fewer humans on weekdays than on weekends during boat surveys (Table 14). The lake section north of the Farrington Bridge showed the largest differences between eagle numbers on weekends versus weekdays. Low eagle numbers may have been responsible for the lack of significance in other lake sections (Table 14).

Because of the importance to eagles of the part of Jordan Lake north of the Farrington Bridge, we closely scrutinized the effect of human presence on eagle distribution and abundance in that area. Only data from 1987 were used for these analyses. Data collected in 1986 did not contain enough information to place people and eagles in the north or south subsection. We first examined the data for a linear relationship between people numbers and eagle numbers. Considering all boat surveys, eagle numbers were not correlated with people numbers ($r = 0.11$, $P = 0.49$). However, considering weekdays and weekends separately, eagle numbers were positively correlated with people numbers ($r = 0.66$, $P = 0.005$, weekdays; $r = 0.63$, $P = 0.009$ weekends). This apparently resulted from the fact that on boat surveys both people and eagle numbers peaked in May and declined throughout the summer. To control for the effect of date, we regressed eagle numbers on date, and plotted residuals against people numbers. The regression of eagle number on date was significant for both weekdays and weekends ($P = 0.0069$, $R^2 = 0.42$ weekdays; $P = 0.0035$, $R^2 = 0.47$ weekends). Resi-

-dual plots showed that , when controlling for date, there was no tendency, within weekdays or weekends, to have fewer eagles with increasing people numbers (Fig. 24 and 25). Moreover, given the regression of eagle numbers on date, the partial regression of eagle numbers on people was not significant ($P = 0.255$ weekdays, $P > 0.5$ weekends).

Similar analyses considering separately the lake section north of the tip of Mason Point with the section between Mason Point and the Farrington Bridge (Fig. 2) and people in boats and on shore, produced no indication that a linear effect or a threshold effect occurred within the range of densities found in the data sets.

During weekdays, eagles and humans per km of shoreline were similar in the two areas. However, on the weekends, human densities between Farrington Bridge and Mason Point were 1.7 times greater than the densities North of Mason Point (4.98 vs. 2.90, $P = 0.003$, Table 15). Correspondingly, eagle numbers and densities did not differ significantly weekday to weekend in the northern section, but were significantly depressed in the southern section on the weekends (Tables 15 and 16).

Weekend densities of people on the shoreline were not significantly different between the north and south sections, (0.49 vs. 0.85 people/km, respectively, $P = 0.339$, Table 15) but boat densities differed significantly between the two areas, (1.2 vs. 3.28 boats/km^2, respectively, $P < 0.001$), we assume therefore that the observed differences between weekdays and weekends are attributable largely to boating activity. The range of boat densities in the north and south subsections on weekdays and weekends were substantially different (Fig. 26), however the range of people on shore densities were similar (Fig. 27). The frequency of boat densities in the north on weekends exceeds 1.2 boats/km^2 on 44% of the surveys (Fig. 26), while the frequency of boat densities in the south section on weekends equals or exceeds 1.2 boats/km^2 on 100% of the surveys (Fig. 26). This suggests therefore, that because the eagle densities in the northern section declined slightly on the weekends and eagle densities in the southern section declined significantly on the weekends (Table 16), the threshold of disturbance density was close to the mean boat density (1.2 boats/km^2) found in the northern section on the weekends.

The weekend boat density obtained during the weekday-weekend surveys overestimated the number of boats on that part of the lake at any instant in time because boat surveys lasted for approximately 4 hours, allowing for boats to come and go during the count. To correct for this bias, we fit a regression of plane survey results on boat survey results. The regression

$$\text{density from plane} = 0.23 + 0.25 \text{ density from boat}$$

($F = 7.787$, $df = 12$, $P = 0.0176$, $R^2 = 0.41$) predicted a threshold density of disturbance of 0.5 boats/km^2 ($SE = 0.065$).

Experimental Eagle Disturbances

Visual Disturbances

Sixty-three intentional disturbances by motorized boat flushed eagles at 0 - 395 m with a mean flush distance of 137.2 m (Table 17). Only 8% of the eagles flushed when the approaching boat was > 250 m from shore (Fig. 28). Flush distances were similar among eagle age classes (Table 17). Eagles flushed at greater distances when approached by walking observers than when approached by motor boats (Table 18). We were unable to test for differences among eagle age classes for this approach due to our low number of pedestrian disturbances.

Stepwise multiple linear regression indicated that flush distance, eagle age, and time of day were not linearly related. Scatter-plots of each explanatory variable on flush distance ruled out the possibilities of strong nonlinear relationships. The only variable that was significant was survey date ($P = 0.007$, $R^2 = 0.11$). As the summer progressed, eagle flush distances tended to increase.

Auditory Disturbance

People were frequently present near the Mason Point roost, so we limited our shooting experiments to three evenings for public relations reasons. Eagles flushed when shots were fired at 600 m, 600 m, and 400 m ($\bar{x} = 533.3$ m) for the three shooting trials respectively. Fewer eagles remained in the roost on the evenings of shooting disturbances than on evenings before and after disturbances (paired t-tests, $P = 0.045$ and 0.013 respectively; Fig. 29). Although shooting decreased eagle numbers on the day of the shootings, the effect was short term. Numbers of eagles seen on evenings before and after shooting disturbances were similar (paired t-test, $P = 0.51$). Some eagles ($\bar{x} = 1.3$) remained in roosts even after shooting as close as 200 m.

Spatial Separation of Eagles and Humans

Eagle and Human Densities

Eagle densities were highest in the upper sections of both lakes (Figs. 9 and 12). These upper sections, north of Farrington Bridge at Jordan Lake and north of Highway 50 at Falls Lake, had the lowest human densities (Figs. 21 and 23). Human densities on the NC98-Dam and NC50-NC98 sections at Falls Lake were greater (185% and 154% respectively) than the highest density sections (Farrington Bridge to US 64 Bridge and the New Hope and Haw

Rivers) at Jordan Lake. Eagle densities in these two high human density sections at Jordan Lake were approximately 90% greater than the eagle densities observed on the two Falls Lake high human density sections.

Coincident Shore Use by Humans and Eagles

Our tests of eagle tolerance to approaching boats and pedestrians allowed us to analyze our aerial eagle and human counts at a scale that approximated human-eagle interaction distances. To do so, we fit a loglinear model to the Jordan Lake frequencies of eagle and humans use of shoreline segments (Table 19). We tested for interactions between eagle and human use of shoreline segments, segment location (north of Farrington Bridge (NFARR), Farrington Bridge to US 64 Bridge (FARR), US 64 Bridge to New Hope River (MAIN), and New Hope and Haw Rivers (HAW)) and the time of year (spring, summer, fall, winter).

We rejected a model testing for independence between eagle presence or absence and the three way interaction between the explanatory variables (G^2 = 695.8, df = 31, $P < 0.0001$). The backward and forward model selection procedures chose the same best model. The overall magnitude of the standardized deviates was small indicating that the model fit the data well (Table 19). The final model indicated that eagle use and human use of shoreline segments interacted, but did so independently of other interactions. There was a three-way interaction between eagle use, lake section, and season. The proportion of segments used by eagles on different lake sections changed seasonally, but did so independently of human use (Fig. 30). Similarly, the proportion of segments used by humans on different lake sections changed seasonally, but independently of eagle use (Fig. 31).

The largest positive deviate from the final model occurred for segments with eagle and human use in the lake section north of the Farrington Bridge during the fall. This indicates that eagles and humans used the same lake segments more during the fall in that lake section. The largest negative deviate from the final model occurred for segments with eagle and humans

-use north of Farrington Bridge during spring. This indicates that eagle use of shoreline segments in this section during spring, is lower than for any other section during any season.

DISCUSSION AND CONCLUSIONS

Eagle Distribution and Abundance

Eagles used most of the area available on Jordan Lake, but used a relatively small portion of Falls Lake. Most use occurred in several small and relatively well defined areas. Sixty-three percent of the eagles observed on Jordan Lake were observed north of the Farrington Bridge. Other areas on Jordan Lake that received consistent use were the upper reaches of Big Beaver Creek, Little Beaver Creek, White Oak Creek, and the Haw River. Eagles may be attracted to these shallow water areas because shallow water concentrates fish. This would potentially increase foraging success. Nintey-two percent of the eagles observed on Falls Lake were north of the NC50 Bridge. Consistent eagle use was observed in the upper reaches of Big Lick Creek, Little Lick Creek, Ledge Creek, and the Ellerbe Creek area. These also were predominantly shallow water areas and may have increased fish availability.

Data on the origin and movements of three radio-tagged bald eagles that used Jordan Lake during 1987 (Table 5) provide additional evidence of Jordan Lake's importance to the Eastern bald eagle population. These lakes serve as a summer residence for a number of eagles, but also appear to serve as a stopping or staging point for eagles migrating north from southern

-states such as Florida. Our data suggest that eagle populations at Jordan Lake and Falls Lake were principally migrating bald eagles from southern states. The peak in eagle numbers during May 1987 may have represented a migratory wave, while the decrease in June and July may have resulted from some eagles (such as 165.021 and 165.899) continuing north. Broley's (1947) work on Florida bald eagles indicated a regular northward movement beginning in April. His band return data from 664 tagged nestlings indicated a coastwise migration from Florida through Georgia, the Carolinas, and Virginia. Adult birds from Florida may have left their nesting areas after their young have fledged in March or early April, or after nest failure, and arrived in North Carolina in late April or May. The abrupt departure of adult eagles in early fall (Tables 4, 7, Figs. 6, 14) may have resulted from these birds moving south to re-establish nesting territories. Nesting begins in October in Florida (Howell, 1937). The slight increase in eagle numbers observed in August (Fig. 6) may be birds seeking areas with more abundant food supplies. Food shortages may occur in certain areas in Florida where hot surface waters cause fish to move to inaccessible locations during summer months. The Florida birds may then move to areas with better food supplies (Bent 1961). Broley's (1947) band recovery data indicated that some immature Florida bald eagles spent late summer and early fall in the north and later returned south in November or December. The increase and subsequent decline of bald eagles at Jordan Lake and Falls Lake, correspond temporally with a similar cycle on the Chesapeake Bay caused by arrival and departure of southern migrants (Chase et al. 1984).

Human Distribution and Abundance

Human activity on Jordan Lake and Falls Lake was greatest during summer months and declined through the fall and winter. However, we observed an increase in use in November 1987. We attributed this increase to duck and other hunting activities that occur at this time of the year. The northern portions of both lakes are used by waterfowl as they migrate south and several COE wildlife subimpoundments have been constructed in these areas to encourage waterfowl and hunter use of the lakes.

As expected, use was much higher on weekends than on weekdays in the summer. All boating and shore activities increased on the weekends. As a proportion of total activity, shore and boat fishing decreased on the weekends while other boating related activities increased. Aerial surveys showed more human activity in the afternoon than in the morning on weekday flights. Fishing activity was greater in the morning whereas boating activities, such as water skiing, were greater in the afternoon. We believe that similar results would be obtained for weekend aerial surveys.

Human activity also may vary according to lake section characteristics. Deep water open areas are favored for water skiing, sailing and power boating. Fisherman prefer more secluded areas often in small coves and inlets and use the stands of flooded timber maintained on both lakes. Pedestrian use of the shoreline appears to be related to shore accessibility. Most shore fishing is located near highways and highway bridges that provide easy access to the lake (state route 751 at Jordan Lake and the Cheek Rd. Bridge at Falls Lake). Other closed roads and trails provide pedestrian access to the shoreline where picnicking, camping, birdwatching, and hiking are common activities.

Eagle and Human Use of Roosts at Jordan Lake

More eagles used the Mason Point roost than the Morgan Creek roost; however the drop in use during the winter was less dramatic at Morgan Creek. The Morgan Creek roost is located in a depression and is closer to water than the Mason Point roost. These conditions may provide more favorable microclimatic conditions for eagles roosting during the winter.

In combination, our aerial survey and roost monitoring results suggest that most eagles spent the majority of the daylight hours near foraging areas, spent the night in roosts, and returned to foraging areas in early morning. These results are similar to results from eagle telemetry studies and roost monitoring on the Chesapeake Bay (Buehler, Mersmann, Fraser, and Chase, unpublished data).

Eagle numbers seen on Jordan Lake aerial surveys increased slightly from 1986 to 1987 (Fig. 6), but eagle numbers decreased in the Mason Point roost over the same period (Fig. 10). The increased use of the Morgan Creek roost in 1987 (Fig. 9) was not large enough to explain the decreased eagle use at Mason Point. This suggests that Jordan Lake eagles were using alternative roosting sites that we did not locate.

The Mason Point roost was subject to substantial human disturbance. Many people were observed at the Mason Point roost during 1986-87 roost counts. Most of these people were birdwatchers and photographers who came to the Mason Point roost specifically to view bald eagles. Although vehicle traffic is apparently less disturbing to eagles than pedestrian traffic (Stalmaster 1976, Nye 1977), Nye (1977) reported that birdwatching (specifically attempting to observe resident eagles) constituted the major form (70%) of human disturbances observed on his study area in southeastern New York. We observed only three incidents of pedestrians flushing roosting eagles. However, roost counts only were conducted weekly during spring and summer and biweekly or monthly during fall and winter, therefore the eagles at the Mason Point roost may be subjected to more disturbance than we actually documented.

The Morgan Creek roost was subjected to much less human disturbance than the Mason Point roost. This difference may be due to the easy access to the Mason Point roost afforded by state route 1728. The Morgan Creek roost had no roads nearby and was only accessed by humans on foot and in boats.

Effects of Humans on Bald Eagle Distribution and Abundance

Weekday/Weekend Comparisons

Our weekday/weekend surveys were paired within lake sections. This paired design controlled for factors such as habitat quality, season, weather conditions, and water depths, which could have confounded the other comparisons. The drop in eagle use on weekends suggests that humans displaced eagles from some lake sections. Similarly, Stalmaster and Newman (1978) reported that boating and pedestrians displaced eagles to areas of lower human activity on a large river system.

Although regression analyses failed to show a relationship between eagle numbers or densities with people numbers or densities, survey date appears to be an important factor. As the summer season progressed, observations of both eagles and people decreased. This may be due to the increasing temperatures over the course of the summer. Eagles may be seeking shade and therefore less visible. People absence may also be a shade seeking phenomenon or may be related to water temperature. As water temperature increases, fish become less active and fishing pressure drops. Approximately 30% of the people observations north of the Farrington Bridge were fishing, hence a reduction in fishing activity may account for the decrease in people observed. Further analyses of two areas north of Farrington Bridge (the area north of the tip of Mason Point and the area between Mason Point and the Farrington bridge), revealed eagles per km of shoreline to be similar on weekdays in the two areas (Table 15). This suggests that the habitat in these two areas is homogeneous with respect to its suitability for eagles. Human densities on weekends in the area between Mason Point and the Farrington Bridge were 170% greater than human densities in the area north of Mason Point. Moreover, eagle numbers and densities were similar in the area north of Mason Point on weekdays and weekends, but differed in the area between Mason Point and the Farrington Bridge. These results suggest that human use of the northern section, even on weekends, was infrequent enough to be relatively nondisturbing to eagles. On the other hand, use patterns in the southern section evidently caused a shift in eagle distribution.

The density of boats that affects eagle distribution and abundance is of fundamental importance. Our regression equation predicted a threshold density of 0.5 boats/km^2. The area of the section south of Mason Point = 4.1 km^2. We therefore estimate that more than 2 boats in this area are likely to negatively affect eagle distribution. Approximately the same number of boats were observed in the upper section as the lower section, suggesting that an overall limit of 4 boats for the region north of the Farrington Bridge would adequately protect eagles from excessive human disturbance. During this study, even without regulation, boat numbers north of the Bridge never exceeded this number during weekday flights. However, if water was higher, it is possible that more boaters would have used the north end of the lake.

Our prediction of a threshold density of disturbance also provided us with a basis for evaluating the effect of boat traffic on eagle distribution and abundance south of the Farrington Bridge. On the Farrington Bridge to US 64 Bridge section, the US 64 Bridge to New Hope River section, and the New Hope and Haw River sections of Jordan Lake, weekday aerial surveys during May - August 1987 disclosed boat traffic exceeding the threshold density on 60%, 35% and 40% of 20 flights, respectively. On the 9 afternoon flights during weekdays in this period, threshold densities were exceeded on 78%, 67%, and 67% of flights. Considering the higher human densities common on summer weekends, it is apparent that, on most days during the summer, the threshold level of boating traffic is surpassed on all three areas south of the Farrington Bridge. This lends support to our conclusion that intensive human use on the southern portions of Jordan Lake has resulted in decreased use of those areas by bald eagles.

Experimental Eagle Disturbances

Visual Disturbances

We conducted 63 intentional disturbances of perched eagles with motor boats and obtained a mean flush distance of 137.2 m. Wallin and Byrd (1984) reported a mean flush distance of 154 m in response to summer motor boat traffic on the Potomac River. Knight and Knight (1984) reported a mean flush distance of 152 m for a wintering eagle population in response to canoe traffic on Washington's Skagit and Nooksack rivers. As in our study, Knight and Knight (1984) and Wallin and Byrd (1984) reported no differences in flush distances among age classes. Stalmaster and Newman (1978) and Fraser et al. (1985) reported eagle responses to human activities to vary geographically, but the boat-induced flush distances of these three studies are similar. Although this is a small sample of eagle populations, the results suggest that the eagle population as a whole responds to certain forms of human disturbance in a similar manner.

Our flush distance for a pedestrian approach (220 m) was greater than the 131 m reported by Stalmaster and Newman (1978) for wintering eagles on Washington's Noonsack River. However, our mean walking flush distance was less than the 393 m reported by Wallin and Byrd (1984) for summering eagles on the Potomac River, and the 476 m reported by Fraser et al. (1985) for breeding eagles on the Chippewa National Forest. Stalmaster and Newman (1978) found significant differences in flush distances among eagle age classes, however they approached eagles directly with no initial pause or pauses during the approach. We conducted our approaches similar to Fraser (1981) and Wallin and Byrd (1984) where 30-60 second pauses were taken every 10-20 m to insure that the perched eagle was aware of the approaching pedestrian. An uninterrupted approach may underestimate the true disturbance distance if the eagle is not immediately aware of the approaching person.

Stepwise multiple linear regression indicated that eagle flush distances tended to increase as the summer progressed. This suggests that eagles did not habituate to human activity during the summer season. Fraser et al. (1985) found that breeding eagles flushed at increasing distances with repeated disturbance, and Knight and Knight (1984) and Stalmaster and Newman (1978) reported that wintering eagles habituated to human activity as winter progressed. Our data suggest that this summer eagle population responded differently to human activity than did wintering eagle populations of the West. Our limited data from radio-tagged eagles suggests that there is some turnover in the Jordan Lake eagle population that could, in part, account for the lack of habituation.

Auditory Disturbances

We obtained a mean flush distance of 533 m for three experimental shooting disturbances conducted at the Mason Point roost. This mean is greater than the maximum flush distances we obtained for boat and pedestrian approaches (395 m and 265 m). This may indicate that this auditory disturbance was more disruptive to eagles than direct visual disturbance by boats or humans. Alternatively, eagles may have been more sensitive to disturbances in the evening. Some individuals were extremely tolerant of the gunshots and remained in the roost when shots were fired as close as 200 m. Other researchers have reported that eagles were not significantly disturbed by normally occurring auditory activities such as vehicular traffic, human vocalization, or logging practices, but were flushed by gunshots (Stalmaster 1976, Stalmaster and Newman 1978).

Spatial Separation of Eagles and Humans

Eagle and Human Densities

The upper sections of both lakes (north of Farrington Bridge at Jordan Lake and north of Highway 50 at Falls Lake) had the highest eagle densities and the lowest human densities. This spatial separation may suggest that eagles avoided areas with high human use. Another possible explanation is that quality eagle foraging areas were marginal for human recreation.

Low human use of the upper portions of both lakes may have resulted from low water levels in these areas (especially during the summer months). Shallow water made access to these lake sections difficult and may have created undesirable conditions for some types of recreation (mainly boating-related activities). These shallow areas may be attractive to eagles because shallow water concentrates fish. This phenomenon and the possible effect of higher fish productivity in nutrient-rich upper reaches of the lakes would potentially increase eagle foraging success. Other lake sections were deeper, received more human use and less eagle use. Thus, eagle habitat preference and human preference for deeper water may confound the apparent relationships between eagle and human densities.

Coincident Shore Use by Humans and Eagles

The loglinear model of eagle and human use of Jordan Lake shoreline segments provides additional information on eagle-human interactions. The final model indicated that human use was influencing eagle use of shoreline segments. The significant interaction between eagle use and human use and the signs of standardized deviates indicated that regardless of lake section and season, segments used by humans were used less frequently by eagles than would be expected under a model of complete independence. These results are consistent with the hypothesis that eagles avoided humans on Jordan Lake. Stalmaster (1976) reported that eagles were displaced from regions of high human activity to regions with low human activity. Similarly, Steenhof (1976) found that eagles increased use of a campground section closed to human use and decreased use of the section remaining open to the public. Eagles also used different lake sections during different seasons, but did so independently of human use. During fall in the north of Farrington Bridge section, eagles and humans used the same lake segments more than would be expected under a model of complete independence. Hunters may be attracted to this area to duck hunt. Eagles may be drawn to this area by crippled waterfowl and may be less sensitive to disturbance near foraging areas or where prey is abundant (Steenhof 1978). During spring in the same section, eagle use was less than expected under a model of complete independence. Eagles may be more sensitive to human presence during this season; however other factors such as food availability and water depths were not addressed in the model, but also may have been important determinants of eagle distributions.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

General Framework

Jordan Lake and Falls Lake clearly provide important habitat for migrating and summering bald eagles. In addition, the nest we found on Falls Lake and the presence of eagles throughout the year suggests that these lakes may be capable of supporting a population of resident breeding eagles.

In addition to legislated responsibility, the Corps of Engineers and cooperating agencies have an exciting opportunity and management challenge. Eagle populations as dense as the summer population at Jordan Lake, in close proximity to urban centers and high density recreation areas, are rare. Careful management of this resource will not only allow the Corps and its cooperators to meet their responsibilities under the law, it will allow them to use bald eagles to enhance recreation at Jordan Lake and Falls Lake, to enhance the life quality of area residents, and to provide existence benefits (Giles 1978) to other people who may never see the Jordan Lake/Falls Lake eagles. These ends will be achieved efficiently only if specific goals are defined clearly and pursued. Although we recognize that eagle management goals and objectives must be coordinated with other land management goals and objectives on the Projects, we offer the following suggestions as a starting place in the development of a comprehensive bald eagle management scheme for the two lakes.

Recommended Goals and Objectives

1. ***GOAL 1: To maintain use by breeding, wintering, summering and migrating bald eagles indefinitely.***

   This goal is consistent with the mandate of the Endangered Species Act, with the favorable attitude of the public toward the bald eagle (Kellert and Berry 1980), and with the additional goal stated below. Some specific objectives that flow naturally from this goal are:

   a. Maintain an eagle population such that annual peak numbers of eagles seen on low altitude aerial surveys are not less than 25 for Jordan Lake and not less than 7 for Falls Lake (or establish a similar objective for boat survey results).

   b. Establish and maintain a winter eagle population of not less than 4 eagles on Jordan Lake and not less than 2 eagles on Falls Lake.

   c. Maintain indefinitely the current distribution pattern of eagles on Jordan Lake. That is, all parts of the Lake should continue to receive use by eagles.

      The target here should be to continue some use of all parts of the lake in all seasons. Although we believe the north section of Jordan Lake should receive priority in eagle management because of its obvious importance to the birds, we must remember that more than 1/3 of our eagle observations were in areas south of the Farrington Bridge. Maintaining eagles in all parts of the lake, therefore, will provide substantial benefits for the eagles. Additionally, maintaining eagle use of the Lake in areas of high recreational use will assist in achieving goal 2, below.

d. Maintain indefinitely the current distribution pattern of eagles on Falls Lake, or increase the amount of lakeshore used.

Only a relatively small part of Falls Lake is used by eagles at present. Eagle conservation and human benefits from eagles will be enhanced if distribution and numbers of eagles can be increased.

e. Maintain on each lake at least 2 suitable communal roosting sites.

These roost sites should be substantially free of human disturbances. By "substantially free of human disturbance" we mean that people should not be within 500 m of roost trees. Roosts created to meet this objective should be at least 100 m from roads, lakeshore, railroad rights of way, and COE land boundaries. They should be at least 500 meters from areas frequented by people when there is a clear line of sight into the roost.

f. Protect and maintain existing and additional communal roost sites that are discovered.

g. Maintain at least two suitable nest sites on each lake that are substantially free of human disturbance within 500 m.

h. Protect and maintain additional nest sites that are discovered.

i. Encourage birdwatchers and photographers to observe eagles only from designated observation points. This minimizes disturbance to 7agles and maximizes viewing opportunity.

j. Throughout both Lakes, maintain forested stretches on shorelines, preferably 100 m or wider, as buffer zones.

k. Maintain boat densities in specified eagle management zones at less than 0.5 boats/km^2

l. Conduct at least one aerial search for eagle nests annually before leaf-out.

m. Monitor use and success of all nests annually. This can be accomplished by checking nests from aircraft three times at the peak of laying and 3 times near the expected fledging dates (Fraser et al. 1983, 1984).

n. Insure that all project management personnel are briefed and comply with eagle management goals, objectives, and practices.

o. Monitor the success of objectives via vegetation surveys and eagle and people surveys.

p. By 1995, evaluate the important characteristics of the prey base with respect to accomplishing goal number 1, and develop a specific set of objectives aimed at ensuring an adequate prey base.

The current eagle population is good evidence that current prey base is adequate for existing eagle use. However, fish populations in reservoirs usually peak and then fall and stabilize within 5-10 years of the beginning of basin filling (Kimmel and Groeger 1986). Additionally, anthropogenic factors may also have a large impact on reservoir aging (Kimmel and Groeger 1986). Long term maintenance of the eagle populations at Jordan Lake and Falls Lake will require a better understanding of the prey species used by eagles in these areas, likely changes in populations and/or distribution of these species, and management techniques to prevent undesirable changes in prey availability.

2. ***GOAL 2: To maximize human benefits from the eagles at Jordan Lake and Falls Lake in a manner consistent with goal 1.***

Goal number 2 is consistent with human recreational objectives for the Projects, and with the concept that wildlife management should provide diverse benefits for people (Giles 1978). Moreover, this goal is consistent with the idea that effective endangered species management depends on public perceptions of species, their problems and management efforts (Kellert 1985). Long term success of the eagle conservation effort at Jordan Lake and Falls Lake will depend upon public understanding of and support for the effort. Maximizing human benefits provided by bald eagles (including educational benefits), will facilitate the pursuit of goal 1.

Specific objectives under this goal should include:

a. Maintain a distribution and abundance of eagles such that each lake user would, on any day in August, have a 10% chance of observing an eagle.

b. Maintain a distribution and abundance of eagles such that people wanting to see eagles, would have a 95% probability of seeing an eagle without interfering with goal 1.

In general, the objectives of providing visitor viewing opportunities are closely linked to the objective under goal 1 of maintaining present distributional patterns. If eagles are crowded off of the southern portions of Jordan Lake, viewing opportunities will be substantially diminished. Unfortunately, the precise relationship between eagle densities and viewer opportunities is unknown. Additionally, viewing opportunity is related to a veiwers knowledge of the species in question. It is likely that many visitors to the Projects see bald eagles but don't know it, because they can't identify them. In general, the problem of finding ways to enhance the benefits visitors get from bald eagles is one that would be a fruitful area of research. Until such research is completed, it seems reasonable to assume that visitor benefits will be directly related to eagle density and distribution, and the information they have about eagles.

c. To insure that each person visiting the projects has access to basic information about eagle biology and conservation. This can be accomplished by the usual visitor interpretation methods including brochures, nature hikes, campfire talks, and displays in visitor centers, campsites, and entrance areas.

The North Farrington Management Zone

Management of all sections of Jordan Lake and Falls Lake should consider potential impacts on eagles and other wildlife; however, some areas have greater potential as eagle management zones. The most important of these zones includes all the waters and land north of the Farrington Bridge, on Jordan Lake. Sixty-three percent of the eagles observed on Jordan Lake were observed in this area and the two known communal roosts were located here. Although our study did not address other species, our impression is that this area is also of particular value to egrets, herons, and cormorants.

We recommend that the principal management goal in this zone be to protect and enhance wildlife populations, including eagle populations. Human densities should be kept low and recreational activities in the zone should be wildlife-dependent. Wildlife dependent such activities as activities include wildlife viewing and photography, interpretive walks, fishing and hunting. High density activities and those that do not require wildlife should be discouraged.

This would include waterskiing, sailing, ORV use, and nonwildlife dependent boating. Shoreline use by people should be minimized. Based on our estimated threshold of disturbance, no more than 4 boats should be allowed in the zone at any time. During 1986 and 1987 low altitude aerial surveys, we never saw more than 4 boats in this area. Thus, if water levels and other factors affecting human distribution do not change in future years, little policing of this policy may be required on weekdays. On weekends accomplishing this objective may require stationing a person at Farrington Bridge to regulate ingress and egress to the area. This kind of management has a number of precedents in National Parks and other management areas.

Use of the shoreline in the zone should be restricted to the small area near near Northeast Creek that currently receives substantial use. Access to other areas should be restricted from April through October by ensuring that all roads and other access ways to the shoreline are closed.

The Mason point area is the key habitat parcel in the proposed Farrington Management Zone. It contains the only two known communal roosts in the area, and many eagle observations during this study occurred there. Moreover, under current management, the Point receives very little human use (Fig. 21), and is a primary foraging area for eagles on Jordan Lake. In short, it appears that the lack of human use of Mason Point is a primary reason for the numbers of eagles inhabiting Jordan Lake.

The importance of Mason Point to bald eagles on Jordan Lake, and the eagles demonstrated sensitivity to human presence in the area, convincingly calls for management actions that minimize human presence on the point. We recommend that the current pattern of low use be preserved by keeping access roads closed and undeveloped, and by refraining from any development in the area. It appears to us that even limited development on Mason Point would encourage unplanned use, including shore use by boaters, that could reduce the number of eagles using the area, and adversely affect time budgets of eagles that remain.

Because of abundant wildlife in the North Farrington Area, this would be an excellent place to engage in wildlife interpretive practices. However, any development in this area should be carried out in a manner that will not adversely affect eagles by direct disturbance or by increasing human traffic in areas commonly frequented by eagles. One such area is the area between Northeast Creek and Indian Creek. The area is infrequently used by eagles because of lack of perch trees and frequent use by anglers brought to the area by state route 751. If an interpretive center were to be constructed in this area, a boat launching facility should not be included, as such a facility would likely increase the boat traffic in the management zone.

Other Lake Zones

Several other smaller zones were used frequently by eagles on Jordan and Falls Lakes; eagles would benefit from providing quality perching, nesting, and roosting habitat and from minimizing human disturbances in these areas. Zones that should be considered in this category are the upper reaches of: Big Beaver Creek, Little Beaver Creek, White Oak Creek, and the Haw River on Jordan Lake and the upper reaches of Big Lick Creek, Little Lick Creek, Ellerbe Creek, and Ledge Creek on Falls Lake. Some of these areas were used frequently by humans during the study and, in the absence of specific plans to discourage increased human use, could become unsuitable for eagles in the future. Thus, strategies to direct human use elsewhere are needed. Unnecessary access roads should be closed and future developments should be planned in areas infrequently used by eagles.

The stretch of shoreline southwest of the Rollingview Recreational Area is a particularly vulnerable area. This shore received the highest concentration of eagle use on Falls Lake and the opening of the Recreation Area may increase human use. This situation should be monitored closely once the Recreation Area is open to the public. If human use of the area increases (as it likely will) and there is a coincident drop in eagle use, then measures to either reduce human use or mitigate for the loss of the area as an eagle foraging site should be considered.

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FIGURES

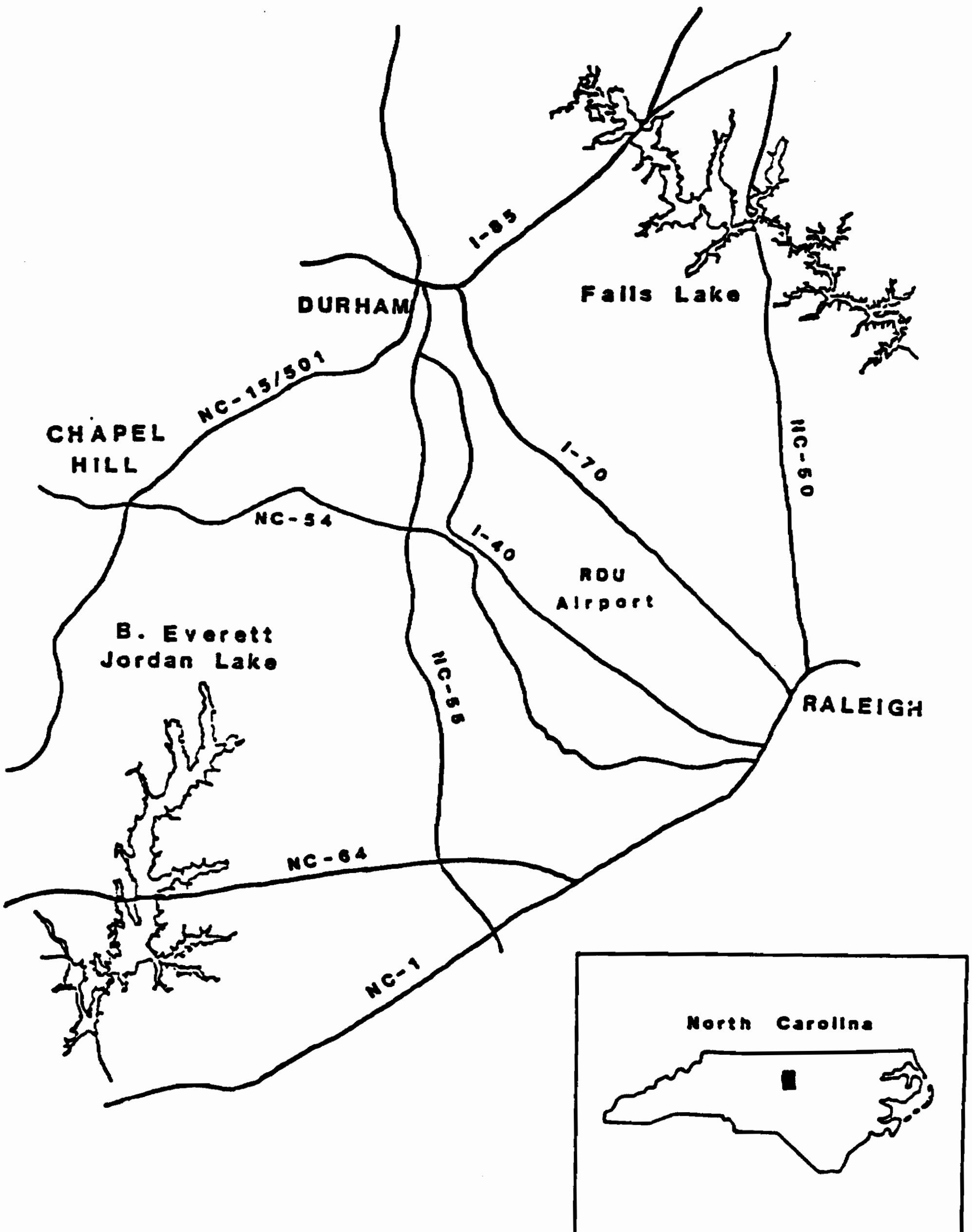

Figure 1. Locations of B. Everett Jordan Lake and Falls Lake, North Carolina.

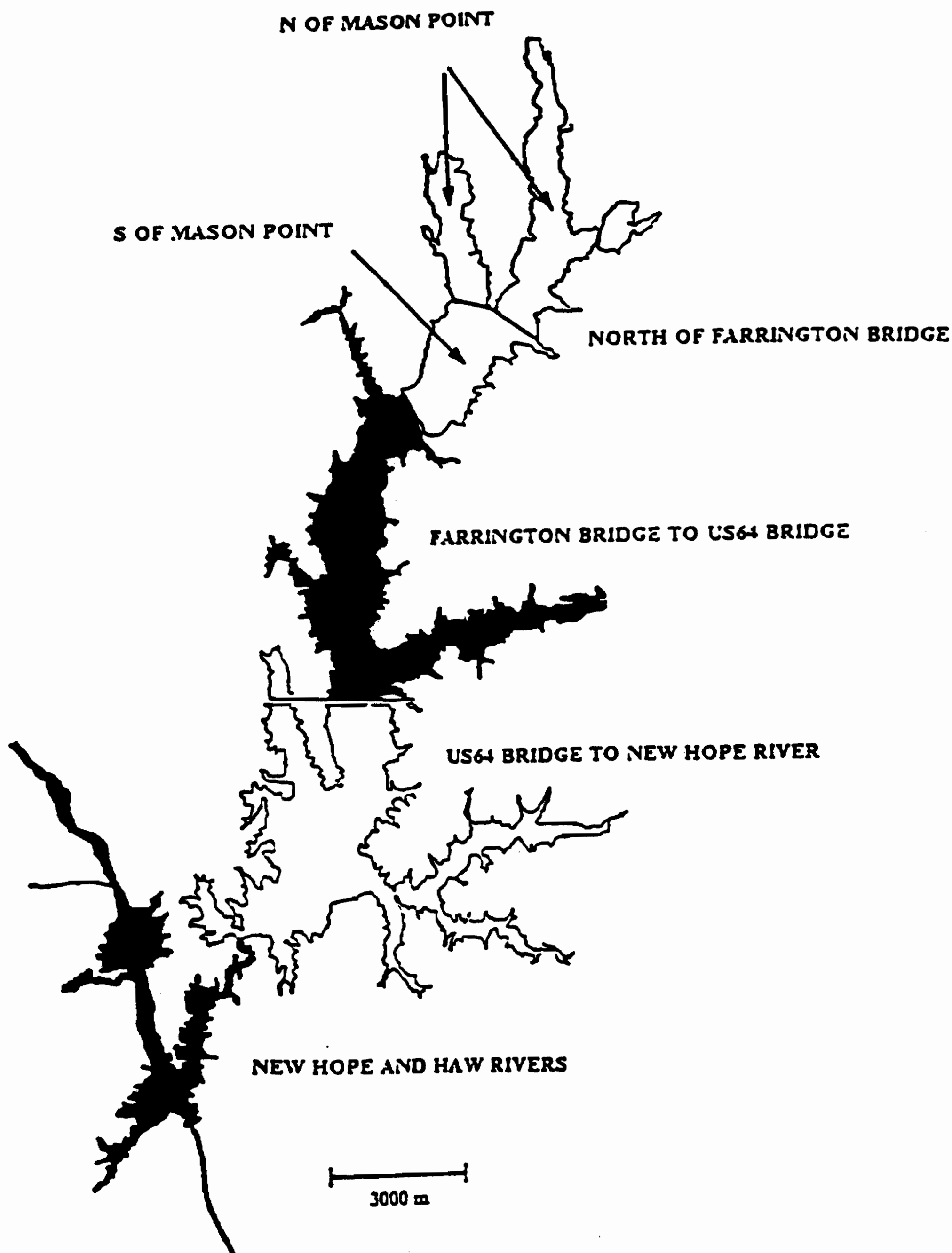

Figure 2. Lake sections, B. Everett Jordan Lake, North Carolina.

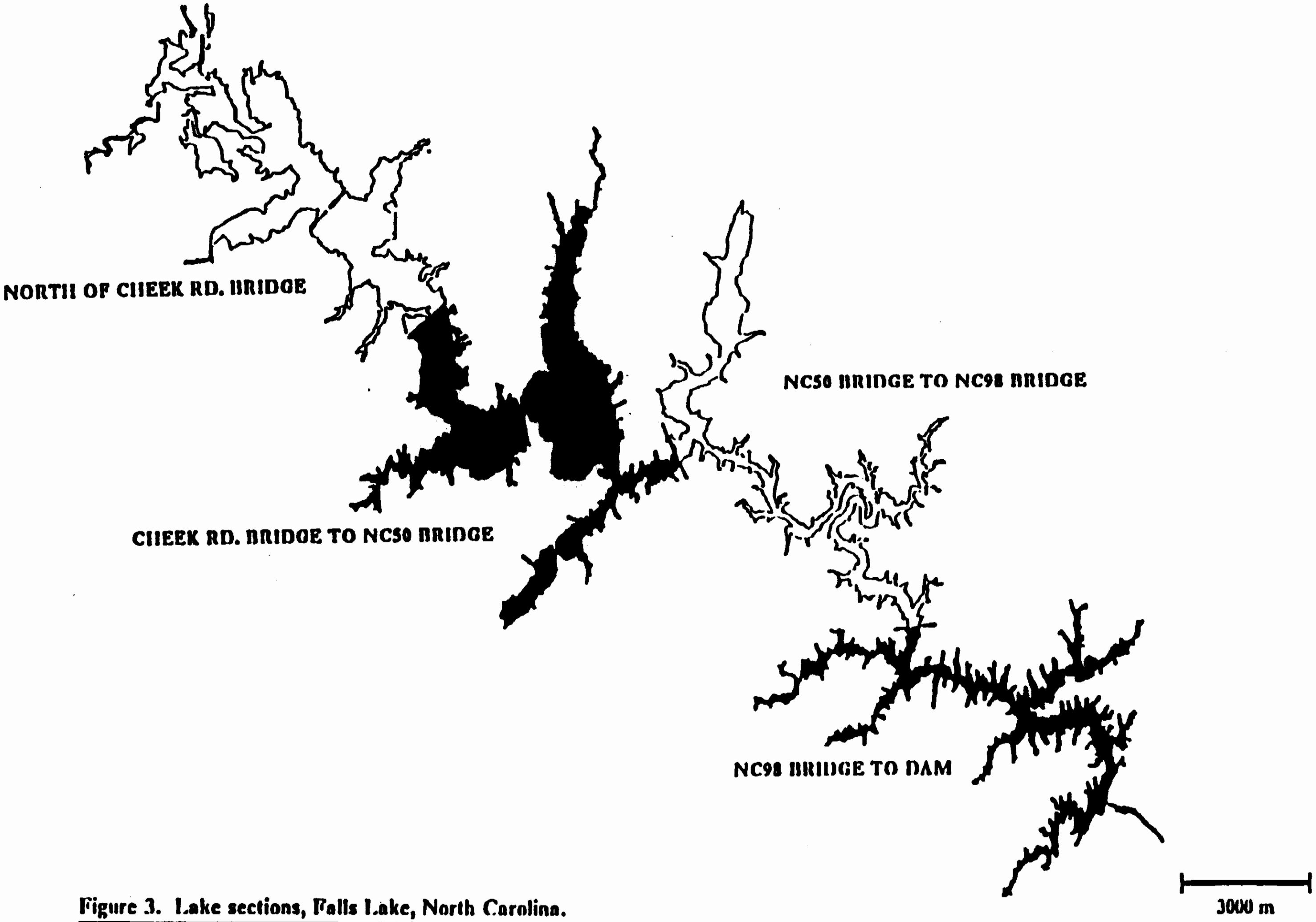

Figure 3. Lake sections, Falls Lake, North Carolina.

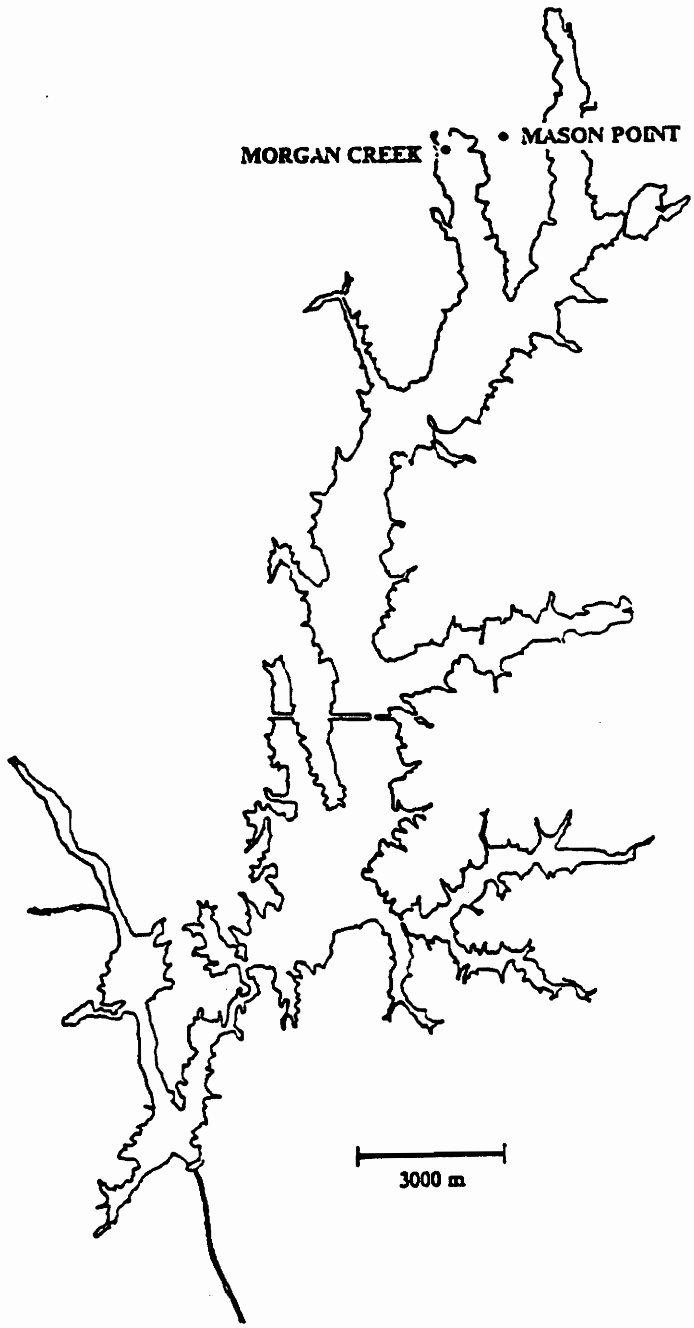

Figure 4. Locations of the Morgan Creek and Mason Point bald eagle roosts, B. Everett Jordan Lake, North Carolina.

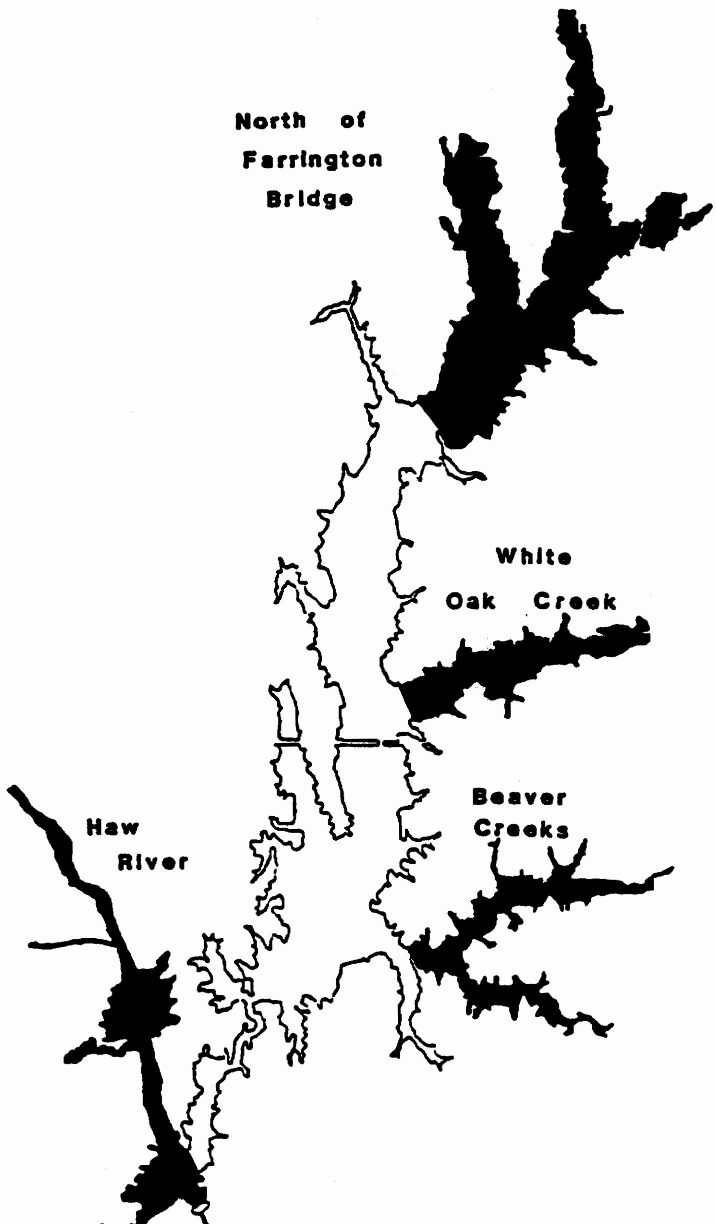

Figure 5. Weekday/weekend survey sections, B. Everett Jordan Lake, North Carolina.

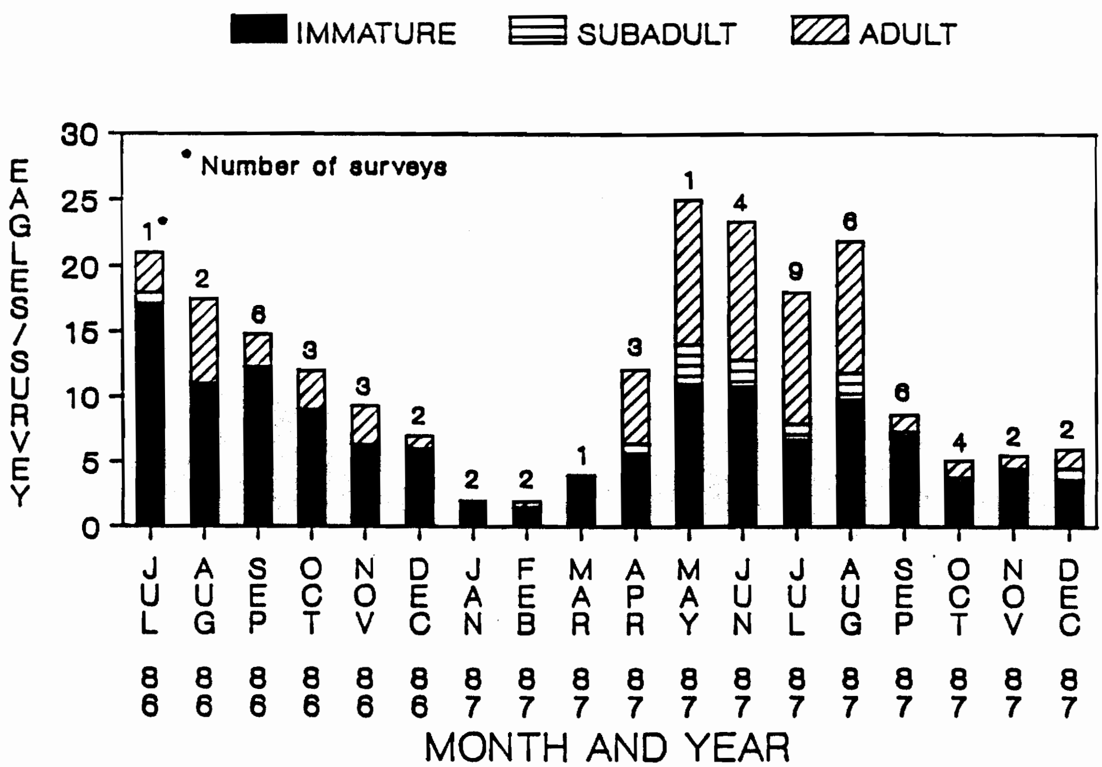

Figure 6. Monthly means for low altitude aerial counts of bald eagles, B. Everett Jordan Lake, North Carolina, 1986-87.

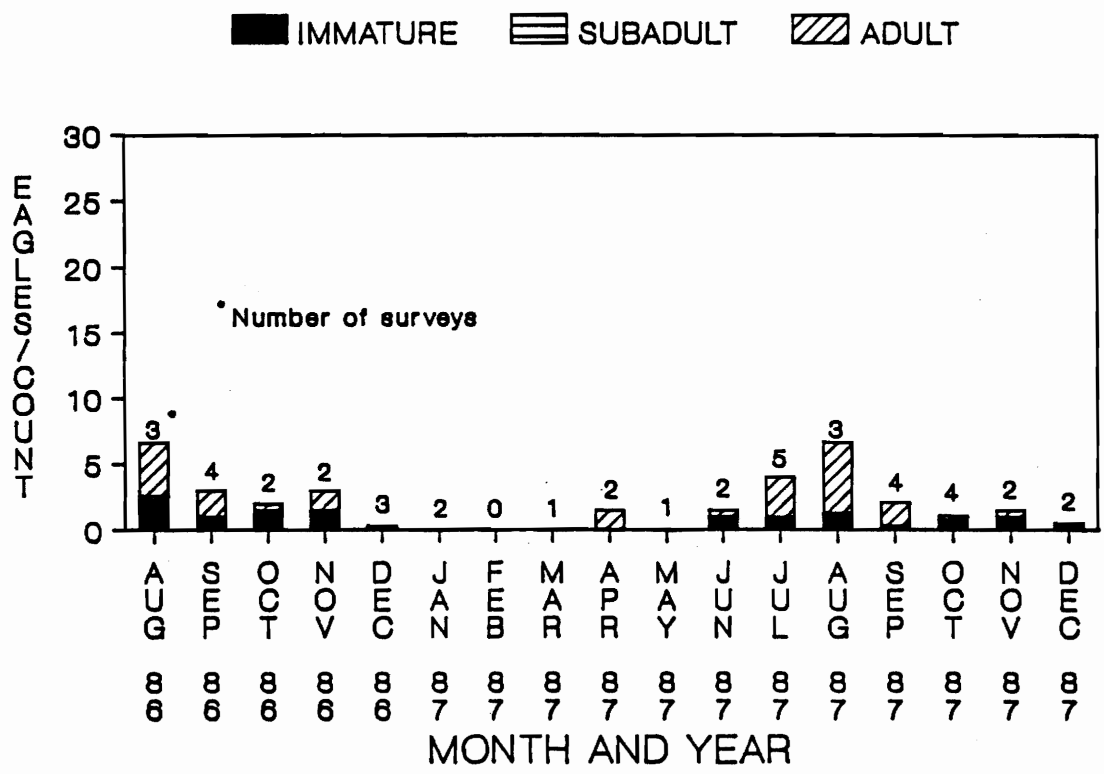

Figure 7. Monthly means for low altitude aerial counts of bald eagles, Falls Lake, North Carolina, 1986-87.

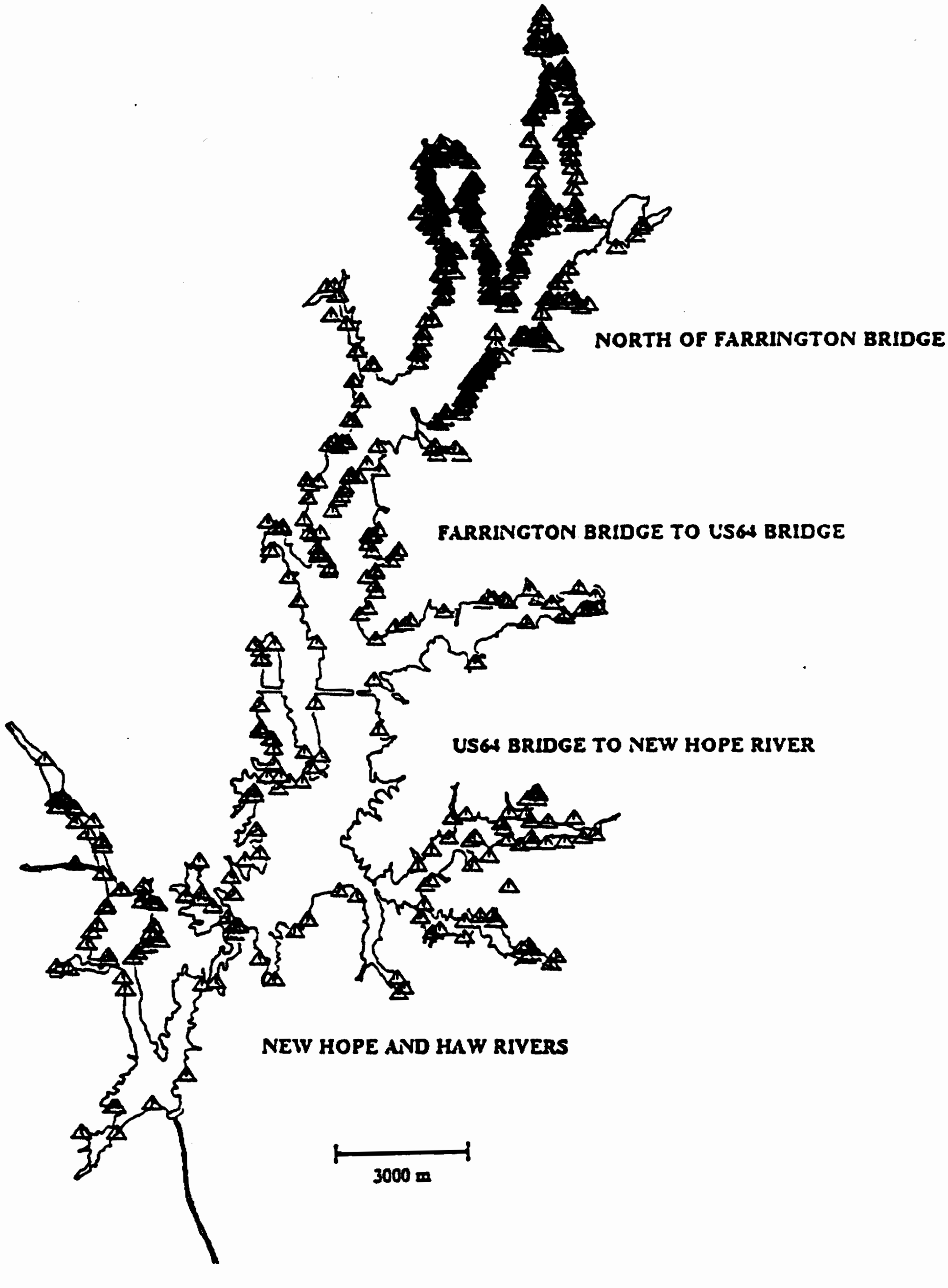

Figure 8. Locations of 778 bald eagles observed during 58 low altitude aerial surveys of B. Everett Jordan Lake, North Carolina, 1986-87.

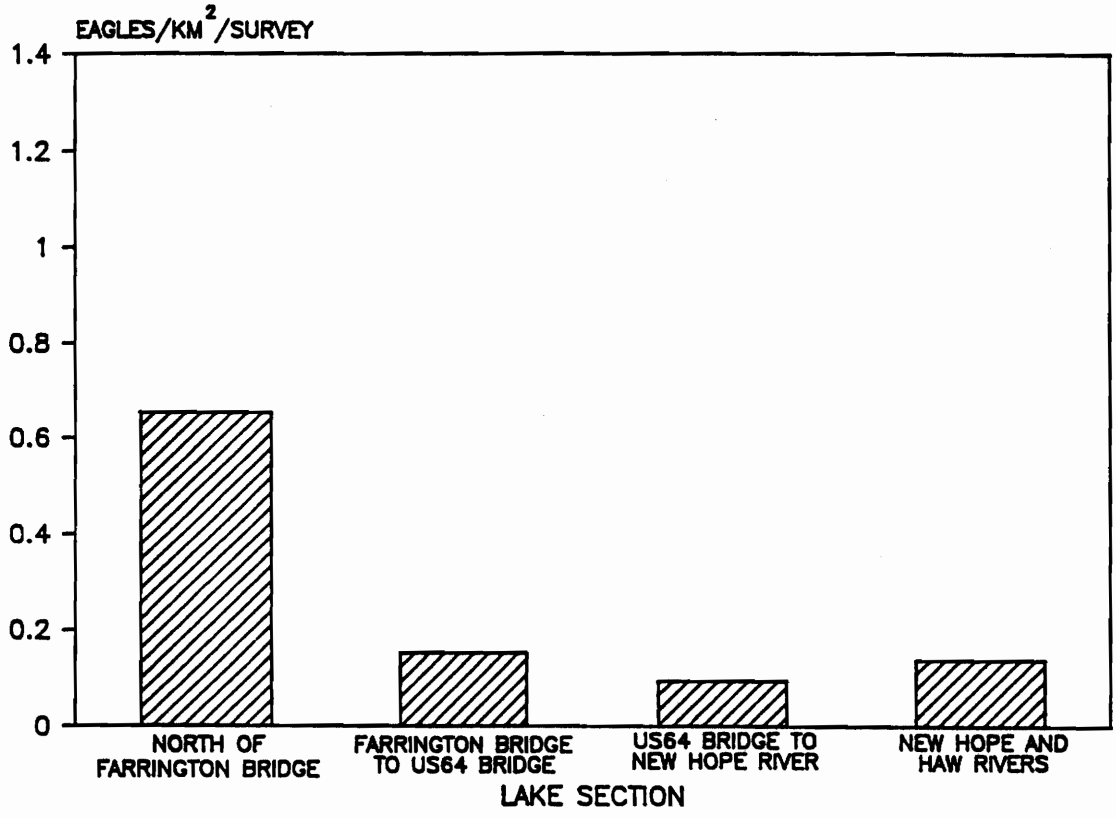

Figure 9. Mean bald eagle densities as determined from 59 low altitude aerial surveys of B. Everett Jordan Lake, North Carolina, 1986-87.

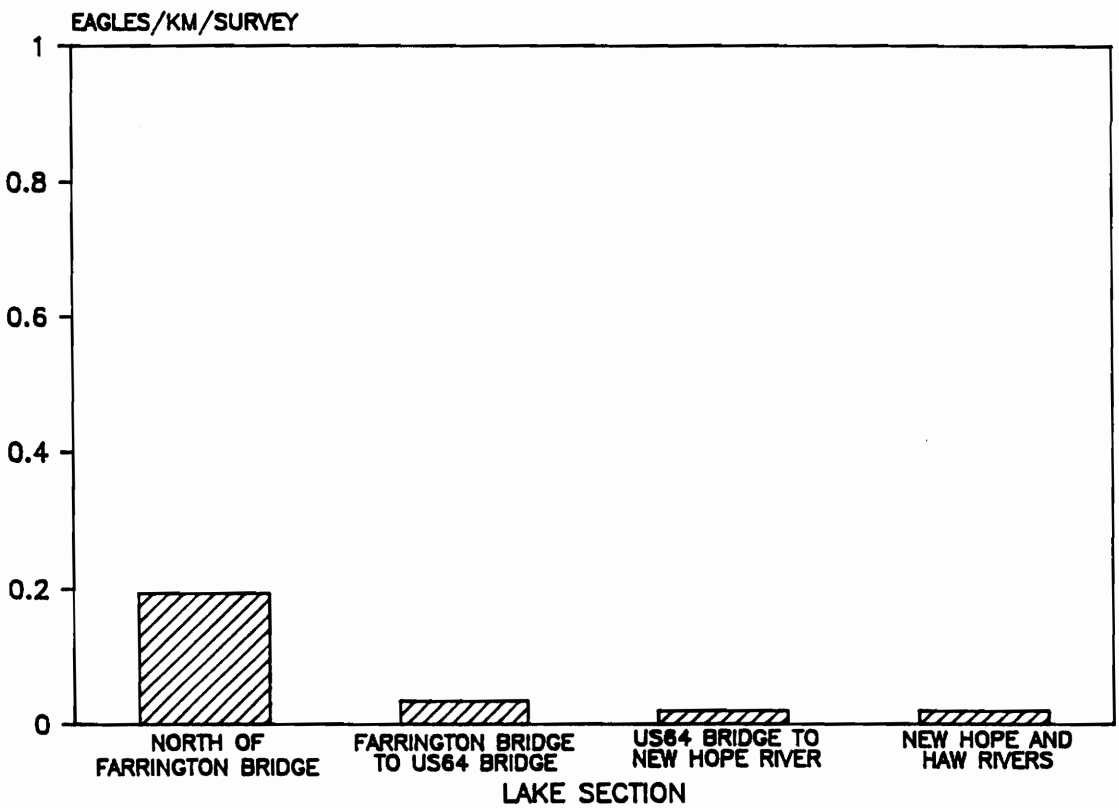

Figure 10. Mean bald eagle densities (per km) as determined from 58 low altitude aerial surveys of B. Everett Jordan Lake, North Carolina, 1986-87.

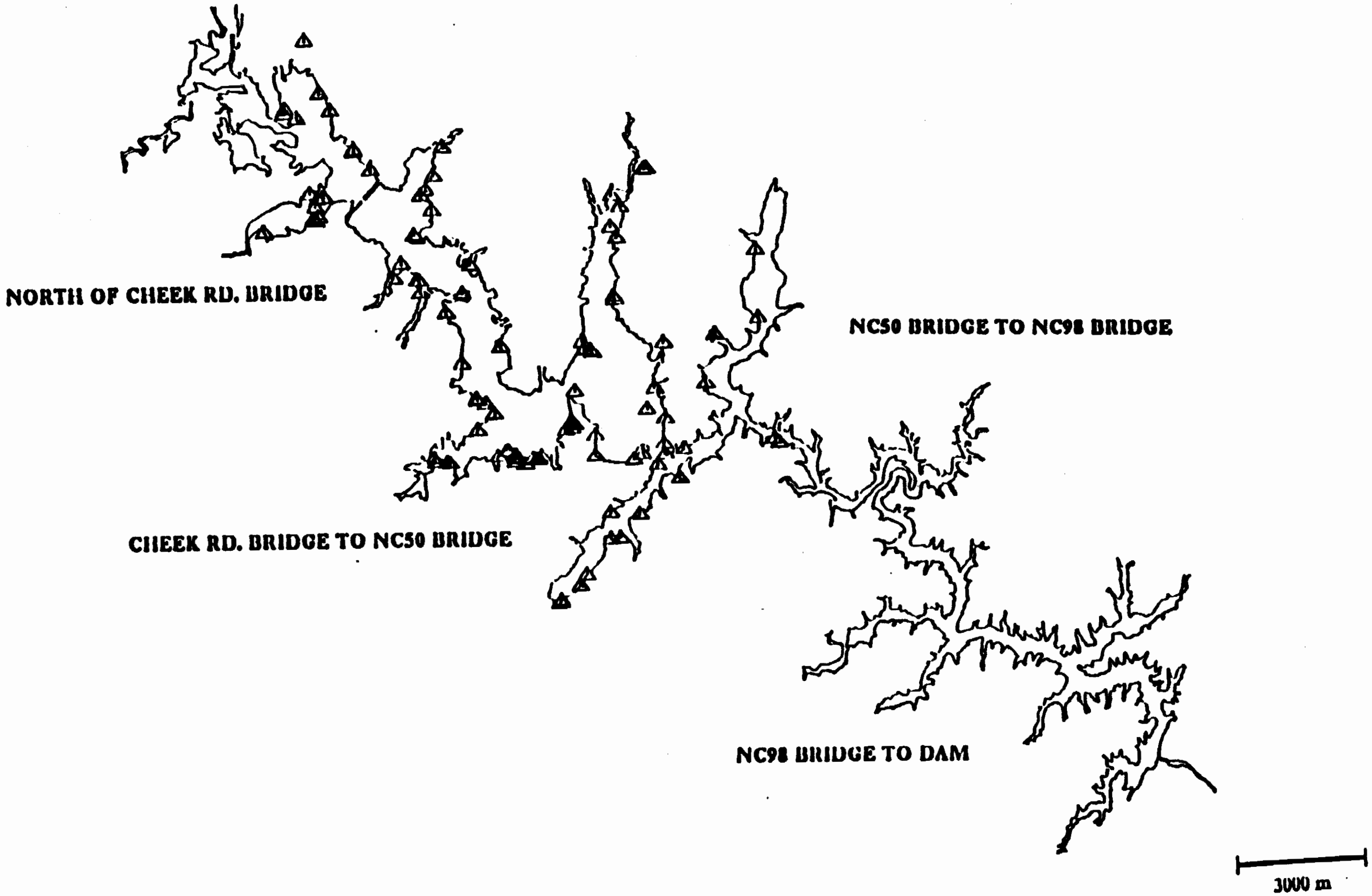

Figure 11. Locations of 108 bald eagles observed during 43 aerial surveys of Falls Lake, North Carolina 1986-87.

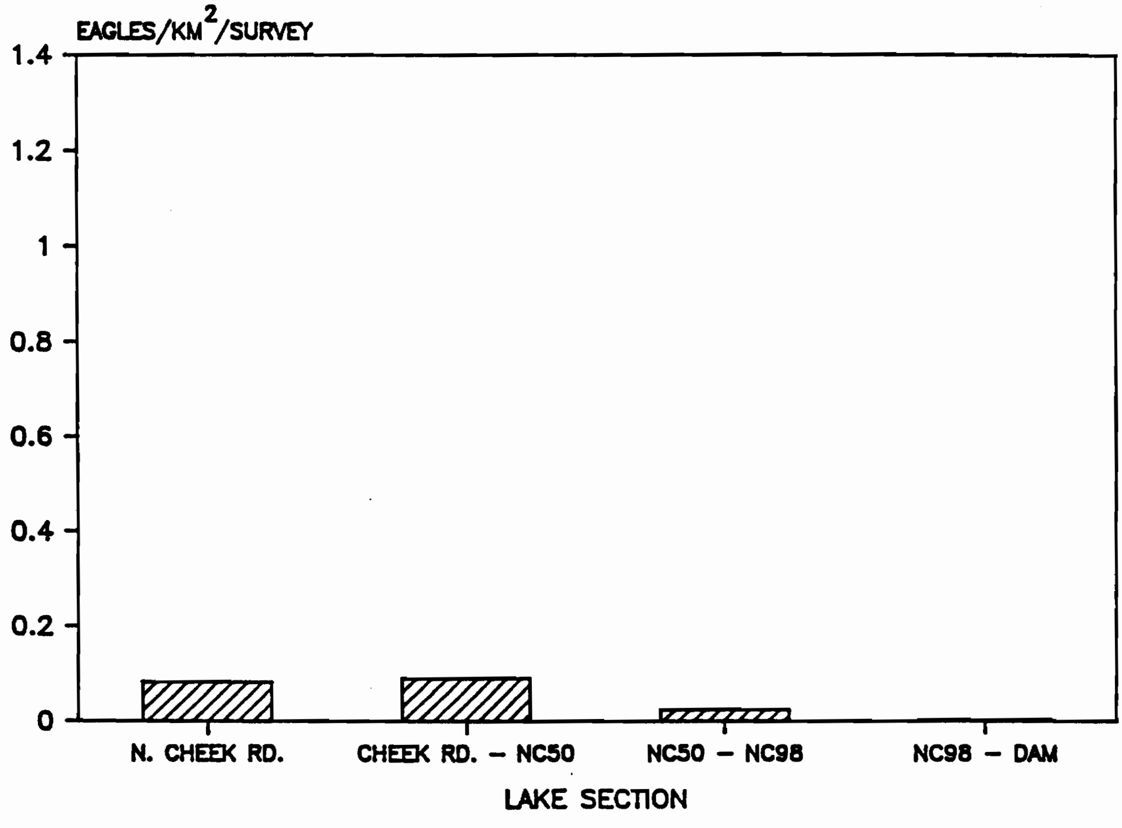

Figure 12. Mean bald eagle densities (per km²) as determined from 43 low altitude aerial surveys of Falls Lake, North Carolina, 1986-87.

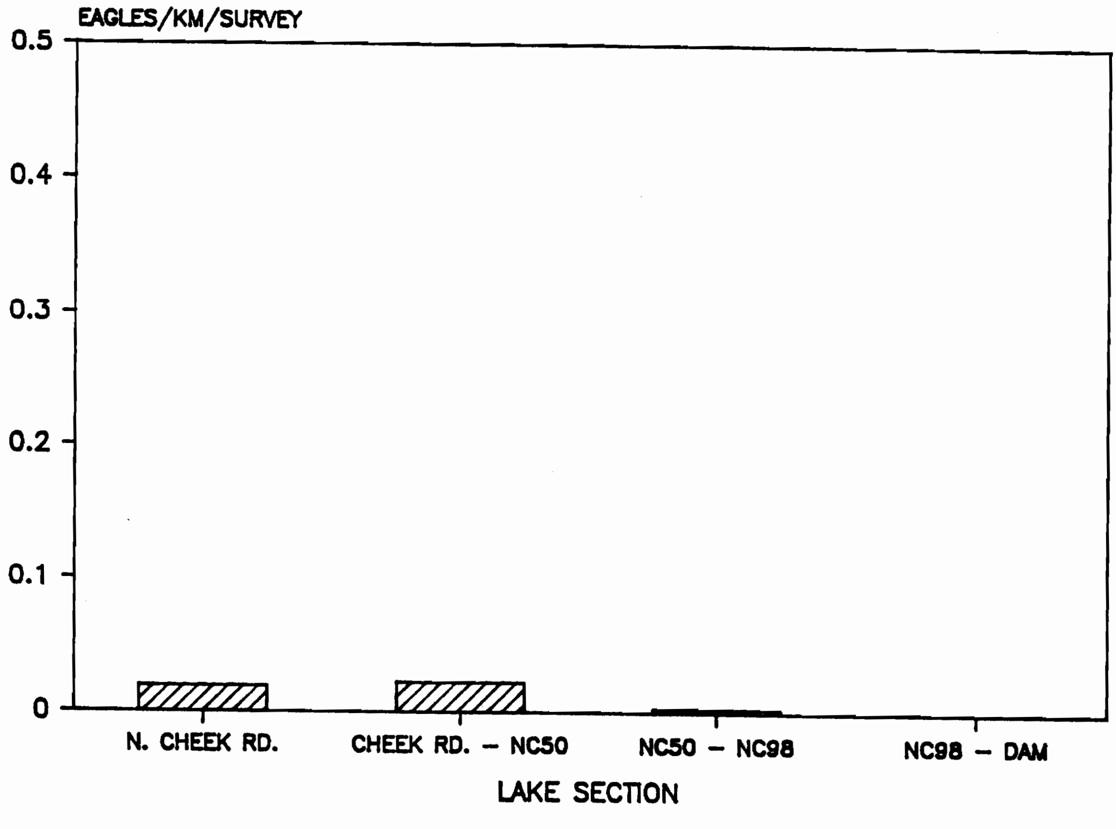

Figure 13. Mean bald eagle densities (per km) as determined from 43 low altitude aerial surveys of Falls Lake, North Carolina, 1986-87.

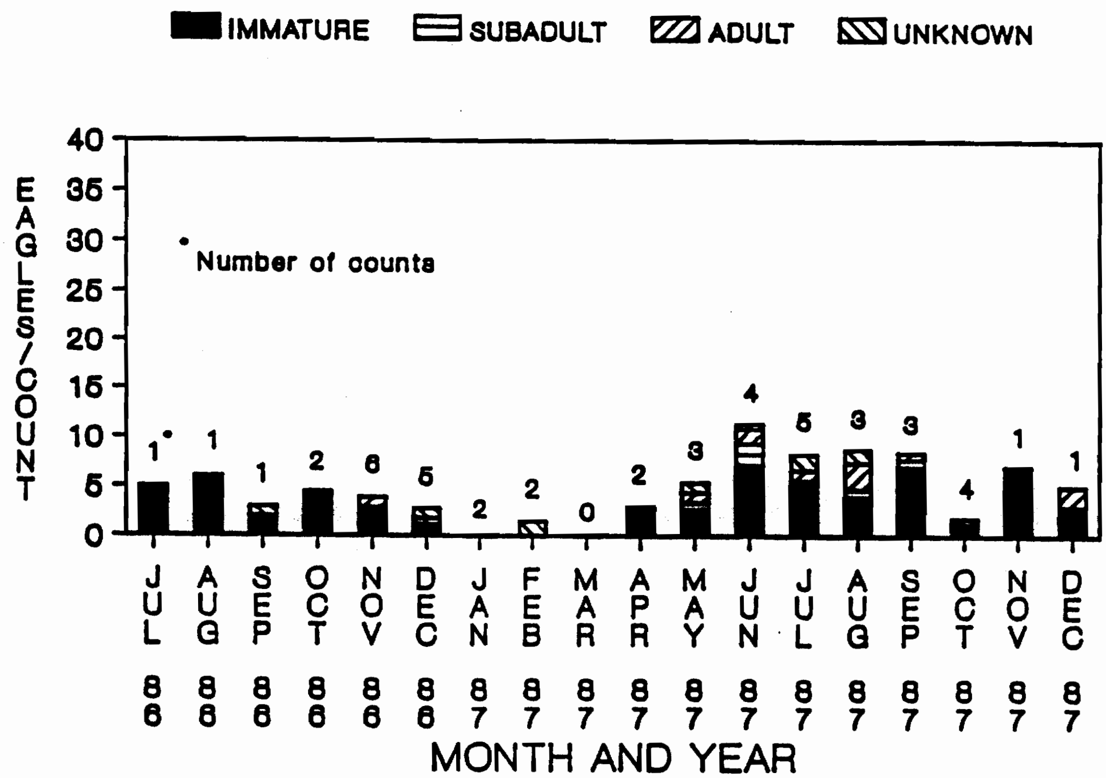

Figure 14. Monthly means of bald eagles counted at Morgan Creek Roost, B. Everett Jordan Lake, North Carolina, 1986-87.

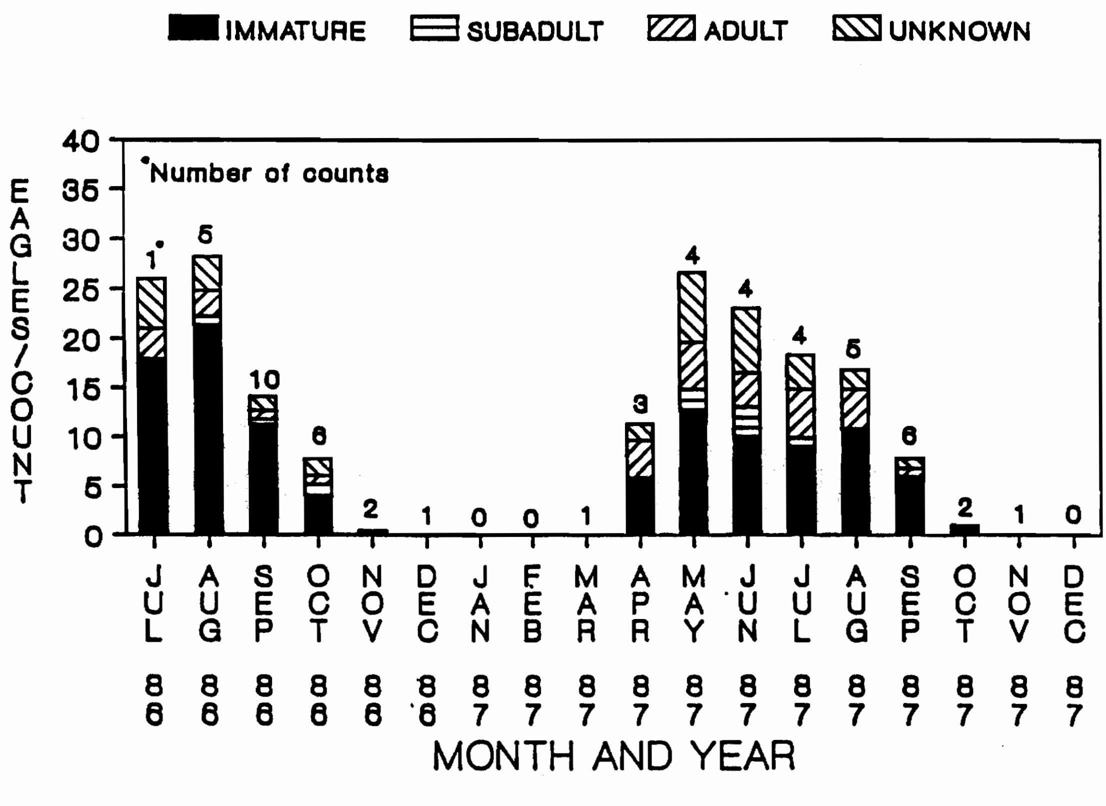

Figure 15. Monthly means of bald eagles counted at Mason Point Roost, B. Everett Jordan Lake, North Carolina, 1986-87.

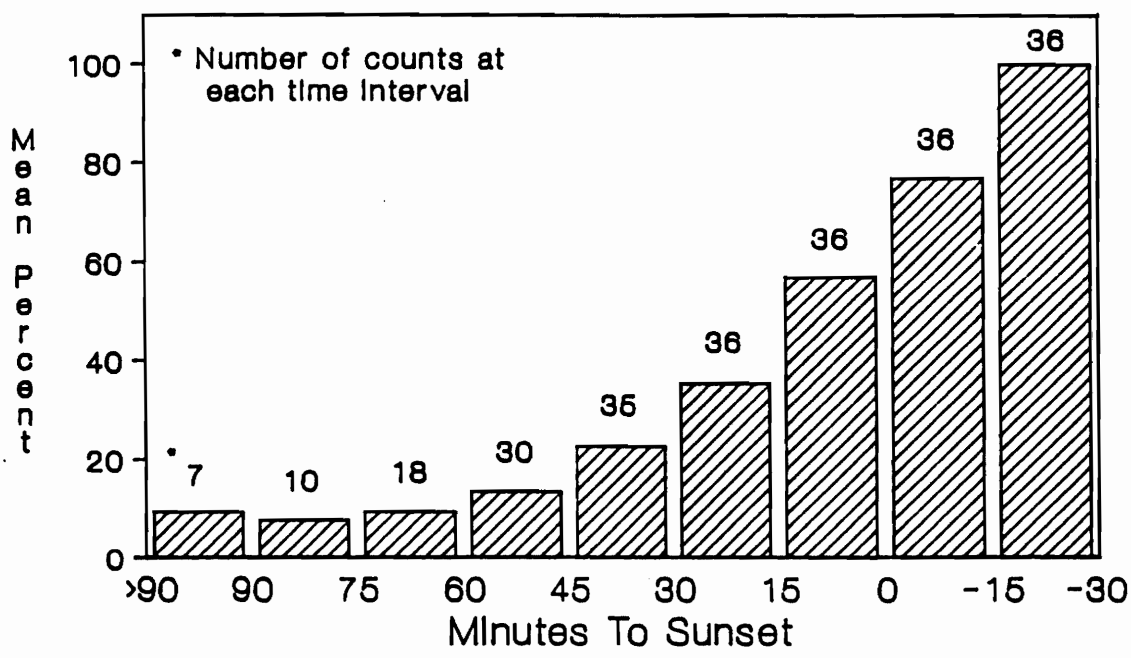

Figure 16. Mean percent of the nightly total number of bald eagles present at the Mason Point Roost site, B. Everett Jordan Lake, North Carolina, 1986-87. Counts were ended 30 minutes after sunset.

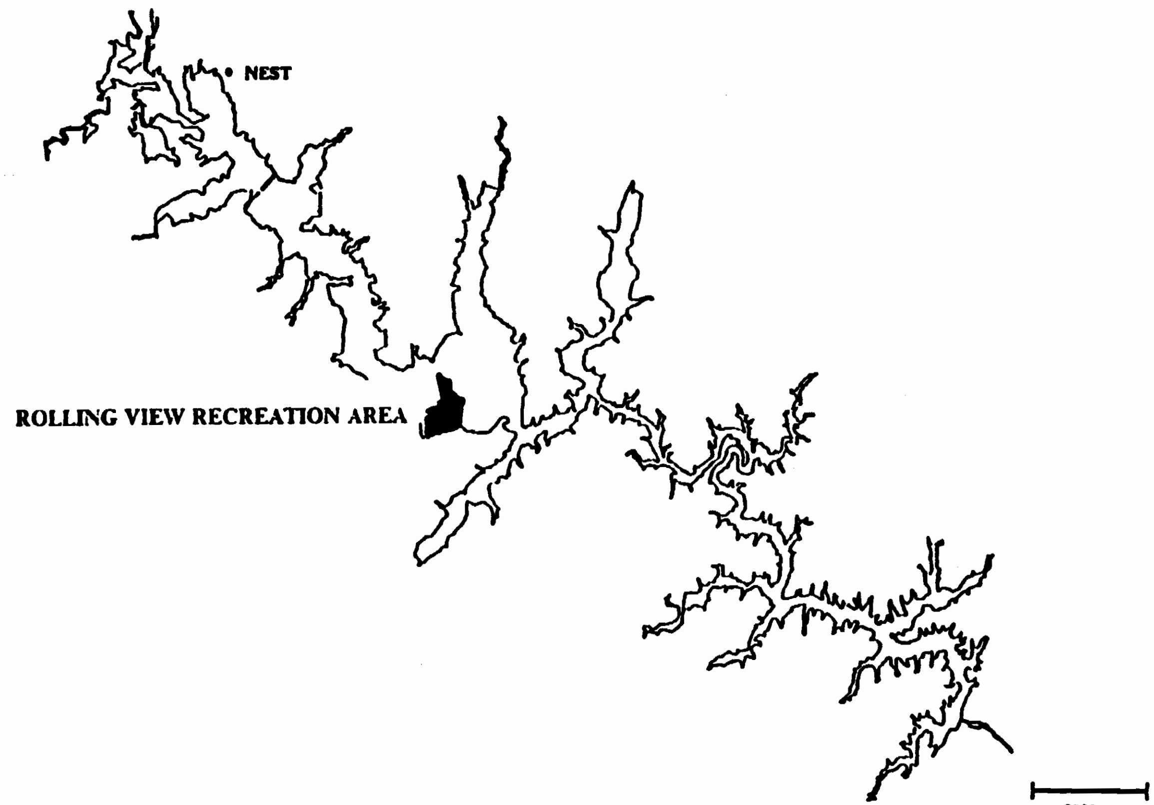

Figure 17. Location of bald eagle nest on Falls Lake, North Carolina 1986-87.

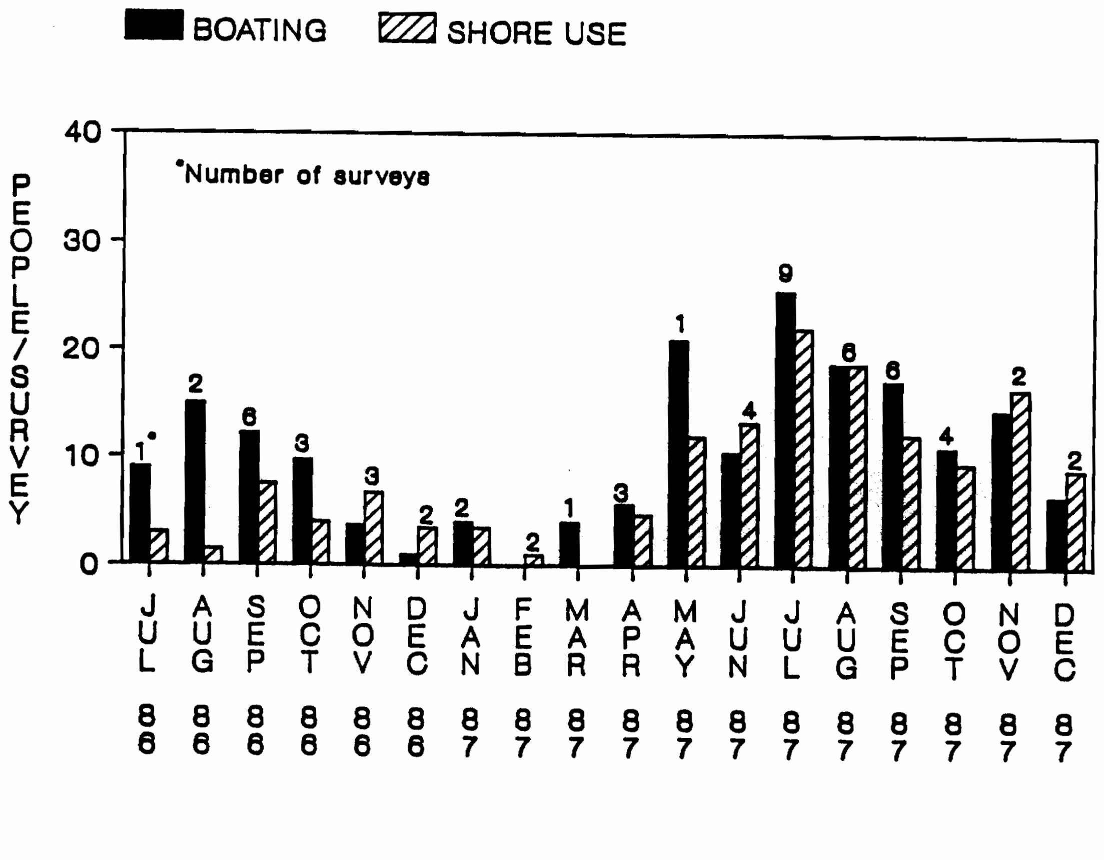

Figure 18. Monthly means for low altitude aerial counts of humans, B. Everett Jordan Lake, North Carolina, 1986-87.

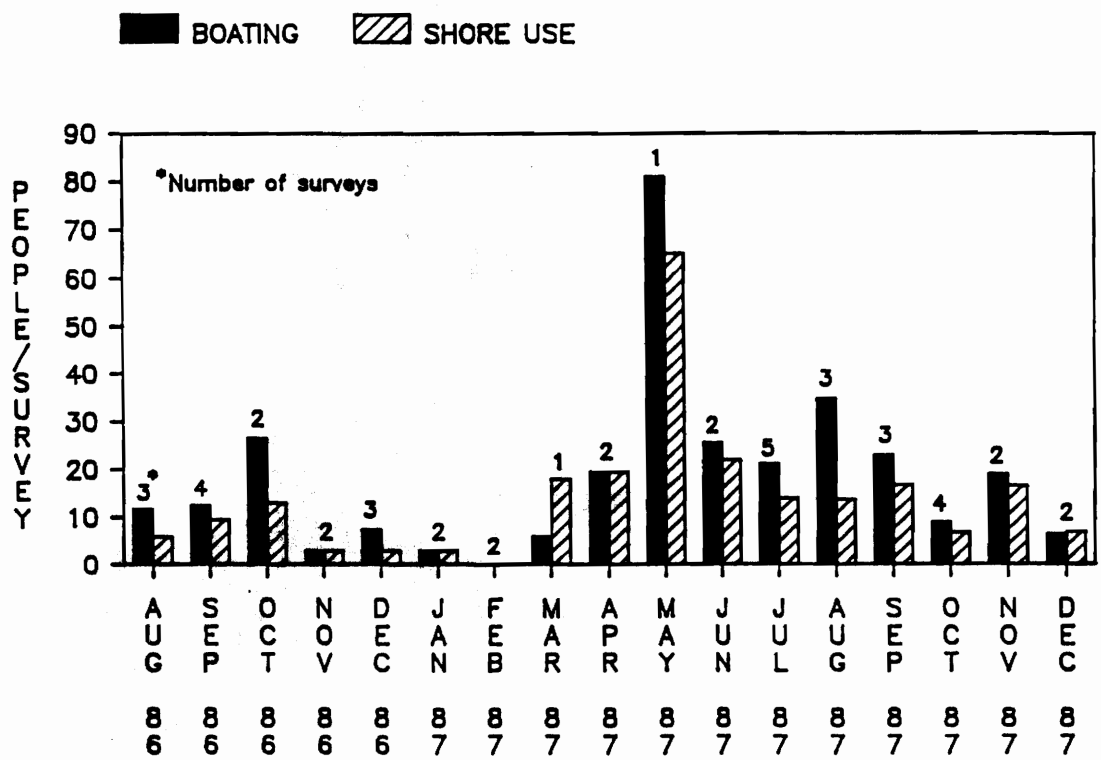

Figure 19. Monthly means for low altitude aerial counts of humans, Falls Lake, North Carolina, 1986-87.

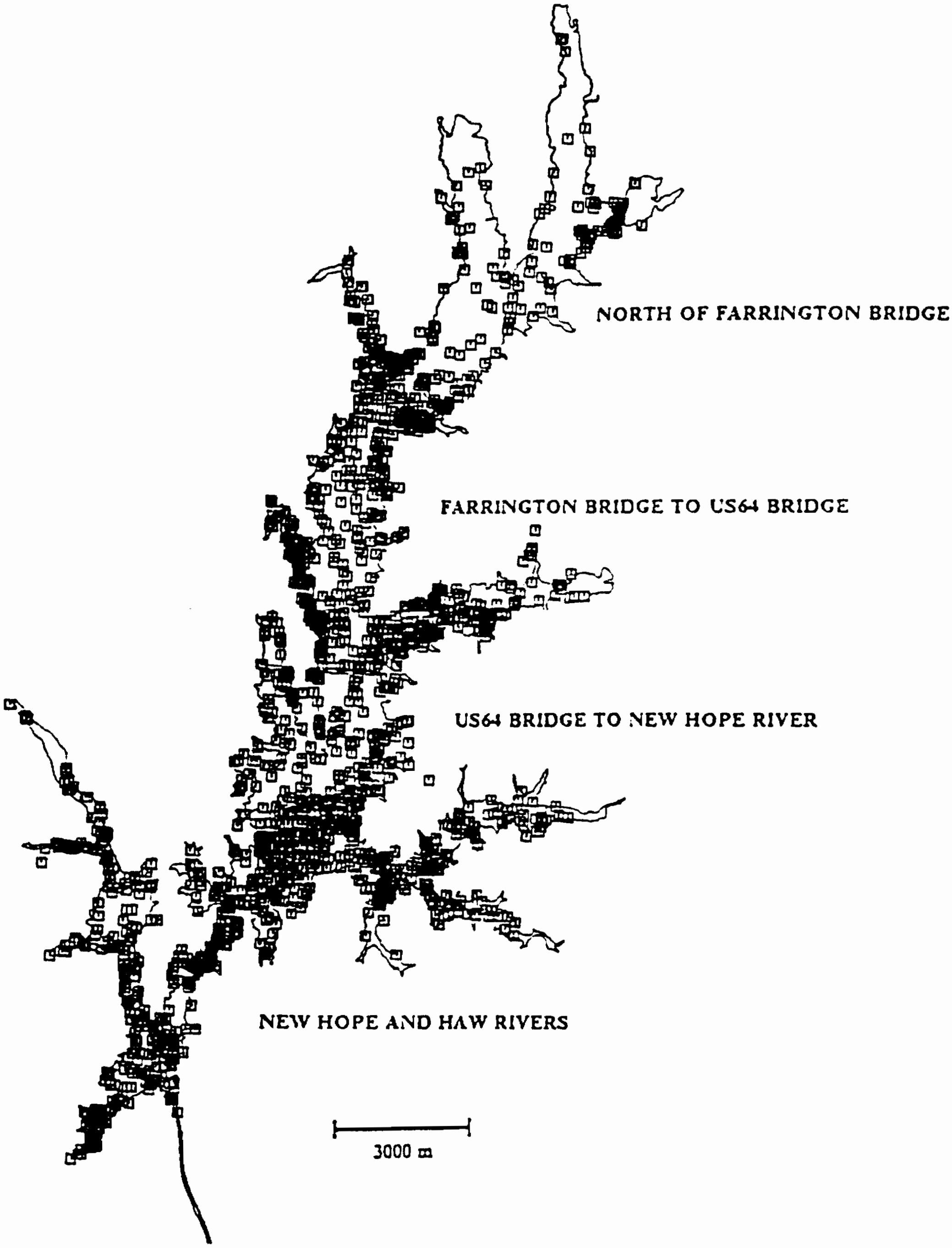

Figure 20. Locations of 1425 humans observed during 58 low altitude aerial surveys of B. Everett Jordan Lake, North Carolina, 1986-87.

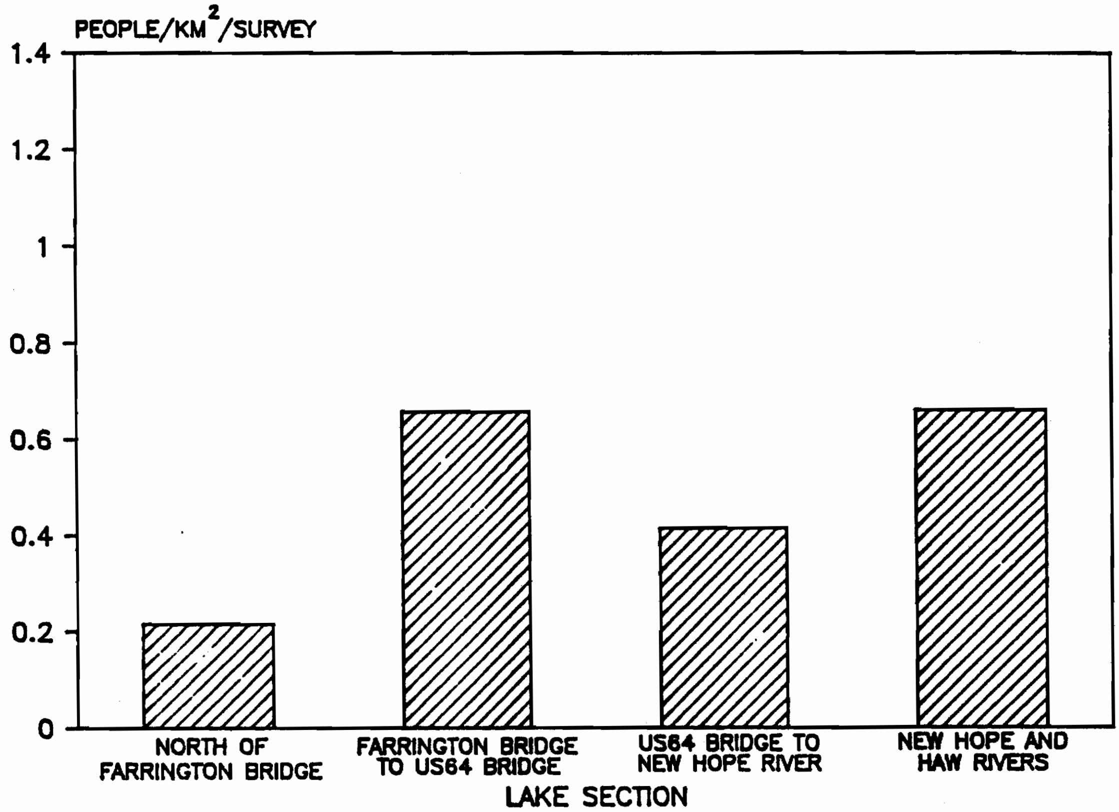

Figure 21. Mean human densities as determined from 58 low altitude aerial surveys of B. Everett Jordan Lake, North Carolina, 1986-87.

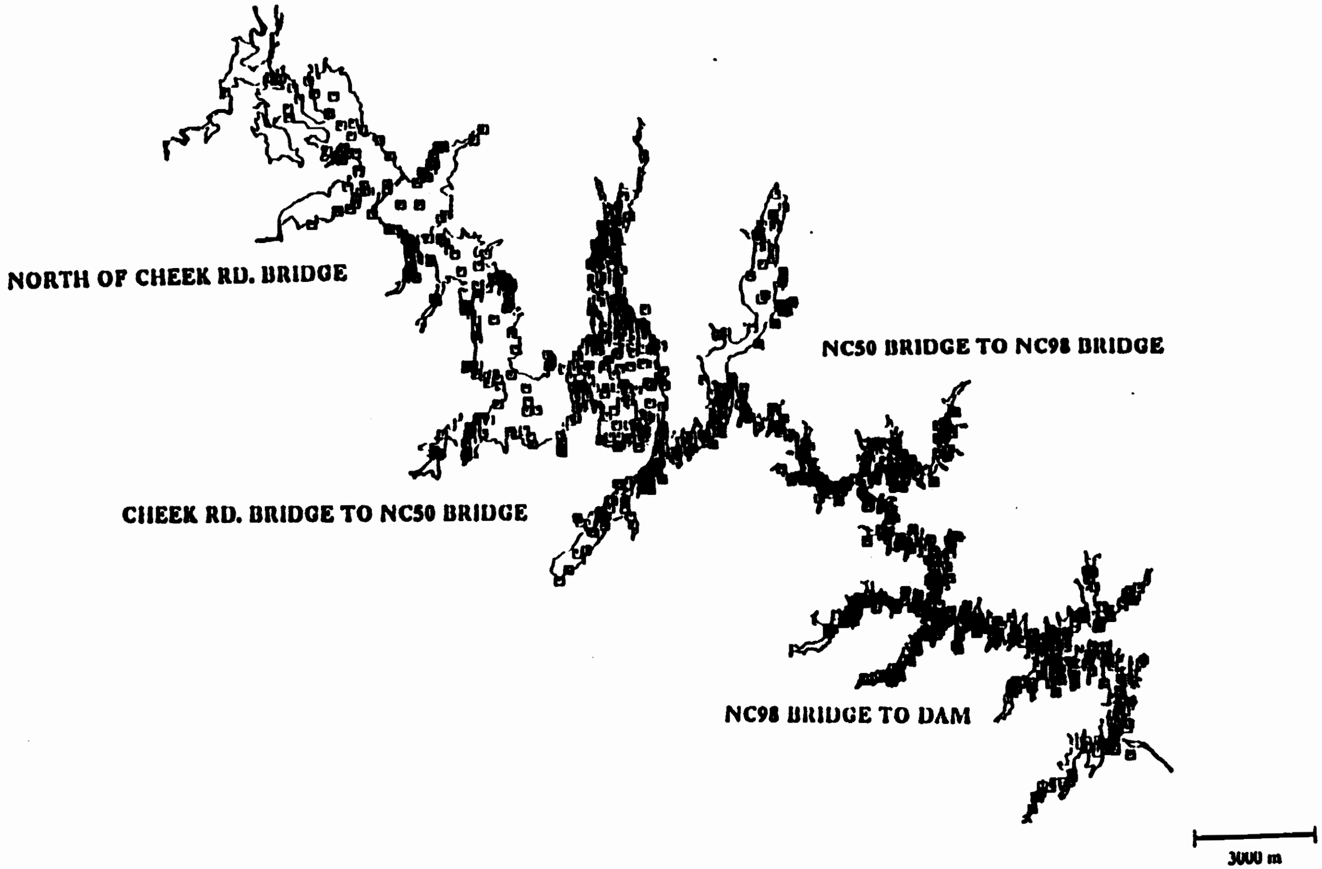

Figure 22. Locations of 1216 humans observed during 43 low altitude aerail surveys of Falls Lake, North Carolina 1986-87.

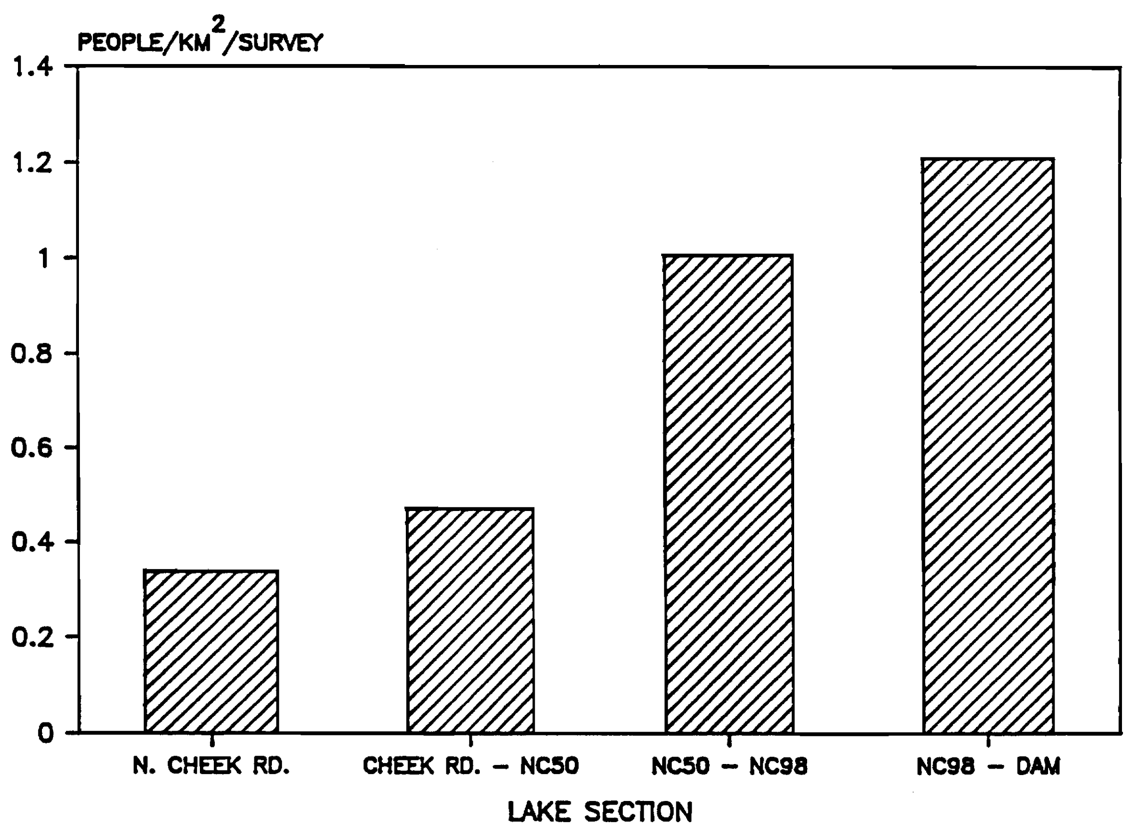

Figure 23. Mean human densities as determined from 43 low altitude aerial surveys of Fall Lake, North Carolina, 1986-87.

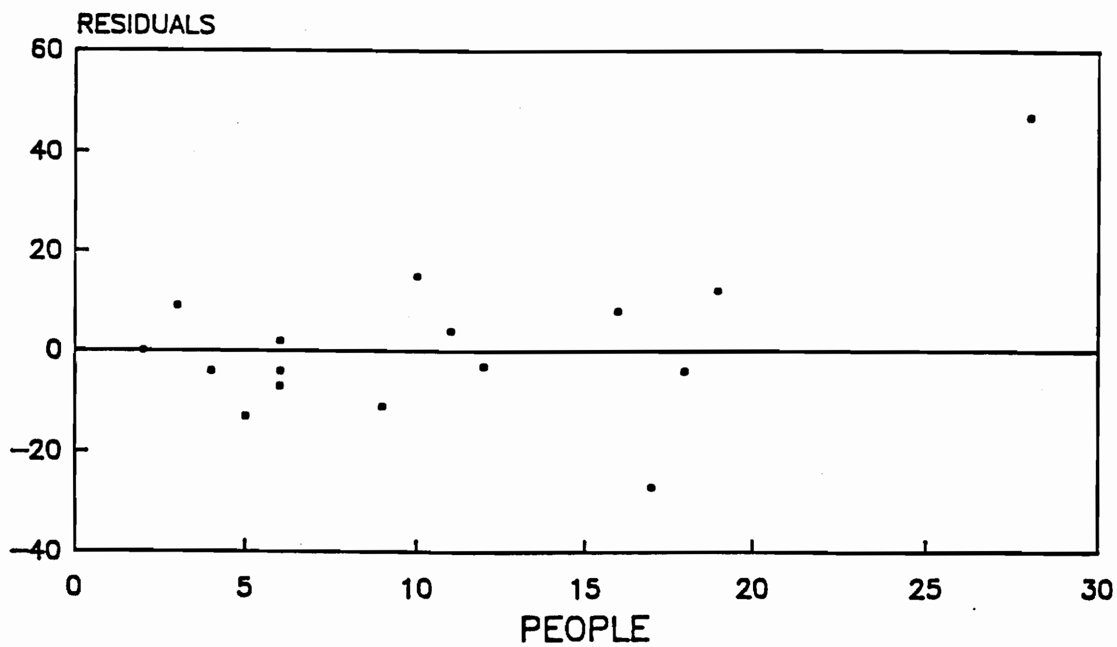

Figure 24. Plot of eagle on date residuals vs. people numbers on weekday boat surveys, north of Farrington Bridge, B. Everett Jordan Lake, North Carolina 1987.

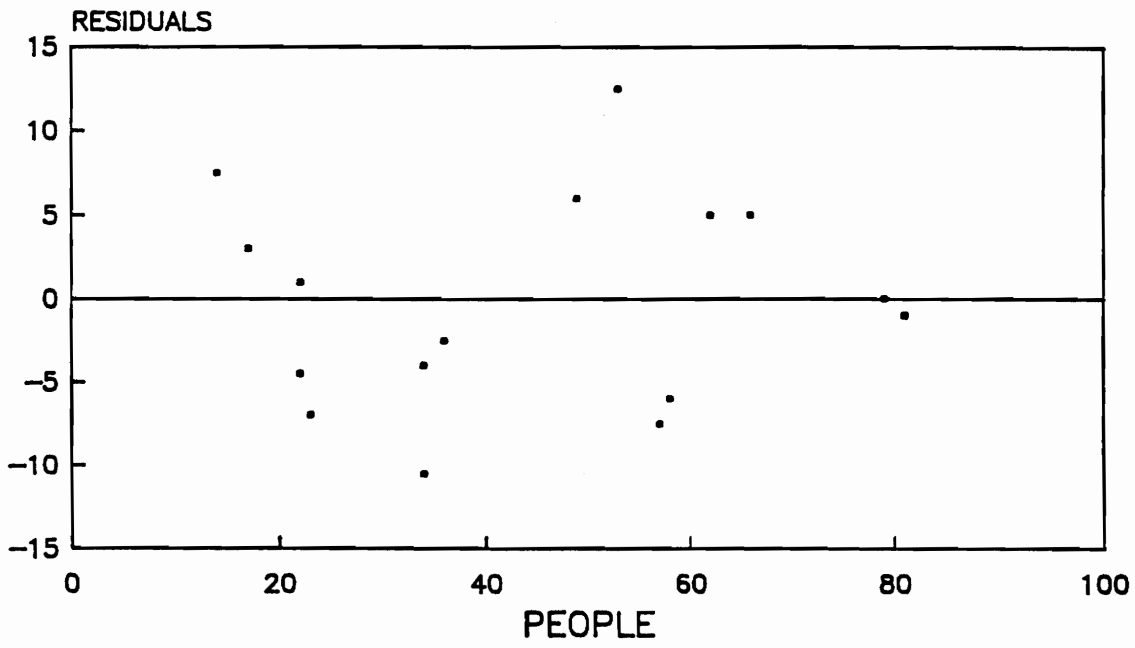

Figure 25. Plot of eagle on date residuals vs. people numbers on weekend boat surveys, north of Farrington Bridge, B. Everett Jordan Lake, North Carolina 1987.

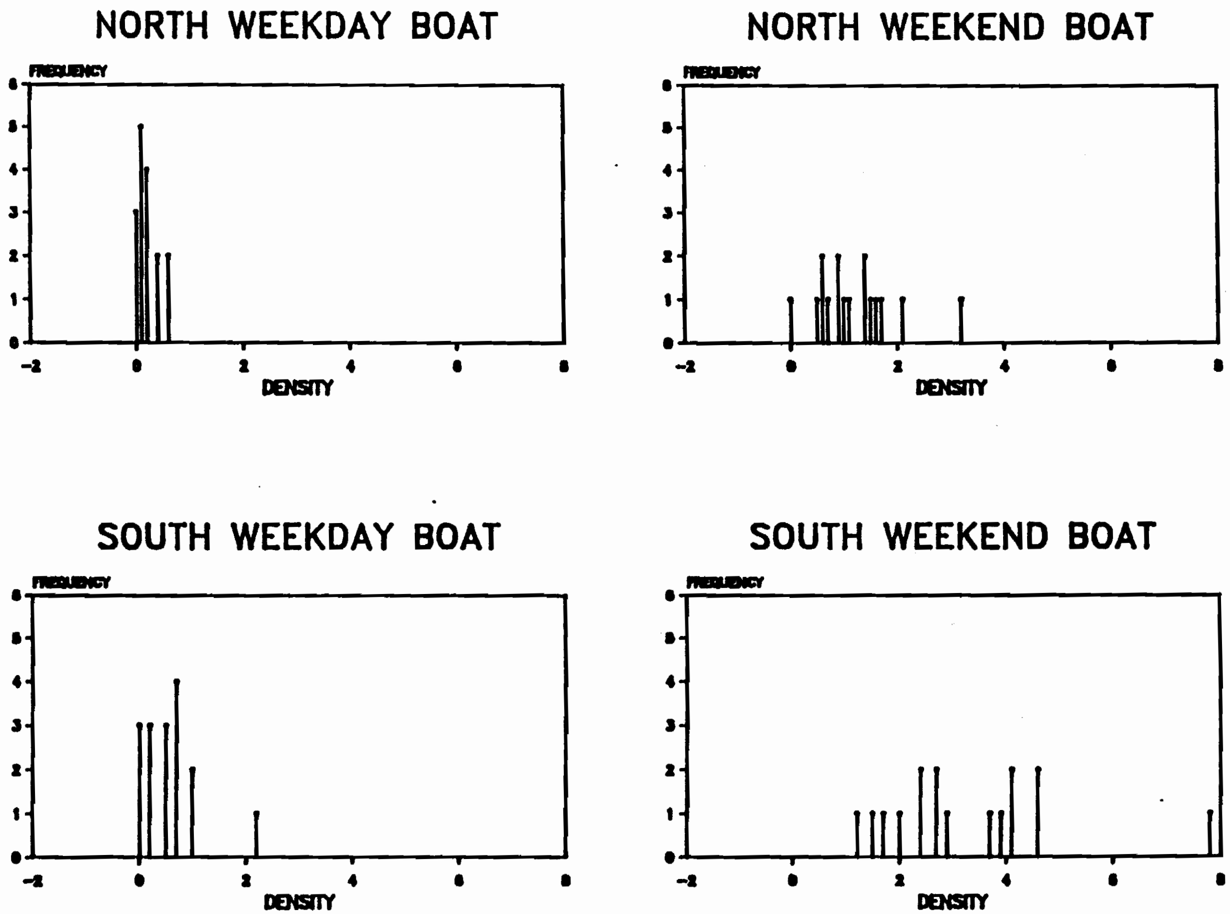

Figure 26. Densities of boats (per km^2) on weekday and weekend boat surveys, on 2 subsections north of the Farrington Bridge, B. Everett Jordan Lake, North Carolina 1987.

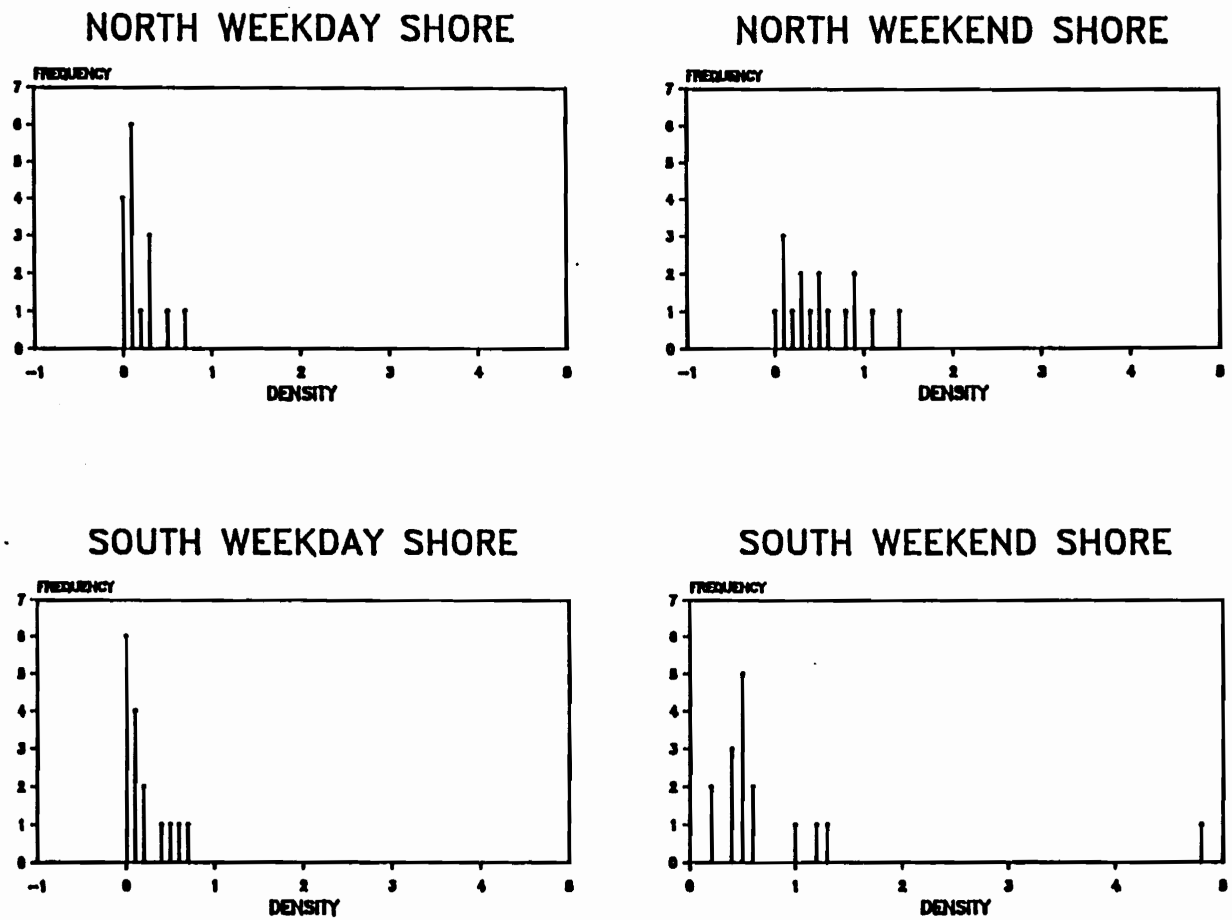

Figure 27. Densities of people (per km) on weekday and weekend boat surveys, on 2 subsections north of the Farrington Bridge, B. Everett Jordan Lake, North Carolina 1987.

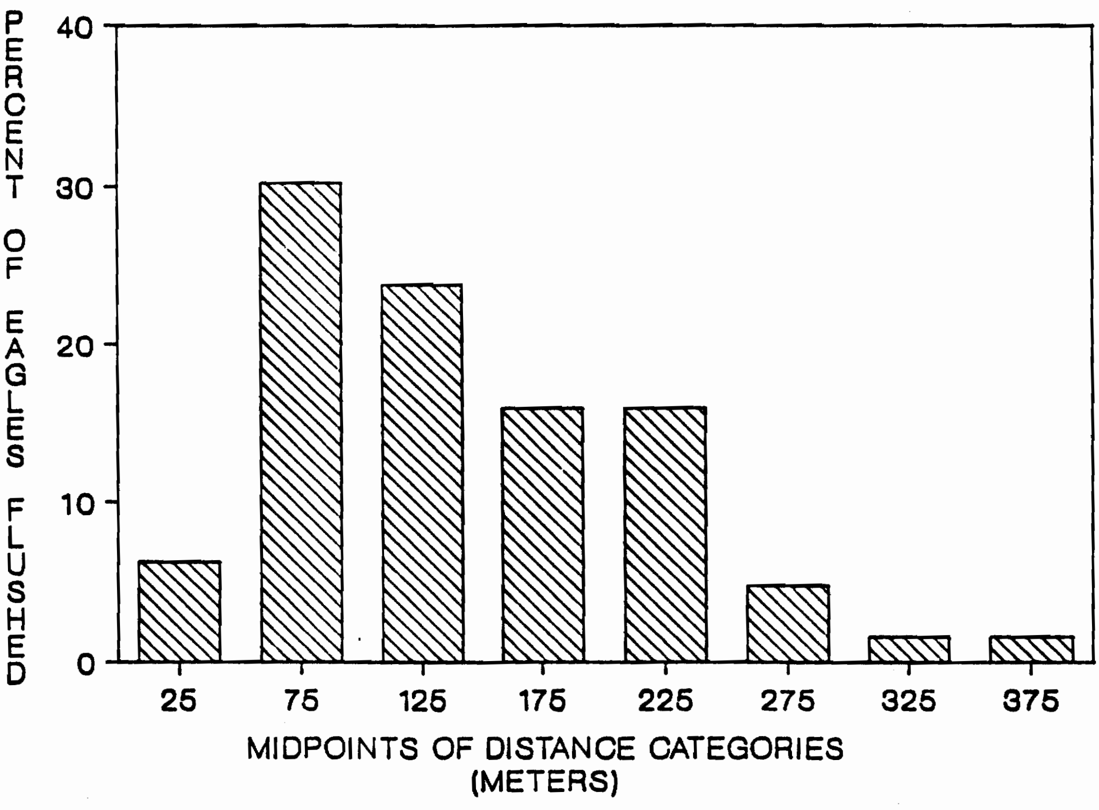

Figure 28. Percent of bald eagle flushes that occurred at different distances from observers approaching in boats, B. Everett Jordan Lake, North Carolina, 1987.

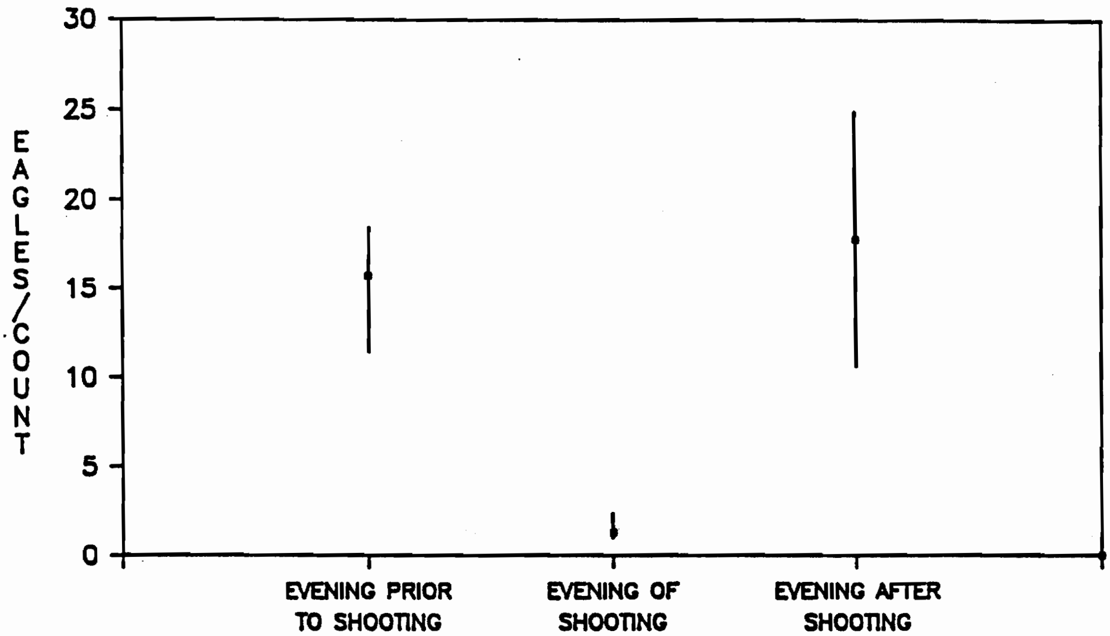

Figure 29. Mean and range of bald eagles counted on evenings prior to, during, and after shooting disturbances, Mason Point Roost, B. Everett Jordan Lake, North Carolina, 1987.

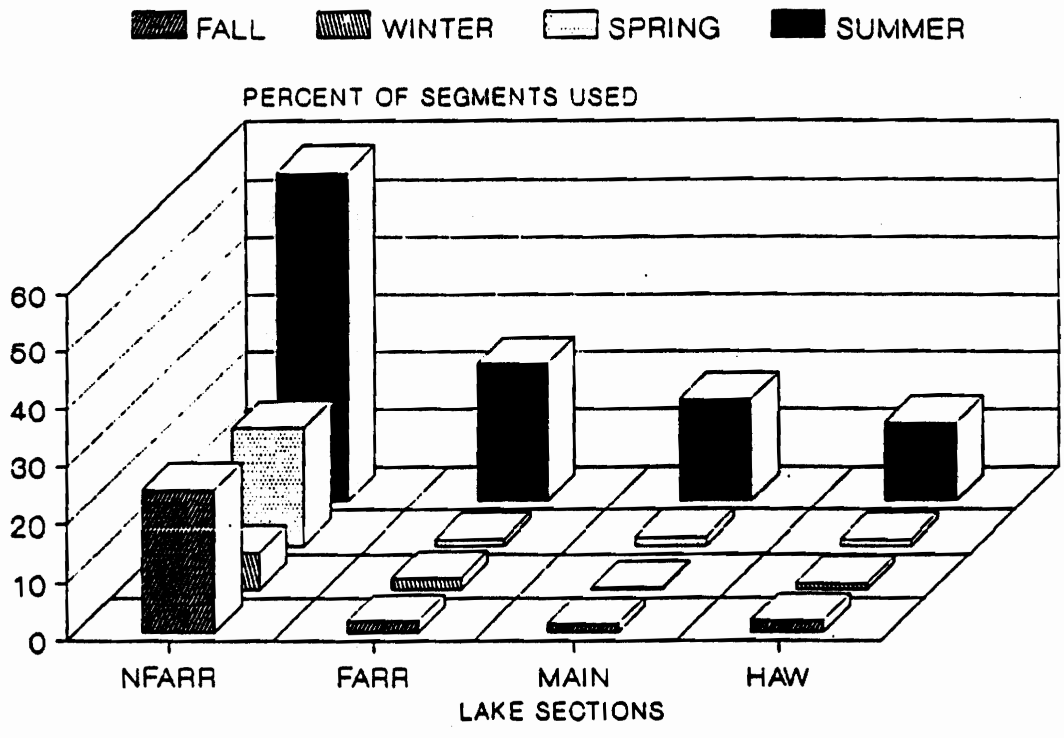

Figure 30. Percent of 250 m shoreline segments used by bald eagles during different seasons and in different lake sections as determined by 58 low altitude aerial surveys of B. Everett Jordan Lake, North Carolina, 1986 -1987.

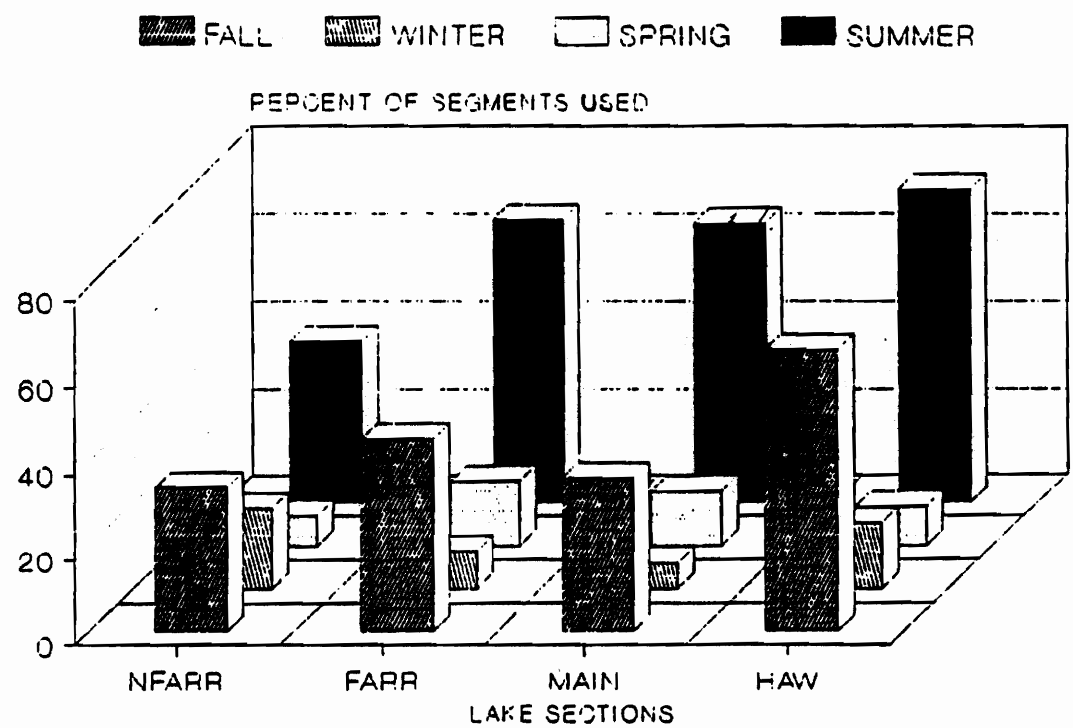

Figure 31. Percent of 250 m shoreline segments with human use in the vicinity (humans ≤ 200 m from a segment) during different seasons and in different lake sections as determined by 58 low altitude aerial surveys of B. Everett Jordan Lake, North Carolina, 1986-87.

TABLES

Table 1. Number of eagles observed during low altitude aerial surveys of B. Everett Jordan Lake and Falls Lake, North Carolina 30 July 1986 - 14 December 1987.

Date	Jordan Lake	Falls Lake
7/30/86	21	-[a]
8/14/86	-	7
8/18/86	11	8
8/26/86	24	5
9/09/86	22	5
9/10/86	17	5
9/11/86	15	-
9/18/86	16	1
9/25/86	9	-
9/29/86	10	1
10/15/86	17	-
10/20/86	-	3
10/24/86	14	-
10/28/86	5	1
11/06/86	10	-
11/10/86	12	2
11/25/86	6	4
12/16/86	8	1
12/22/86	-	0
12/23/86	6	-
12/30/86	-	0
1/06/87	2	0
1/21/87	2	0
2/10/87	1	0
2/23/87	3	0
3/17/87	4	0
4/07/87	11	
4/21/87	7	1
4/27/87	18	2
5/07/87	25	0
6/11/87	31	2
6/22/87	16	1
6/25/87	24	-
6/29/87	22	-

Table 1. Continued

Date	Jordan Lake	Falls Lake
7/02/87	16	-
7/06/87	11	5
7/09/87	16	2
7/13/87	24	-
7/16/87	10	-
7/20/87	29	1
7/23/87	14	6
7/27/87	20	6
7/30/87	22	-
8/03/87	21	-
8/06/87	22	7
8/13/87	12	6
8/18/87	29	7
8/20/87	20	-
8/24/87	27	-
9/03/87	6	-
9/10/87	14	4
9/15/87	13	-
9/22/87	10	0
9/29/87	10	4
10/06/87	9	1
10/13/87	7	2
10/20/87	3	1
10/29/87	1	2
11/02/87	5	2
11/17/87	6	-
11/18/87	-	1
12/07/87	5	0
12/14/87	7	1

[a] Lake not surveyed.

Table 2. Monthly means and standard errors of eagles observed on low altitude aerial surveys of B. Everett Jordan Lake and Falls Lake, North Carolina, 1986-87.

		Jordan Lake			Falls Lake		
Month	Year	n	$\bar{x}$	SE	n	$\bar{x}$	SE
July	1986	1	21.0	-			
August	1986	2	17.5	6.5	3	6.7	0.9
September	1986	6	14.8	2.0	4	3.0	1.2
October	1986	3	12.0	3.6	2	2.0	1.0
November	1986	3	9.3	1.8	2	3.0	1.0
December	1986	2	7.0	1.0	3	0.3	0.3
January	1987	2	2.0	0.0	2	0.0	0.0
February	1987	2	2.0	1.0	2	0.0	0.0
March	1987	1	4.0	-	1	0.0	-
April	1987	3	12.0	3.2	2	1.5	0.5
May	1987	1	25.0	-	1	0.0	-
June	1987	4	23.3	3.1	2	1.5	0.5
July	1987	9	18.0	2.1	5	4.0	1.0
August	1987	6	21.7	2.4	3	6.7	0.3
September	1987	5	10.6	1.4	3	2.6	1.3
October	1987	4	5.0	1.8	4	1.5	0.3
November	1987	2	5.5	0.5	2	1.5	0.5
December	1987	2	6.0	1.0	2	0.5	0.5

Table 3. Means and standard errors of eagles observed during morning and afternoon low altitude aerial surveys of B. Everett Jordan Lake and Falls Lake, North Carolina 1986-87.

Lake		n	$\bar{x}$	SE
Jordan				
	Morning[a]	18	15.50	2.11
	Afternoon	18	14.00	1.55
Falls				
	Morning[b]	13	2.69	0.70
	Afternoon	13	3.38	0.76

[a] Signed rank test comparing eagle numbers morning vs. afternoon at Jordan Lake (P = 0.760).
[b] Signed rank test comparing eagle numbers morning vs. afternoon at Falls Lake (P = 0.350).

Table 4. Monthly means and standard errors of eagles by age class for 58 low altitude aerial surveys of B. Everett Jordan Lake, North Carolina 1986-87.

			Immature		Subadult		Adult	
Month	Year	n	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
July	1986	1	17.0	-	1.0	-	3.0	-
August	1986	2	11.0	4.0	0.0	0.0	6.5	2.5
September	1986	6	12.3	1.3	0.0	0.0	2.5	0.8
October	1986	3	9.0	2.1	0.0	0.0	3.0	1.5
November	1986	3	6.3	0.7	0.0	0.0	3.0	1.2
December	1986	2	6.0	1.0	0.0	0.0	1.0	0.0
January	1987	2	2.0	0.0	0.0	0.0	0.0	0.0
February	1987	2	1.5	0.5	0.0	0.0	0.5	0.5
March	1987	1	4.0	-	0.0	-	0.0	-
April	1987	3	5.7	2.7	0.7	0.3	5.7	0.3
May	1987	1	11.0	-	3.0	-	11.0	-
June	1987	4	10.8	1.2	2.0	0.9	10.5	2.2
July	1987	9	6.7	0.9	1.2	0.3	10.1	1.4
August	1987	6	9.8	1.2	2.0	0.5	10.0	1.6
September	1987	5	8.6	1.2	0.4	0.2	1.6	0.7
October	1987	4	3.5	1.0	0.2	0.2	1.2	0.8
November	1987	2	4.5	0.5	0.0	0.0	1.0	0.0
December	1987	2	3.5	0.5	1.0	0.0	1.5	0.5

Table 5. Origin and known locations of radio-tagged eagles using B. Everett Jordan Lake, North Carolina, 1986-88.

Eagle	Location	Date
165.502[a]	Chesapeake Bay	12 September 1985 - 10 October 1985
	Northern Florida	4 December 1986 - 16 April 1987
	Jordan Lake, N.C.	8 June 1987 - 29 September 1987
	Northern Florida	16 December 1987 - 15 April 1988
165.021[b]	Chesapeake Bay	28 September 1985 - 17 October 1985
	Chesapeake Bay	8 May 1986 - 9 September 1986
	Northern Florida	23 November 1986
	Jordan Lake, N.C.	5 May 1987 - 5 June 1987
	Chesapeake Bay	22 July 1987 - 30 August 1987
	Northern Florida	17 September 1987 - 15 April 1988
165.899[c]	Chesapeake Bay	7 August 1986 - 22 August 1986
	Northern Florida	23 November 1986
	Jordan Lake	22 May 1987
	Chesapeake Bay	22 July 1987
	Northern Florida	21 September 1987

[a] Trapped and radio tagged 13 September 1985 as an immature on the Chesapeake Bay.
[b] Trapped and radio tagged 28 September 1985 as an immature on the Chesapeake Bay.
[c] Trapped and radio tagged 3 August 1986 as an immature on the Chesapeake Bay.

Table 6. Monthly means and standard errors of eagles by age class for 43 low altitude aerial surveys of Falls Lake, North Carolina, 1986-87.

			Immature		Subadult		Adult	
Month	Year	n	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
August	1986	3	2.3	0.9	0.3	0.3	4.0	1.0
September	1986	4	1.0	0.1	0.0	0.0	2.0	1.1
October	1986	2	1.5	0.5	0.0	0.0	0.5	0.5
November	1986	2	1.5	3.0	0.0	0.0	1.5	3.0
December	1986	3	0.3	0.3	0.0	0.0	0.0	0.0
January	1987	2	0.0	0.0	0.0	0.0	0.0	0.0
February	1987	2	0.0	0.0	0.0	0.0	0.0	0.0
March	1987	1	0.0	-	0.0	-	0.0	-
April	1987	2	0.0	0.0	0.0	0.0	1.5	0.5
May	1987	1	0.0	-	0.0	-	0.0	-
June	1987	2	1.0	0.0	0.0	0.0	0.5	0.5
July	1987	5	0.8	0.2	0.2	0.2	3.0	1.0
August	1987	3	1.3	0.3	0.0	0.0	5.3	0.7
September	1987	34	0.3	0.3	0.0	0.0	2.3	1.2
October	1987	4	1.3	0.5	0.0	0.0	0.3	0.3
November	1987	2	1.0	1.0	0.0	0.0	0.5	0.5
December	1987	2	0.5	0.5	0.0	0.0	0.0	0.0

Table 7. Monthly means and standard errors of eagles observed at the Mason Point and Morgan Creek roost sites, B. Everett Jordan Lake, North Carolina, 1986-87.

		Mason Point			Morgan Creek		
Month	Year	n	$\bar{x}$	SE	n	$\bar{x}$	SE
July	1986	6	34.7	2.1	1	5.0	-
August	1986	5	28.2	4.6	1	6.0	-
September	1986	10	14.1	2.7	1	3.0	-
October	1986	6	7.0	2.3	2	4.5	0.5
November	1986	2	0.5	0.5	6	3.8	0.9
December	1986	2	0.0	0.0	5	2.8	0.8
January	1987	2	0.0	0.0	2	0.0	0.0
February	1987	1	0.0	-	2	1.5	1.5
March	1987	1	0.0	-	0	-	-
April	1987	3	11.3	2.9	2	3.0	1.0
May	1987	4	26.5	1.8	3	5.3	1.8
June	1987	4	21.8	2.7	4	11.3	1.5
July	1987	4	18.3	1.2	5	8.2	2.3
August	1987	5	16.8	0.7	3	8.7	1.8
September	1987	6	7.8	1.7	3	8.3	2.2
October	1987	2	1.0	0.0	4	1.8	0.9
November	1987	1	0.0	-	1	7.0	-

Table 8. Monthly means and standard errors of humans observed on low altitude aerial surveys of B. Everett Jordan Lake and Falls Lake, North Carolina, 1986-87.

		Jordan Lake			Falls Lake		
Month	Year	n	$\bar{x}$	SE	n	$\bar{x}$	SE
July	1986	1	12.0	-			
August	1986	2	28.5	20.5	3	17.6	1.4
September	1986	6	19.7	4.1	4	22.0	3.5
October	1986	3	13.7	5.2	2	39.5	9.5
November	1986	3	10.3	3.4	2	6.0	2.0
December	1986	2	4.5	2.5	3	8.7	4.4
January	1987	2	7.5	5.5	2	6.0	1.0
February	1987	2	1.0	1.0	2	0.0	0.0
March	1987	1	4.0	-	1	24.0	-
April	1987	3	10.3	4.9	2	39.0	20.0
May	1987	1	33.0	-	1	146.0	-
June	1987	4	23.8	1.9	2	47.5	5.5
July	1987	9	47.7	6.9	5	35.2	10.7
August	1987	6	37.7	9.1	3	48.3	7.3
September	1987	5	29.4	3.2	3	39.7	0.9
October	1987	4	20.5	5.7	4	15.8	6.9
November	1987	2	31.0	12.0	2	36.5	9.5
December	1987	2	15.5	1.5	2	13.5	5.5

Table 9. Number of humans observed during low altitude aerial surveys of B. Everett Jordan Lake and Falls Lake, North Carolina 30 July 1986 - 14 December 1987.

Date	Jordan Lake	Falls Lake
7/30/86	12	-[a]
8/14/86	-	20
8/18/86	8	15
8/26/86	49	18
9/09/86	21	32
9/10/86	18	19
9/11/86	29	-
9/18/86	1	21
9/25/86	21	-
9/29/86	28	16
10/15/86	7	-
10/20/86	-	30
10/24/86	24	-
10/28/86	10	49
11/06/86	17	-
11/10/86	8	8
11/25/86	6	4
12/16/86	7	12
12/22/86	-	0
12/23/86	2	
12/30/86	-	14
1/06/87	2	7
1/21/87	13	5
2/10/87	0	0
2/23/87	2	0
3/17/87	4	24
4/07/87	4	-
4/21/87	20	19
4/27/87	7	59
5/07/87	33	146
6/11/87	24	53
6/22/87	20	42
6/25/87	29	-
6/29/87	22	-

Table 9. Continued

Date	Jordan Lake	Falls Lake
7/02/87	52	-
7/06/87	65	21
7/09/87	52	63
7/13/87	16	-
7/16/87	70	-
7/20/87	19	22
7/23/87	71	59
7/27/87	33	11
7/30/87	51	-
8/03/87	16	-
8/06/87	47	50
8/13/87	70	60
8/18/87	26	35
8/20/87	52	-
8/24/87	15	-
9/03/87	41	-
9/10/87	29	40
9/15/87	30	-
9/22/87	25	41
9/29/87	22	38
10/06/87	30	6
10/13/87	6	13
10/20/87	17	36
10/29/87	29	8
11/02/87	43	46
11/17/87	19	-
11/18/87	-	27
12/07/87	14	19
12/14/87	17	8

[a] Lake not surveyed.

Table 10. Means and standard errors of humans observed during morning and afternoon low altitude aerial surveys of B. Everett Jordan Lake and Falls Lake, North Carolina 1986-87.

Lake		n	$\bar{x}$	SE
Jordan				
	Morning[a]	18	21.61	3.45
	Afternoon	18	36.72	4.53
Falls				
	Morning[b]	13	16.62	3.18
	Afternoon	13	38.92	5.61

[a] Signed rank test comparing people numbers morning vs. afternoon at Jordan Lake (P = 0.012).
[b] Signed rank test comparing people numbers morning vs. afternoon at Falls Lake (P = 0.006).

Table 11. Monthly means and standard errors of human activities observed during 58 low altitude aerial surveys of B. Everett Jordan Lake, North Carolina, 1986-87.

Month	Year	n	Boats		Shore Use		Total	
			$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
July	1986	1	9.0	0.0	3.0	0.0	12.0	0.0
August	1986	2	15.0	11.5	13.5	9.0	28.5	20.5
September	1986	6	12.2	2.5	7.5	1.9	19.7	4.1
October	1986	3	9.7	3.7	4.0	1.7	13.7	5.2
November	1986	3	3.7	2.3	6.7	1.2	10.3	3.4
December	1986	2	1.0	1.0	3.5	1.5	4.5	2.5
January	1987	2	4.0	2.0	3.5	3.5	7.5	5.5
February	1987	2	0.0	0.0	1.0	1.0	1.0	1.0
March	1987	1	4.0	0.0	0.0	0.0	4.0	0.0
April	1987	3	5.7	1.7	4.7	3.3	10.3	4.9
May	1987	1	21.0	0.0	12.0	0.0	33.0	0.0
June	1987	4	10.5	0.9	13.3	2.2	23.8	1.9
July	1987	9	25.6	4.0	22.1	3.2	47.7	6.9
August	1987	6	18.8	6.3	18.8	3.0	37.7	9.1
September	1987	5	17.2	2.5	12.2	1.6	29.4	3.2
October	1987	4	11.0	5.3	9.5	1.6	20.5	5.7
November	1987	2	14.5	5.5	16.5	6.5	31.0	12.0
December	1987	2	6.5	0.5	9.0	2.0	15.5	1.5

Table 12. Monthly means and standard errors of human activities observed during 43 low altitude aerial surveys of Falls Lake, North Carolina, 1986-87.

Month	Year	n	Boats		Shore Use		Total	
			$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
August	1986	3	11.7	0.3	6.0	1.5	17.6	1.4
September	1986	4	12.5	1.8	9.5	2.9	22.0	3.5
October	1986	2	26.5	12.5	13.0	3.0	39.5	9.5
November	1986	2	3.0	2.0	3.0	0.0	6.0	2.0
December	1986	3	7.5	1.5	3.0	3.0	8.7	4.4
January	1987	2	3.0	2.0	3.0	1.0	6.0	2.0
February	1987	2	0.0	0.0	0.0	0.0	0.0	0.0
March	1987	1	6.0	0.0	18.0	0.0	24.0	0.0
April	1987	2	19.5	7.5	19.5	12.5	39.0	20.0
May	1987	1	81.0	0.0	65.0	0.0	146.0	0.0
June	1987	2	25.5	4.5	22.0	1.0	47.5	5.5
July	1987	5	21.2	7.4	14.0	3.6	35.2	10.7
August	1987	3	34.7	6.9	13.7	1.2	48.3	7.3
September	1987	3	23.0	0.6	16.7	0.7	39.7	0.9
October	1987	4	9.0	3.2	6.8	4.1	15.8	6.9
November	1987	2	19.0	10.0	16.5	0.5	36.5	9.5
December	1987	2	6.5	2.5	7.0	3.0	13.5	5.5

Table 13. Vehicle counts at the Mason Point Roost, B. Everett Jordan Lake, North Carolina 1986-87.

Date of counts	Vehicles/Day
10/11/86-10/31/86	4.0
11/01/86-11/15/86	5.0
11/25/86-12/30/86	5.0
12/31/86-01/05/87	4.8
01/20/87-02/10/87	1.1
02/10/87-03/16/87	1.0
03/17/87-04/20/87	1.1
05/06/87-05/11/87	3.6
05/12/87-05/21/87	2.1
05/22/87-05/30/87	3.1
06/01/87-06/05/87	4.7
06/06/87-06/11/87	6.3
07/20/87-08/03/87	2.5
08/24/87-09/01/87	7.3
09/02/87-09/07/87	7.2
09/08/87-09/21/87	5.4
09/22/87-10/12/87	5.1
10/13/87-10/19/87	4.8
10/20/87-11/06/87	4.8

Table 14. Means and standard errors of eagles and people observed on weekday/weekend boat surveys of selected B. Everett Jordan Lake sections, 1986-87.

			PEOPLE						EAGLES				
				Weekdays		Weekends				Weekdays		Weekends	
Section	Year	P[a]	n	$\bar{x}$	SE	$\bar{x}$	SE	P[b]	n	$\bar{x}$	SE	$\bar{x}$	SE
North of Farrington Bridge	1986	0.181	3	5.3	0.9	27.7	8.8	0.181	3	18.7	7.5	11.0	9.0
	1987	< 0.001	16	10.8	1.8	44.2	5.5	0.011	16	25.9	3.7	18.0	2.2
	Combined	< 0.001	19	9.9	1.6	41.6	4.9	0.005	19	24.7	3.3	16.9	2.3
White Oak Creek	1986	0.181	3	2.3	0.7	12.3	0.7	1.000	3	1.0	0.6	1.0	0.6
	1987	< 0.001	16	5.4	0.9	28.4	3.3	1.000	16	1.6	0.4	1.5	0.3
	Combined	< 0.001	19	4.9	0.9	25.9	3.1	1.000	19	1.5	0.4	1.4	0.2
Beaver Creeks	1986	0.059	5	4.6	1.2	27.4	6.1	0.424	5	1.2	0.5	0.8	0.5
	1987	0.004	11	5.9	1.2	48.7	7.1	0.901	11	1.8	0.4	1.8	0.3
	Combined	< 0.001	16	5.5	0.9	42.1	5.7	0.822	16	1.6	0.3	1.5	0.3
Haw River and Kirk's Creek	1986	0.106	5	7.0	1.6	55.4	24.3	0.345	5	2.8	1.5	1.2	0.6
	1987	0.004	11	11.4	2.2	75.9	7.5	0.281	11	1.0	0.3	0.5	0.2
	Combined	< 0.001	16	10.1	1.6	69.5	9.0	0.112	16	1.6	0.5	0.8	0.2

[a] Signed rank test comparing people numbers on weekdays vs. weekends.
[b] Signed rank test comparing eagle numbers on weekdays vs. weekends.

Table 15. Means and standard errors of eagle and people densities observed on 16 weekday/weekend boat surveys of north of Mason Point and south of Mason Point, north of Farrington Bridge, B. Everett Jordan Lake, North Carolina, 1987.

			Densities		Numbers	
Weekday/Weekend	Section	P[a]	$\bar{x}$	SE	$\bar{x}$	SE
Weekdays						
Eagles	North	0.856	0.71	0.11 (/km)	19.9	3.16
	South		0.73	0.10	6.1	0.85
Boats	North	0.036	0.22	0.05 (/km^2)	1.8	0.39
	South		0.58	0.14	2.4	0.55
People on Shore	North	0.776	0.18	0.05 (/km)	5.1	1.32
	South		0.20	0.06	1.6	0.48
Total People	North	0.776	0.85	0.18 (/km^2)	6.9	1.47
	South		0.98	0.23	4.0	0.95
Total People	North	0.776	0.25	0.05 (/km)	6.9	1.47
	South		0.48	0.11	4.0	0.95
Weekends						
Eagles	North	0.002	0.58	0.08 (/km)	16.2	2.11
	South		0.23	0.04	1.9	0.36
Boats	North	< 0.001	1.20	0.19 (/km^2)	9.7	1.53
	South		3.28	0.41	13.4	1.68
People on Shore	North	0.339	0.49	0.10 (/km)	13.8	2.81
	South		0.85	0.28	7.0	2.30
Total People	North	0.003	2.90	0.46 (/km^2)	23.5	3.76
	South	0.003	4.98	0.90	20.4	3.71
Total People	North	0.003	0.84	0.14 (/km)	23.5	3.76
	South	0.003	2.47	0.45	20.4	3.71

[a] Signed rank test comparing eagle and people densities North of Mason Point with densities South of Mason Point weekdays and weekends.

Table 16. Means and standard errors of eagles and people observed on 16 weekday/weekend boat surveys north of Mason Point and south of Mason Point, north of Farrington Bridge, B. Everett Jordan Lake, North Carolina, 1987.

			Numbers		Densities	
Section		P[a]	$\bar{x}$	SE	$\bar{x}$	SE
North of Mason Point, north of Farrington Bridge						
Eagles	Weekdays	0.144	19.9	3.16	0.71	0.11 (/km)
	Weekends		16.2	2.11	0.58	0.08
Boats	Weekdays	< 0.001	1.8	0.39	0.22	0.05 (/km^2)
	Weekends		9.7	1.53	1.20	0.19
People on Shore	Weekdays	0.007	5.1	1.32	0.18	0.05 (/km)
	Weekends		13.8	2.81	0.49	0.10
Total People	Weekdays	0.002	6.9	1.47	0.85	0.18 (/km^2)
	Weekends		23.5	3.76	2.90	0.46
Total People	Weekdays	0.002	6.9	1.47	0.25	0.05 (/km)
	Weekends		23.5	3.76	0.84	0.14
South of Mason Point, north of Farrington Bridge						
Eagles	Weekdays	0.001	6.1	0.85	0.73	0.10 (/km)
	Weekends		1.9	0.36	0.23	0.04
Boats	Weekdays	< 0.001	2.4	0.55	0.58	0.14 (/km^2)
	Weekends		13.4	1.68	3.28	0.41
People on Shore	Weekdays	0.001	1.6	0.48	0.20	0.06 (/km)
	Weekends		7.0	2.30	0.85	0.28
Total People	Weekdays	< 0.001	4.0	0.95	0.98	0.23 (/km^2)
	Weekends		20.4	3.71	4.98	0.90
Total People	Weekdays	< 0.001	4.0	0.95	0.48	0.11 (/km)
	Weekends		20.4	3.71	2.47	0.45

[a] Signed rank test comparing eagle and people numbers on weekdays vs. weekends.

Table 17. Flush distances of eagles by age class in response to motor boat approaches, B. Everett Jordan Lake, North Carolina, 1987.

Age[a]	n	$\bar{x}$	SE	Range
Immature	26	129.7	17.4	0 - 395
Subadult	3	124.0	39.7	66 - 200
Adults	34	144.1	12.1	38 - 323
Ages Combined	63	137.2	9.8	0 - 395

[a] No significant differences were found among age classes (Kruskal-Wallis test, $P = 0.495$).

Table 18. Flush distances of eagles in response to motor boat and pedestrian approaches, B. Everett Jordan Lake, North Carolina, 1987.

Approach[a]	n	$\bar{x}$	SE	Range
Boat	63	137.2	9.8	0 - 395
Pedestrian	3	220.0	15.9	191-246

[a] A significant difference was found between approaches (Wilcoxon rank sum test (normal approx.), $Z = 1.97$, $P = 0.049$).

Table 19. Observed frequencies, expected frequencies, and standardized deviates from the loglinear model fit to 961 shoreline segments on B. Everett Jordan Lake, North Carolina, 1986-87.

Eagle	People	Lake Area	Summer Obs.[a]	Summer Exp.[b]	Summer Std. dev.[c]	Fall Obs.	Fall Exp.	Fall Std. dev.	Winter Obs.	Winter Exp.	Winter Std. dev	Spring Obs.	Spring Exp.	Spring Std. dev.
Use	Use	NFARR[d]	35	35.6	-0.1	16	12.3	1.0	2	1.6	0.3	0	1.9	-1.4
		FARR[e]	32	31.4	0.1	0	1.7	-1.3	0	0.2	-0.5	0	0.2	-0.5
		MAIN[f]	29	33.0	-0.7	2	1.3	0.6	0	0.0	-0.2	1	0.4	0.9
		HAW[g]	19	16.7	0.6	3	2.2	0.5	0	0.2	-0.5	0	0.1	-0.3
Use	No Use	NFARR	72	71.4	0.1	30	33.7	-0.6	10	10.4	-0.1	38	36.1	0.3
		FARR	23	23.6	-0.1	5	3.3	1.0	4	3.8	0.1	2	1.8	0.2
		MAIN	30	26.0	0.8	3	3.7	-0.3	1	1.0	0.0	4	4.6	-0.3
		HAW	7	9.3	-0.8	1	1.8	-0.6	2	1.8	0.2	2	1.9	0.1
No Use	Use	NFARR	35	34.4	0.1	47	50.7	-0.5	33	33.4	-0.1	13	11.1	0.6
		FARR	130	130.6	-0.1	112	110.3	0.2	22	21.8	0.1	38	37.8	0.0
		MAIN	187	183.0	0.3	119	119.7	-0.1	20	20.0	0.0	42	42.6	-0.1
		HAW	119	121.3	-0.2	122	122.8	-0.1	29	28.8	0.0	17	16.9	0.0
No Use	No Use	NFARR	44	44.6	-0.1	93	89.3	0.4	143	140.6	0.0	135	136.9	-0.2
		FARR	64	63.4	0.1	132	133.7	-0.2	223	223.2	0.0	209	209.2	0.0
		MAIN	89	93.0	-0.4	211	210.3	0.0	314	314.0	0.0	288	287.4	0.0
		HAW	46	43.7	0.3	65	64.2	0.1	160	160.2	0.0	172	172.1	0.0
		Total	961	961.0		961	961.0		961	961.0		961	961.0	

[a] Observed frequencies.
[b] Expected frequencies.
[c] Standardized deviates.
[d] North of Farrington Bridge
[e] Farrington Bridge to US64 Bridge
[f] US64 Bridge to New Hope River
[g] New Hope and Haw Rivers

VITA

Timothy J. Smith was born on June 7, 1963 to Dr. Thomas W. and Patricia K. Smith. He graduated from Olean High School, Olean, New York in 1981. He attended St. Bonaventure University and SUNY College of Environmental Science and Forestry and received a Bachelor of Science degree (*Magna cum laude*) in Forest Biology from SUNY in December 1985. He was granted a graduate research assistantship at Virginia Polytechnic Institute and State University and began graduate studies in April 1986. He was elected treasurer of the Virginia Tech chapter of The Wildlife Society 1987-88 and served on the Graduate Student Advisory Committee, School of Forestry and Wildlife Resources.

Timothy J. Smith

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